"FasTracking" Plum Breeding

Plum, peach, cherry, apricot, and almond trees—what do they have in common? Well, they are all members of the genus *Prunus,* and their fruits are well loved among American consumers. But perhaps the most significant similarity is that the trees take a very long time to mature and produce fruit.

The time it takes for these fruit trees to reach maturity from seed has a considerable effect on the development of new varieties with desired traits, such as an improved mix of sugars or resistance to disease. "Fruit tree breeding still remains a slow, arduous process that has changed little over the centuries," explains horticulturist Ralph Scorza. "In addition to the long juvenile period (3 to 10 or more years during which trees do not fruit), other limitations include the need for large land areas with significant field costs and yearly limitations on flowering and fruiting related to chill and heat requirements. Temperate fruit tree crops require a period of dormancy to induce flowering and to bear fruit."

But what if there were a way to get around those limitations?

That's exactly what Scorza and his colleagues at the USDA-ARS Appalachian Fruit Research Station in Kearneysville, West Virginia, aimed to do when they started "FasTrack," an advanced fruit tree breeding system. Plant physiologist Chinnathambi Srinivasan, molecular biologist Christopher Dardick, and geneticist Ann Callahan join Scorza on this project.

The team is focused on improving the breeding system for plum, a fruit the scientists have spent many years working on. With FasTrack, they have found a way to lessen the time it takes to create new, improved plums. Instead of taking 15-20 years to breed trees with a combination of desired traits, such as disease resistance and high-quality fruit, the scientists can now accomplish this task in just 3-5 years.

CHINNATHAMBI SRINIVASAN (D2142-1)

Rather than the 3 to 10 years normally required for a seedling plum to produce fruit, FasTrack plum lines carrying the early-flowering gene produce fruit in less than a year after being planted from seed.

Inducing Early Flowering

Genes for early flowering have been previously reported in several plants. By over-expressing certain flowering genes, scientists were able to induce early flowering in the model species *Arabidopsis* as well as in poplar and citrus. "But this early-flowering construct was never developed into a practical system for breeding," says Dardick. "Our research represents one of the first efforts to implement this technology in fruit trees."

Unlike conventional breeding, FasTrack uses plum lines that have been transformed with a special gene called *"PtFT1"* that induces early flowering. The scientists inserted this gene, previously discovered in California poplar *(Populus trichocarpa),* into the plum cultivar Bluebyrd to stimulate early and continual flowering.

The research team, spearheaded by the genetic engineering work of Srinivasan, produced 196 transgenic plum plants in total, many of which flowered and set fruits within 1 year. These plants don't look like trees, but rather like shrubs. And instead of single flowers, some buds produced flower clusters.

"Because of their growth habit, these transgenic trees aren't suitable for standard orchard practices," explains Dardick. "So we keep them in the greenhouse, which provides a controlled environment where we can continually makes crosses all year long and produce offspring at a faster rate. By coupling FasTrack technology with new molecular marker technologies, we will ultimately be able to produce a new variety in less than half the time it would take with conventional breeding practices."

At the very last step of breeding in the greenhouse, the scientists select trees that don't have the *PtFT1* gene but still possess traits of interest, such as sweet fruit, resistance to a certain disease, or higher nutrient levels. In this way, FasTrack technology uses genetic modification during the breeding process, but in the final step, the trees that are selected for use as cultivars are not genetically modified; that is,

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At the Appalachian Fruit Research Station, Kearneysville, West Virginia, plant physiologist Chinnathambi Srinivasan evaluates developing transgenic plum shoots for evidence of the expression of the early-flowering gene. These will be transferred to the greenhouse for use in FasTrack breeding.

they don't have the *PtFT1* gene, do flower normally, and are no different than if they had been produced through traditional breeding practices.

The scientists are the only group in the country conducting this kind of research at the moment. According to the researchers, FasTrack can be adapted for any plant, but it is more useful for plants that take a long time to mature.

The technology can also be used to produce fruit in new ways, especially considering the challenges we face in dealing with climate change. The transgenic tree's shrublike stature could make it possible to grow fruit in greenhouses or high tunnels. And because it doesn't require a chilling period, it could be adapted for growing in tropical climes and could be used to produce fruit year round. It might also be appealing to home gardeners as an ornamental plant that continually flowers and fruits.

Building a Better California Plum

Funded by the Specialty Crop Research Initiative, the Kearneysville scientists are now using FasTrack to improve trait quality for the California dried plum industry. They are collaborating with researchers at the University of California (UC) at Davis, Clemson University, and Pennsylvania State University.

One cultivar, Improved French, is currently planted on more than 98 percent of the total dried-plum acreage in California. This monoculture situation makes the industry vulnerable to disease and pest outbreaks and statewide yield decline. Using one cultivar also means the industry must harvest and dehydrate the crop within the span of a few weeks.

"Because of the long generation time, only two plum varieties have been released for the dried-plum industry since 1985," explains Scorza. "Developing new cultivars will increase the efficiency of California dried-plum production and ensure the two top traits of interest—improved sugar content and resistance to plum pox virus, a devastating disease of plum and other stone fruits—are incorporated into the germplasm."

The research team will use FasTrack to cross dried-plum germplasm developed at UC-Davis by Ted DeJong with Kearneysville-developed breeding stock possessing improved sugar content and resistance to plum pox virus. The improved germplasm will then be sent back to UC-Davis and used by breeders to develop new varieties.

With ARS and university partnerships, California will continue to be the world leader in dried-plum production.—By **Stephanie Yao,** formerly with ARS.

This research is part of Plant Genetic Resources, Genomics, and Genetic Improvement, an ARS national program (#301) described at www.nps.ars.usda.gov.

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FasTrack allows scientists to pollinate flowers and evaluate fruit from the same plants in the greenhouse year round. In the background, geneticist Ann Callahan measures sugar content of plum fruit as plant molecular biologist/pathologist Chris Dardick measures fruit size. In the foreground, horticulturist Ralph Scorza pollinates plum flowers.

STEPHEN AUSMUS (D2116-10)