Population Control: Developing Non-Invasive Nursery Crops©

Thomas G. Ranney
Department of Horticultural Science, North Carolina State University, Mountain Horticultural Crops Research and Extension Center, 455 Research Drive, Fletcher, North Carolina 28732

INTRODUCTION

There has been considerable debate over the impact of invasive exotic plants and the best approach to address this problem. The problem, briefly, is that some non-native plants are weedy to the point of being invasive, i.e., they naturalize over large areas, displace native plants, and disrupt natural ecosystems (Westbrook, 1998). There are many examples of exotic plants that fit this category. *Ligustrum sinense* (Chinese privet) has displaced the native shrub layer in 1 million ha (2.4 million acres) in the Southern United States. *Cytisus scoparius* (Scotch broom) has invaded 404,700 ha (1 million acres) in Oregon alone.

The nursery industry has been a significant contributor of invasive plants. Of 235 invasive woody plants in North America, it has been estimated that 85% were introduced for ornamental and landscape purposes (Reichard and Hamilton, 1997). Some of these species are still being produced and sold. Concern and awareness over the threat of invasive plants has been growing. In 1999, President Clinton issued Executive Order 13112 (<http://www.invasivespecies.gov/laws/execorder.shtml>) calling upon federal cabinet agencies to coordinate their efforts to combat invasive alien species and established the National Invasive Species Council (<www.invasivespecies.gov>), which, in turn, developed the National Invasive Species Management Plan (<http://www.invasivespecies.gov/council/main.shtml>) in 2001.

Most states have since formed exotic plant pest councils (<http://www.invasivespecies.gov/other/orgcounci.shtml>) and many agencies, organizations, and individuals have developed and distributed "black lists" of plants that they feel should not be grown. Many of these lists include plants that are actively being grown by the nursery industry. The Connecticut legislature recently passed Public Act 04-203 (<http://search.cga.state.ct.us/>) prohibiting the importing, moving, selling, purchasing, transplanting, cultivating, or distributing of 81 different plants with penalties of up to $100 per individual plant. The Commissioner of Agriculture in New Hampshire recently adopted an Invasive Species Rule (3800) prohibiting the collection, transportation, selling, distribution, propagation, and transplanting of 21 plants (<http://agriculture.nh.gov/pdf/topics/hyperlinks/Rules_8.pdf>) with a number of economically important nursery crops [e.g., *Acer platanoides* (Norway maple), *Berberis thunbergii* (Japanese barberry), and *Euonymus alatus* (winged euonymus)] being included. Most likely, other states will follow suit.

POTENTIAL SOLUTIONS

There are few simple means to eradicate plants that have already naturalized. However, methods are available that can help to prevent their further introduction. In addition to the more careful screening and selection of plants for sale (avoiding species and cultivars with known invasive properties), conventional and new biotechnologies can be employed to develop new, non-invasive cultivars. These methods encompass selection, traditional breeding, and genetic engineering approaches to prevent, or greatly impair, sexual reproduction. By doing so, many of these economically important plants can be grown and used to enhance our environment while minimizing their potential for invasiveness. Other benefits of these approaches include enhanced flowering and re-blooming, reduced fruit litter, and reduced pollen allergens.

BREEDING AND SELECTION

Selecting Naturally Occurring Seedless/Infertile Plants. Seedless plants periodically arise naturally. The problem is finding them! Reproduction is a complicated process and natural mutations can result in reduced fertility or sterile plants. For example, in the 1920s *Liquidambar styraciflua* 'Rotundiloba' (sweetgum), an unusual foliage form with rounded lobes, was found in North Carolina. Interestingly, this cultivar is highly infertile (though some branches will occasionally revert and produce fruit) and has now been widely planted as a fruitless form. Other examples of naturally occurring cultivars that have been purported to be infertile, nonflowering, or fruitless include *Catalpa bignonioides* 'Nana' (southern catalpa), *Betula nigra* 'Fox Valley' (river birch), *Cornus sanguinea* 'Compressa' (bloodtwig dogwood), *E. fortunei* var. *coloratus* (wintercreeper euonymus), and *Hebe cupressoides* 'McKean' (hebe) (though these have not undergone controlled testing). The mechanism(s) that prevents fruiting in these plants is generally not know and it is certainly possible that under certain conditions some fruit could be produced, but fertility appears to be extremely low if not nonexistent. There are certainly many opportunities for selecting naturally occurring, infertile forms of invasive species. We just need more people searching.

Wide Hybridization. Wide hybridization involves crosses between distantly related taxa (e.g., interspecific, intergeneric). In many cases wide hybrids are sterile due to dissimilarities of the chromosomes resulting in meiotic failure. A few examples of sterile hybrids include certain clones of: ×*Schimlinia floribunda* (mountain schimlinia), ×*Chitalpa* (chitalpa), *Prunus* ×*bleriana* (blireana plum), *Prunus* ×*cistena* (sand cherry), *Cornus kousa* × *C. florida* (Stellar® dogwoods), and *Hibiscus* (e.g., 'Loehngrin' and 'Tosca') (hibiscus).

Selecting and Breeding for Double Flowers (Additional Sets of Petals). The development of a flower represents a fine balance between the relative expression of sepals, petals, stamens, and carpels (pistil) (Weigel, 1995). An increased number of petals usually occurs at the expense of reproductive parts of the flower (stamens and carpels). Plants with lots of extra petals often have low fertility. A few examples of double flowering plants with purported low fertility or sterility include: *Aesculus hippocastanum* 'Bowmanii' (common horsechestnut), *Camellia japonica* 'Nuccio's Gem' (Japanese camellia), *C.* ×*erubescens* 'Victoria' (catalpa); *Chaenomeles* 'Dragons Blood' (flowering quince); *Crataegus laevigata* 'Paul's Scarlet' (English hawthorn); *Hydrangea arborescens* 'Hayes Starburst' (smooth hydrangea); *H. involucrata* 'Hortensis' (hydrangea); *Kerria japonica* 'Plenaflora' (Japanese kerria); *Punica granatum* 'Ato Shibori', 'Hiza Kuro', and 'Judai Zakuro' (pomegranate); *Philadelphus* 'Virginal' (mockorange); *Prunus* 'Kenroku-en-kiku-zakura' (flowering cherry); *ArdSyringa* 'Miss Ellen Wilmott' (lilac).

Triploids. One common approach for developing seedless plants is to create triploids — plants with an extra set of chromosomes. Although triploids typically grow and function normally, they have an inherent reproductive barrier in that the three sets of chromosomes cannot be divided evenly during meiosis yielding unequal segregation of the chromosomes (aneuploids) or complete meiotic failure. Triploids have been developed for many crops including seedless bananas (*Musa* sp.), watermelons (*Citrullus lanatus*), grapes (*Vitis* sp.), and althea (*Hibiscus syriacus*) (Egolf, 1988). Natural polyploids frequently occur in nature (Arnold, 1997). Triploids can also occur naturally or can be bred by hybridizing a tetraploid (4X) with a diploid (2X) to create seedless triploids (3X). Triploids can also be developed by regenerating plants from endosperm tissue, which is naturally 3X, found in seeds — though this can be very difficult for many woody plants. Triploids are not always seedless. However, even in the unusual case when a triploid plant can produce seeds (apples are an example), it happens infrequently, and seedlings generally have poor viability.

Our research group, including Zenaida Viloria, Tom Eaker, Joel Mowrey, Nathan Lynch, and Richard Olsen are currently working on developing non-invasive triploids of the following: *Acer ginnala* (amur maple), *Acer platanoides* (Norway maple), *Albizia julibrissin* (mimosa), *Campsis ×tagliabuana* (trumpet vine), *Cytissus scoparius* (scotch broom), *Euonymus alatus* (burning bush), *Elaeagnus* spp. (elaeagnus), *Hedera helix* (English ivy), *Hypericum andorsaemusm* (tutsan St. Johnswort), *Koelreutaria paniculata* (goldenraintree), *Ligustrum* sp. (privet), *Miscanthus sinensis* (maiden grass), *Pyrus calleryana* (callery pear), and *Ulmus parvifolia* (lacebark elm). We have identified tetraploids of most of these species and have successfully developed triploids of *Pyrus, Hypericum,* and *Campsis*. Because this approach involves controlled breeding, it also provides additional opportunities for plant improvement. In addition to breeding for seedlessness, we are simultaneously working on enhancing pest resistance, environmental adaptability, and commercial potential of these crops.

Induced Mutations. Random mutations induced by chemical and radioactive mutagens often result in reduced fertility. This approach had been used to a limited extent to reduce seed number in some fruit including *Citrus* sp. (oranges, grapefruit, etc.). However, due to the randomness of this approach, it requires that large numbers of plants be grown to maturity in hopes of finding a few individuals with greatly reduced fertility and is a relatively inefficient strategy.

TRANSGENIC APPROACHES

Biotechnology or genetic-engineering-based approaches utilize knowledge of the genes that are needed for fertility. Genes can be isolated, modified so that they impede normal reproductive development, used in combination with other genes, and then inserted into target crops via gene transfer methods. Strategies that insert novel genes to prevent reproduction may have broad applications to many genera. These molecular approaches are largely emerging technology and considerable work needs to be done in the area of gene discovery, transformation methods, and efficacy. Substantial advances in basic methods for regeneration of transformed plants are needed for rapid and cost-effective application of genetic engineering to the diversity of species grown by the nursery industry. Difficulties in licensing proprietary technologies, regulatory requirements, and public acceptance are additional hurdles that exist for this approach.

Dr. Steve Strauss, at Oregon State University, is a leader in developing transgenic methods for modifying reproduction in plants and is currently working on improving gene transfer technology and testing different methods for producing sterile trees using *Liquidambar styraciflua* and *Malus* sp. (crabapple) as model systems. Dr. Margaret Pooler at the U.S. National Arboretum is also working on complimentary projects to develop regeneration systems for important nursery crops that will provide a necessary foundation to allow for further improvement through transgenic approaches.

Acknowlegements. Funding for this research and development has been provided by: the USDA Floral and Nursery Research Initiative, North Carolina Association of Nurserymen, the Landscape Plant Development Center, Horticultural Research Institute, J. Frank Schmidt Family Foundation, Spring Meadow Nursery, and the Golden LEAF Foundation.

LITERATURE CITED

Arnold, M.L. 1997. Natural hybridization and evolution. Oxford Univ. Press. New York, New York.

Egolf, D.R. 1988. 'Aphrodite' rose of Sharon (althea). HortScience 23(1):223.

Reichard, S.H. and **C.W. Hamilton.** 1997. Predicting invasions of woody plants introduced into North America. Conservation Biol. 11:193-203.

Weigel, D. 1995. The genetics of flower development: from floral induction to ovule morphogenesis. Annu. Rev. Genetics. 29:19-39.

Westbrooks, R. 1998. Invasive plants, changing the landscape of America: Fact book. Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW), Washington, D.C. <https://www.denix.osd.mil/denix/Public/ES-Programs/Conservation/Invasive/intro.html>.