Genetic Engineering Approaches to Breeding Sterility and Reduced Invasiveness

PRINCIPAL INVESTIGATOR:
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PROJECT OBJECTIVES:
The primary objective of this work is to develop techniques, methods, and plant germplasm that will lead to sterile or highly infertile cultivars of invasive or potentially invasive nursery crops. The general approach is to use biotechnology or genetic engineering to create seedless and/or pollenless plants, or to develop methods that will lead to the creation of such plants. We have focused on methods development with respect to 1) broad improvements in capability for genetic engineering of the diverse plant species used in ornamental horticulture and floriculture, and 2) testing of new and potentially broadly effective approaches for inducing sterility using ornamental sweetgum and poplar as test species. In contrast to most forms of agricultural biotechnology, in vitro and genetic engineering methods that are specifically adapted to a single species or genotypes would have limited value.

ACCOMPLISHMENTS:
We report evidence of significant improvements in rate and efficiency of recovery of genetically engineering plant tissues as a result of the use of genes whose induced expression promotes cell division and growth during the regeneration phases of gene transfer. For example, the poplar GA20-oxidase gene both increased the rate of development of transgenic shoots in vitro, as well as their frequency. The work needs to be repeated with diverse germplasm to see if it is of general applicability, if it is effective in highly recalcitrant species/genotypes, and if additional genes with similar effects can further improve efficiency. We are also working with USDA scientists to develop vectors to enable transformation-enhancing genes to be rapidly excised from plant genomes, or transiently expressed, so they do not have adverse effects on further plant development.

A major focus of our efforts to test sterility genes has been in the model woody ornamental sweetgum, where we have produced and studied in the field approximately 50 types of genetically engineered trees for 3 years. Though not flowering, it is clear that nearly all of the genetically engineered trees are healthy, grow well, and are well-adapted; the genes added and genetic engineering process have not significantly harmed their health and development. A focus of this work is the use of the AGAMOUS gene as a tool to induce sterility. We are working on its suppression via two approaches: insertion of double stranded RNA (RNAi, RNA interference forms) against both of the sweetgum AGAMOUS genes, and modified AGAMOUS proteins that inhibit activity of the wild-type forms. We have collected tissues from all of the field plants for gene expression analysis, and expect to quantify the level of gene suppression this coming year based on vegetative tissues. We will study the effects of the inserted sterility genes on flowering this or the following fiscal year (when flowering is expected to first begin). We have also produced new forms of gene constructs for interfering proteins for the floral regulatory

protein LEAFY, inserted them into poplar, and are stimulating the rapid flowering of poplars with the FT gene to speed analysis of results.

TECHNOLOGY TRANSFER/IMPACT:

So far our communications have been directed mostly at the scientific literature, where we have produced a problem analysis paper that identified the strong potential and avenues for progress to improve basic transformation technology in ornamental and other difficult plant species:

Arias, R., S. Filichkin, and S.H. Strauss. (2006) Divide and conquer: development and cell cycle genes in plant transformation. Trends Biotechnol. 24:267-273.

We have recently published a paper that provides new tools for detecting the effects of genes that promote transformation and in vitro regeneration in the model woody plant poplar:

Bao, Y., Dharmawardhana, P., Arias, R., Allen, M.B., Ma, C., and S.H. Strauss. (2009) WUS and STM-based reporter genes for studying meristem development in poplar. Plant Cell Rep 28:947–962.

To explain biotechnology work and its potential to the landscape plant community, we published a paper on our related work on dwarfism genes:

Etherington, E., H. Gandhi, V. Busov, R. Meilan, C. Ma, K. Kosola, and S.H. Strauss. (2007) Dwarfism genes for modifying the stature of woody plants: A case study in poplar. Landscape Plant News. 18:3-6

ADDITIONAL FUNDING/EXTERNAL SUPPORT:

The large majority of our funding for this project comes from USDA-ARS under this project. However, we have received funds for related work from the Schmidt Foundation, the National Science Foundation, the USDA Biotechnology Risk Assessment Grants Program, the Consortium for Plant Biotechnology Research, and the industrial members of the Tree Biosafety and Genomics Research Cooperative.

COLLABORATORS:

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