Floriculture Germplasm Enhancement: Using Genetic Engineering to Improve Postproduction Quality

PRINCIPAL INVESTIGATOR:
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PROJECT OBJECTIVES:
This research will increase our understanding of the environmental and endogenous signals that trigger senescence in flowers and leaves. The goal of the research is to create ornamental plants with delayed senescence and enhanced stress tolerance.

Specific objectives:

- To identify genes and proteins involved in senescence.
- To characterize expression of senescence-related genes during development (i.e. age related senescence) and following drought and nutrient stress.
- To investigate the regulation of senescence-related genes by the plant hormone ethylene.
- To identify the best gene targets to enhance postproduction quality and performance using genetic engineering.

ACCOMPLISHMENTS:
Proteomic analysis of petal senescence: Two dimensional gel electrophoresis followed by tandem mass spectroscopy (proteomics) identified 133 proteins that were differentially expressed between senescing and nonsenescing petunia petals. Ninety of these proteins were either newly detected in senescing petals or increased in abundance (i.e. up regulated) during the progression of senescence. The proteins were identified based on sequence homology with known proteins in other plants or by comparison to translated Expressed Sequence Tags (ESTs) from Petunia. The identification of the petunia proteins from this study would not have been possible without the petunia gene sequencing project of Dr. David Clark at the University of Florida. The majority of the senescence up regulated proteins were classified as defense or stress response proteins or were enzymes putatively involved in macromolecule degradation and nutrient remobilization. Some proteins not previously reported to be involved in petal senescence were identified.

Nutrient remobilization during petal senescence: Senescence is an active process that requires energy. The programmed senescence of flower petals allows the plant to systematically dismantle cell contents and remobilize essential nutrients before the petals are shed. In petunia flowers only N and P were remobilized from dying petals. Additional macro and micronutrients are remobilized during leaf senescence, so this represents a substantial difference between the senescence programs in leaves and petals. A high affinity phosphate transporter protein involved in P transport during senescence was identified from petunia. This gene was directly regulated by ethylene (i.e. it is an ethylene primary response gene).

Genetic control of postproduction drought stress: Floriculture crops, especially bedding plants, can experience drought stress during shipping and retailing. Drought stress accelerates leaf and

flower senescence and can result in decreased plant quality and salability. While developmental leaf senescence in many plants involves the remobilization of nitrogen (N) and phosphorus (P), we found that drought-induced leaf senescence in petunia resulted in N, but not P, remobilization. Proteases and nucleases believed to be involved in nucleic acid and protein degradation during senescence were found to be up regulated by drought stress only late in the response when leaves were visibly yellowing. The gene encoding the phosphate transporter protein was not up regulated by drought stress, supporting the idea that P remobilization is not occurring during drought-induced senescence. One of the senescence up regulated proteins identified from the proteomic study described above is closely related to the abscisic stress and ripening related protein family in tomato. We cloned this gene and found that it was up regulated during petal senescence, and that it also increased in abundance during drought stress. In contrast to the other genes studied, this gene was very responsive to water deprivation and was up regulated early in the stress response when soil water content began to decrease and well before any visual symptoms of senescence. We believe this gene may function as a transcription factor that controls both drought stress responses and petal senescence. This research has identified differences and similarities between developmental and stress-induced senescence pathways.

TECHNOLOGY TRANSFER/IMPACT:

This research provides valuable knowledge about the execution of senescence in plants and how senescence is influenced by ethylene and environmental stresses. This information will be used to increase the shelf life of flowering plants, which will reduce postproduction shrinkage and increase the profitability of floriculture producers.

The protein experiments were submitted to the Journal of Experimental Botany and this manuscript will be the first proteomic evaluation of petal senescence to be published in a peer reviewed scientific journal. As such it will provide a substantial contribution to our understanding of the proteins that control the initiation and execution of senescence. This research was conducted by Dr. Shuangyi Bai, a recent Ph.D. graduate, and was included in the OSU dissertation “Identification and Characterization of Senescence-Associated Proteins in Petunia Corollas”.

The evaluations of nutrient changes during petal senescence provide us with an understanding of the biological relevance of senescence. It helps explain why plants would invest energy in a genetically controlled death program in leaves and petals. This will lead to more efficient ways to manipulate senescence. This also represents the first report of ethylene’s role in nutrient remobilization during senescence. Research results have been published in the Journal of Experimental Botany, Plant Science, and Acta Horticulturae.

Research results have been presented at a number of International and National Conferences including: the International Conference on Quality Management in Supply Chains of Ornamentals (Bangkok, Thailand, 2007), the International Ethylene Symposium (Pisa, Italy, 2006; Ithaca, New York, 2009) and the annual meeting of the American Society for Horticultural Science (2008 and 2009). These presentations have been a vital part of disseminating our research results and have led to the formation of additional collaborations and the development of future research projects.

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