RESEARCH RESULTS FOR THE YEAR 2013 'FASTRACK' - A REVOLUTIONARY APPROACH TO LONG-GENERATION CYCLE SPECIALTY CROP BREEDING

OBJECTIVES

The objectives of the project are the development of a practical rapid cycling breeding system for plum, the development of improved plum germplasm and varieties, and the demonstration of FasTrack breeding as a model for the rapid breeding of other long breeding cycle crops, in particular tree fruits.

PROPOSED RESEARCH AND DEVELOPMENT

The American tree fruit industry is facing challenges of climate change, reductions in available labor, the need for reduced chemical inputs, the spread of exotic pests and pathogens, and consumer demands for improved fruit quality and healthful attributes. To meet these challenges the development of improved varieties is more vital than ever. Yet, fruit tree breeding remains a slow, arduous process that has changed little over the centuries. Limitations include long juvenility periods (3-10+ years), large land areas with significant field costs, and yearly limitations on flowering and fruiting related to chill and heat requirements. Recently, research has focused on marker assisted selection (MAS), germplasm characterization, and genetic engineering (GE) as means to advance tree fruit breeding. However, these strategies are all still limited by the inherently slow generation cycles of tree fruits. To address this need, a system has been developed to shorten the breeding cycle of tree fruits and other long breeding cycle crops. We have overcome the juvenility and environmental limitations of flowering and fruiting by incorporating a flowering-related gene from poplar (FT) to induce trees to flower early and continually and to produce viable fruits and seeds within one year. In plum (*Prunus domestica*), the normal generation cycle is 3-6 years. We are using the early flowering trait to develop a rapid breeding system-'FasTrack'. The system will allow for the rapid incorporation of important traits into plums and other long-generation-cycle crops and then in the final generation, when substantial improvements are clearly evident, the FT gene construct would then be selected against in segregating seedlings and the resulting "null segregants" (those seedlings not containing the early flowering transgene, or any transgene sequences) would not be genetically engineered. This improved germplasm may be used directly as new varieties or improved lines for further conventional breeding. Such an approach would provide breeders of long-generation-cycle crops the ability to respond to new market demands, climatic changes, introductions of exotic diseases and pests in a way never before possible with these species.
The FasTrack proposal, funded by the USDA Specialty Crops Research Initiative and supported in-kind by the California Dried Plum Board, UC, Davis, Clemson University, Andres Bello University, International Food Information Council (IFIC) and Penn State University began in the fall of 2009. The research team includes from USDA-ARS Kearneysville, WV, Ralph Scorza, Chinnathambi Srinivasan, Ann Callahan, Chris Dardick-, and Doug Raines; from UC, Davis, Ted DeJong; from Clemson University, Albert Abbott; and from Penn State University, Jayson Harper.
Project goals cover the areas of research, extension, and outreach. Progress in these areas in 2013 is briefly summarized below.

SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS 2013

- FasTrack breeding parameters continue to be optimized through the cycling of greenhouse temperatures. These conditions will increase the numbers of seedling obtained and improve the efficiency of the FasTrack breeding system.

- Additional third generation plants that contain genes for early flowering combined with the 'HoneySweet' plum PPV resistance gene and 'Improved French' genetic background have been germinated and these will be available for an additional backcross breeding generation to combine PPV resistance with 'Improved French' traits.

2013 RESULTS NARRATIVE

Research Component Progress

Additional third generation seedlings are being grown out. The project completed its fourth year and has entered the third backcross generation. Considering that we are beginning the fourth year of the project and that a typical generation cycle for *P. domestica* plum is on average 4 years, the timeline for FasTrack breeding is extremely rapid. To reach this stage in the breeding program would normally require around 12 years.

All seedlings from crosses of the genetically engineered Plum pox virus resistant plum variety 'HoneySweet' by FT (early flowering) elite lines have been screened for the presence of the PPV resistance construct and the presence of the FT construct. All seedlings from California germplasm by FT elite lines have been screened for the presence of the FT construct.

Since FasTrack breeding is greenhouse-based, comparisons of fruit quality in the greenhouse and field are important. Our studies continue to suggest that fruit grown in the greenhouse and field are similar in size, brix, color and other phenotypic traits. Additional years and genotypes will be sampled and additional phenotypic traits will be evaluated

Grafting studies have shown that while grafting early flowering plant onto seedling plum rootstock increases vegetative growth of the early flowering plants flowering and fruiting is reduced. Additional rootstocks will be tested. While fruit production is reduced on grafted plants fruit phenotype is nearly identical on early flowering plants grafted onto non-GE rootstocks and self-rooted early flowering plants indicating that fruit qualities of seedling early flowering trees will remain stable when trees are grafted onto standard rootstocks. Grafting studies also suggest that there is movement of the flowering signal from the early flowering scion to the conventional plum seedling rootstock but the occurrence of flowering on conventional rootstocks is sporadic and very limited with only a few root suckers flowering. Nevertheless it does show that there is movement of the early flowering signal through the plant and across the graft union.

We have developed a temperature cycling system in the greenhouse to produce higher temperatures (29 C) for vegetative growth and flower bud development followed by cooling (21 C) to produce abundant flowering for cross pollination. This has improved the amount of flowering and fruiting and allowed for better efficiency of the breeding program.

Early flowering plum trees in the field have continued to produce flowers and fruit throughout spring and early summer with flowering resuming in the fall. The prolonged flowering period in spring/summer allowed for the escape from spring frost events and this year while an early spring freeze event destroyed the flowers and developing stone fruits in our orchard the early flowering lines were able to produce flowers and fruit as the season continued.

Field grown early flowering trees may provide additional hybridization opportunities for FasTrack breeding and also novel production potentials. These opportunities are under investigation.

Extension/Outreach Components Progress

It is important to liaison with the plum industry, fruit breeders, consumers, and regulators, in order to obtain scientific and societal input into this novel technology for plant improvement. The FasTrack website is publicly available (**http://ucanr.org/sites/fastrack/)** and we plan to continue to work with this website to reach out to other scientists, industry and the general public.

Additional outreach activities in 2013 include presentations at professional meetings in the U.S. and Europe on the FasTrack approach to breeding. We have maintained communication with the dried plum industry and participate in the CDPB annual meetings. We have completed the planning and organization of the First International Conference on Rapid Cycle Crop-Breeding to be held January 7-10 2014. The meeting will bring together experts in the field that are working on rapid cycle crop-breeding in other crops and provide for interaction with these groups and breeding programs to exchange information that will move forward this approach to fruit breeding. The meeting will also provide opportunities to gain insights that will help improve the plum FasTrack breeding project. Training by the International Food Information Council in biotechnology communication to be held as part of the conference will improve the ability of researchers to discuss biotechnology and accelerated breeding to the general public and help to improve acceptance of this technology for fruit improvement.