Discovery May Speed Tree Breeding, Biotechnology

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Researchers have discovered the genetic controls that cause trees to stop growing and go dormant in the fall, as well as the mechanism that causes them to begin flowering and produce seeds – a major step forward in understanding the basic genetics of tree growth.

The findings were made by scientists from the Swedish University of Agricultural Sciences, Oregon State University and two other institutions, and published in the journal Science. They represent a significant fundamental advance in explaining the annual growth cycles and reproduction of trees.

By knowing the genes that control these processes, it should be possible to genetically engineer trees that flower and reproduce more quickly. The long, slow growth of trees before they produce seed has been a major stumbling block toward the types of breeding that has been common with annual crop plants. This may open the door to important advances in intensive forestry and fruit tree improvement.

Information of this type, researchers say, may also help scientists better predict how some types of trees and tree populations will respond to climate change.

"Before this we never really knew what genes were involved in the initiation of tree flowering or the cessation of growth in the fall," said Steven Strauss, a professor of forest genetics at OSU. "At least in theory, it may now be possible to dramatically speed up tree breeding programs and strategies.

"Trees grow for a long time before they begin to produce seed, several years and sometimes decades," he said. "Because of that, a lot of breeding approaches common with short-lived species that flower rapidly, such as corn and wheat, have been too slow to be practical."

A remaining obstacle, Strauss said, is public understanding of the nature and safety of genetic engineering with trees, which has led to limited interest in the field by private industry and sometimes unwieldy regulations by government agencies. These genes could be used just to speed up conventional breeding, and then removed prior to commercial plantings, he said. However, the level of regulation and concern about genetic engineering may prevent even this application.

In this research, scientists studied the genes CO and FT that were first isolated from the annual plant Arabidopsis. The genes in that plant are responsible for the day-length regulation of flowering. They discovered that the same genes had been conserved through millions of years of separate evolution and also performed similar functions in aspen trees.

To their surprise, however, the researchers found that the CO/FT combination also controlled the cessation of vegetative tree growth in the fall – something that Arabidopsis plants, which die after a single growing season, do not need to do.

These processes, scientists say, reflect a critical tradeoff between tree growth and survival. Temperate trees have to stop growing and go dormant in the winter or they literally freeze to death.

"From an evolutionary perspective, it's easy to understand why forest trees don't flower and produce seed and pollen earlier," Strauss said. "When they are young, the trees that survive need to focus their energy on growth and height in order to compete for sunlight with other trees, and only later in their life do they divert energy to produce seed."

Strauss noted that for the same reasons, any releases of such early-flowering genes into wild populations are unlikely to be of ecological concern, as trees bearing them would have a competitive disadvantage when growing with wild forest trees, and thus would not spread to any significant degree.

It also appears that the CO/FT genetic combination is critical to help trees adapt to local conditions, the researchers found. They studied aspen trees from different populations, and found that trees adapted to colder northern climates shut down growth earlier in the summer to prepare for long, harsh winters. The genetic mechanisms that adapt trees to these conditions and control it are so strong that trees will behave about the same even if they are transplanted to warmer regions, the scientists say.

For applied research, Strauss said, researchers can now induce activation of the FT gene earlier, so that trees will reproduce at much younger ages – months instead of years – and better lend themselves to conventional genetic manipulation. It could be possible, he said, to more rapidly breed some desirable traits, and then, via normal sexual crosses, remove the FT gene to leave behind trees that no longer have it, nor reproduce abnormally early.

In other cases, a modestly strong FT gene might be left in place to provide sustained benefits, such as earlier or more heavily flowering fruit tree varieties. Especially in situations where conventional approaches are ineffective, the gene could provide a new option for modifying flower and fruit production, which fruit tree breeders do routinely.

A better understanding of these processes could also provide information about how trees may react and adapt to climate change, or perhaps identify tree populations based on their DNA that are most at risk. Such populations might benefit from accelerated breeding or transplantation to aid their survival. This would give ecologists and conservation geneticists more tools to work with, Strauss said.

Source: Oregon State University

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