Minimizing Nutrient and Pesticide Exodus: A Collaborative Nursery and Floriculture Initiative Research Project©

Ted Whitwell
Department of Horticulture, Clemson University, Clemson, South Carolina 29634

INTRODUCTION

Production of high quality landscape and greenhouse container plants in the least amount of time with minimal costs necessitates the use of significant quantities of water, fertilizers, and pesticides. The availability of abundant water and nutrients provides optimum growing conditions for landscape plants and weeds, insects, and diseases. The high densities of a single plant species can result in rapid and devastating outbreaks of pests. While some progress in adopting IPM strategies are evident, weed, disease, and insect control measures are too often used on calendar-based schedules. Applications of pesticides are targeted at the prevention rather than the control of pests as economical damaging thresholds are very low for container-grown plants.

Plant production surfaces at container nurseries are commonly covered with plastics, fabric, or gravel. These surfaces facilitate placement and handling of containers and also function as a weed barrier. All ground covers have the potential to allow greater surface runoff than bare ground because they prevent infiltration and create sheet flow. Dependent upon pot spacing, up to 80% of an applied granular pesticide can fall off target directly onto the ground cover. Overhead irrigation creates runoff water, which quickens transport of pesticides and fertilizers to containment ponds and/or off site. Pesticides and excessive nutrient levels were detected in nursery retention basins in the southeastern U.S.A.

Many greenhouse systems either capture or contain their nutrient and pesticide-enriched runoff water, monitoring quality prior to reintroduction to the crop, or retaining runoff on site in collection basins. However, recapture systems must be routinely purged as pollutant levels reach unsafe levels. And, the resulting water must be treated prior to disposal or reused as irrigation. Urban landscapes are not exempt in their contribution to water quality problems. Nutrients and pesticides leave urban sites in irrigation or storm runoff water similar to the migration at a container nursery.

Concern for environmental, wildlife, and human protection dictates that practical and effective methods of reducing pesticide and nutrient migration and remediating runoff water from nurseries, greenhouses, and landscapes. Similar measures could be implemented to improve water quality from urban lawns and landscapes.

The USDA-ARS Nursery and Floriculture Initiative funded a cooperative project between researchers at Clemson University, North Carolina State University, Tennessee State University, University of Florida, and ARS-McMinnville and Ft. Pierce in 2002. The Environmental Resource Management Systems for Nurseries, Greenhouses, and Landscapes Project is developing ways to reduce nutrients and pesticides in nursery/greenhouse runoff water and improve overall water quality through the use of new technologies. The exciting feature of this project is the collaboration of scientists from four southeastern universities and two USDA-ARS units. The combined scientific expertise for this project greatly enhances the scope and depth of the research and education activities.

PROJECT OBJECTIVES

The overall goal of this project is to develop and demonstrate methods to harmonize high quality, economically viable production horticulture (landscape, nursery, and floriculture) with high environmental water quality.

Specific objectives include:

(a) Maximization of nutrient and water utilization efficiency,
(b) Mitigation of nutrient and pesticide contaminants in off site drainage, and (c) development of strategies for the use of ornamentals to improve water quality in the urban landscape.

Maximize Water Utilization and Nutrient Efficiency. Scientists at North Carolina State and ARS-McMinnville, Tennessee, are evaluating the effects of irrigation and fertilization scheduling on plant growth and photosynthesis, water use efficiency, and substrate temperature. Studies at NCSU and Tennessee State also are underway to increase substrate nutrient retention, increase plant nutrient uptake, and minimize losses by varying clay particle size and rates in potting substrates for nursery and greenhouse crops.

With current environmental concerns, research efforts should evaluate all inputs from irrigation application, efficiency, and substrates as well as plant response. Plants that take up and metabolize nutrients can help reduce elements of environmental concern such as phosphorus and nitrogen, as well as add aesthetic value to the landscape. Therefore, the objectives of this project will address nutrient management, nutrient loading, and uptake of nitrogen and phosphorus under controlled irrigation applications for container-grown plants using several species of native trees.

Mitigate Nutrient and Pesticide Contaminants in Offsite Drainage. The use of constructed wetlands has become popular as a low-energy-input method for improving water quality. Constructed wetlands have been used for the treatment of wastewater for more than 20 years. These wetlands effectively remove or reduce biological oxygen demand, chemical oxygen demand, suspended solids, metals, nutrients, and pesticides from waste and contaminated water. Constructed wetlands differ in substrate types, resident plant communities, and operating parameters depending on the purpose of the wetland. They may have substrates ranging from crushed gravel to field soil, vegetation ranging from floating plants and algae to emergent species such as *Typha latifolia*, and effluent flow regimes ranging from surface- to subsurface-flow.

Scientists at Clemson University are working with Wight Nurseries, now Monrovia Growers, located in Cairo, Georgia, which is one of the largest nurseries in the country with an estimated stock of over 10 million container plants. The nursery recaptures about 85% of the water used for irrigation in retention structures. It has also installed 10 acres of wetland areas planted with typical wetland vegetation. The area was designed to collect runoff water in excess of recapture needs. It was designed to have a certain retention time for nutrient absorption. Water flows through trench drains between wetland cells and eventually into a final wetland area before it is allowed to exit the nursery.

We are developing an understanding of the loading from pesticide and nutrient runoff into each wetland cell, the remediation efficiency of each cell and the overall system, and an understanding of how downstream water quality is affected by discharges from the nursery. We have determined that the changes have occurred in the

Table 1. Institutions, scientists, expertise, by objective involved in this project.

Institution	Scientist	Expertise	Research Objective
Clemson	Ted Whitwell	Pesticides	Wetland remediation, plant evaluation
Clemson	Steve Klaine	Environmental toxicology	Wetland remediation, plant evaluation
Clemson	Mickey Taylor	Environmental toxicology	Wetland remediation, plant evaluation
NC State	Ted Bilderback	Substrates irrigation	Nutrient and water utilization efficiency
N C State	Stewart Warren	Physiology	Nutrient and water utilization efficiency
Tennessee State	Chris Cantazaro	Floriculture substrates	Nutrient and water utilization efficiency
Univ. of FL	Tom Yeager	Plant nutrition	Nutrient and pesticide mitigation
Univ. of FL	Chris Wilson	Environmental toxicology	Nutrient and pesticide mitigation
USDA - ARS McMinnville, TN	Donna Fare	Plant Nutrition	Nutrient and water utilization efficiency
USDA – ARS Ft. Pierce, FL	Joe Albino	Physiology	Nutrient and pesticide mitigation

efficiency of the wetland over the past 3 years of the project. A thorough assessment/evaluation of the efficiency of an established nursery runoff remediation/treatment wetland system such as the one at Wight Nurseries will provide nursery managers with the necessary information to make informed choices among water treatment systems when faced with water restrictions, discharge permitting regulations, or other governmental instituted water quality criteria.

Researchers at the University of Florida and USDA-ARS Ft. Pierce are investigating bioremediation with common filtration technology used by the aquaculture industry. This may offer an economical method for reducing agrichemical loads in surface water for smaller nurseries or nurseries with limited land area for constructed wetlands. This technology basically consists of a variety of substrate materials that provide a tremendous surface area for microbial and periphyton colonization. Once colonized, these organisms effectively remove nutrients from the water column by tying them up in biological tissues [or as N_2 (gas), as with denitrifiers]. It relies on microbial organisms and physical/chemical processes to remove agrochemicals from contaminated water. Depending on the types or microorganisms colonizing the substrates, these systems may also efficiently remove/degrade pesticides present in water. These materials are commonly used in the aquaculture industry for nutrient by-product removal. Systems are being evaluated and samples are analyzed for pesticides, nitrate + nitrite, total kjeldahl nitrogen, ammonia, ortho-phosphorus, and total phosphorus.

LANDSCAPE PLANTS TO IMPROVE WATER QUALITY IN THE URBAN ENVIRONMENT

Pesticides and fertilizers are introduced into the urban environment as homeowners and professional applicators apply them to lawns and gardens, for improved plant growth and reduced pest problems. For example, the insecticides chlordane, diazinon, and malathion, and the herbicide 2,4-D were detected frequently at concentrations between 0.1 and 4.0 $\mu g \cdot L^{-1}$ in three studies of water samples from storm sewers draining residential and commercial areas of San Diego and Fresno, California, and Denver, Colorado. There is also substantial evidence that nutrient loading of surface waters can result from transport of nutrients from runoff and leaching of the fertilizers applied to turfgrass by urban homeowners, lawn maintenance personnel, and golf and park managers. With the increasing urbanization of the rural landscape, there is a significant risk of adversely affecting local streams, rivers, and estuaries through cultural eutrophication.

Scientists at Clemson University are investigating landscape plant species to phytoremediate pesticides and uptake/accumulate nitrogen and phosphorus. Plant cultivars are tested for their phytoremediation potential using replicated testing of microcosms and comparing the results to turfgrass and bare soil microcosms.

Impacts, Benefits, and Deliverables. The direct result of this research will be an improvement in the quality of water exiting horticulture production facilities and landscapes. Landscaped developments and horticulture production facilities will be able to become self-contained and self-remediating with respect to runoff water. Benefits to the horticulture industry further will include an increase in production efficiency, the development of new markets for ornamental plants, and the development of a better selection of landscape plants. In addition, technology transfer vehicles will be developed and implemented to insure that all stakeholders have access to this information and can successfully implement the strategies and methodologies developed in this research.