Fate of Herbicides in Container Nursery Runoff

Ted Whitwell, Jeanne A. Briggs, M. B. Riley, and **N. D. Camper**
Clemson University, Box 34007, Poole Agriculture Center, Clemson, South Carolina 29634-0375

Multiple preemergence herbicides applications are used in nurseries to control troublesome weeds throughout the growing season. Much of the applied chemicals are subject to runoff losses from the irrigation water, and recycled irrigation water may contain herbicide residues that could be harmful in the production of landscape plants. In 1991, we started research to determine the fate of herbicides in nursery runoff water. Two nurseries that recycle irrigation water were surveyed over a 2-year time period by analyzing containment pond water and sediment samples monthly. Pendimethalin, oxyfluorfen, and oryzalin herbicides were detected in water and sediment at times in both nurseries; however, herbicides did not accumulate over time and there was no strong correlation between amount detected and amount or timing of herbicide application. On-site, nursery runoff studies were used to evaluate quantities lost from a single herbicide application and the length of residual activity in containment pond water. Approximately 5% of the amount of oryzalin and oxyfluorfen applied moved in the runoff water from the first irrigation after treatment. Herbicide residues decreased over time in the containment pond and no residues were detected 3 weeks after herbicide application. Micro plot studies indicated plastic bed covers enhanced runoff losses compared to gravel. Other field runoff studies with Snapshot TG (isoxaben and trifluralin) revealed that as much as 12.5% of the applied isoxaben was lost in the first 5 days after application. Isoxaben dissipated below detection limit in the pond water 60 days after application. Sprayable isoxaben was more subject to runoff losses than granular formulations and light played an important role in the dissipation of isoxaben. Greenhouse studies revealed that herbicide residue levels detected in the irrigation water were 100 times lower than the level that would cause measurable landscape plant damage. Grassed water ways and vegetated filter strips will lower the levels of pesticides reaching the surface water bodies.

INTRODUCTION

Current management practices in the production of containerized plant materials require the frequent use of pesticides to control weeds, insects, and pathogens, but information on the movement and environmental fate of these chemicals is limited. Granular pesticide formulations are popular because of applicator safety and handling ease, but up to 80% of the pesticide may be deposited onto the production surface around the containers (Gilliam, et al. 1992). Overhead irrigation, typically 30% efficient, generates runoff water which may transport the pesticide off site or into ponds used for irrigation. Recycling of runoff water presents the potential for the introduction of injurious levels of herbicides onto the growing beds.

In 1991, questions were asked by a research team as to the magnitude and fate of herbicides in nursery runoff water. A survey project began to determine the nature of herbicide residue at two nurseries in South Carolina that frequently use preemergence herbicides and recycle their irrigation water. On-site runoff studies were conducted to ascertain the quantities of herbicides lost in runoff water and residual activity in ponds. Microplot studies evaluated the influence of bed cover composition and herbicide formulation on quantities of herbicide moving into water bodies. Greenhouse experiments were used to quantify the residue levels and irrigation frequency for herbicide injury to occur on liners of landscape species.

Our research indicated that herbicides were reaching the irrigation water sources but they did not accumulate. However, the herbicides did persist at low concentrations for 3 to 7 weeks after application but these concentrations were well below potentially damaging levels to landscape plant production. Since detectable concentrations of herbicides in surface water could be problematic to government agencies and nontarget plants and animals, efforts focused on reducing and/or eliminating herbicide movement in surface water through the use of grassed/ vegetated waterways. The objective of this paper is to provide the readers with an over view of what we have learned about the fate of herbicides in runoff water and what may be done to minimize the off-site movement of herbicides.

METHODS AND MATERIALS

Two commercial nurseries in the coastal and piedmont areas of South Carolina were surveyed monthly for herbicide residue in containment pond water and sediment from February 1991 through January 1993. Samples were taken in areas where runoff entered the ponds and the greatest probability of residues existed. Water was sampled from the top 15- to 31-cm (6 to 12 inch) depth and sediment samples were taken from the top 10 cm (4 in.) of the mud. Herbicide residues in samples were determined using high-pressure-liquid chromatography with detection limits of 1 ppb. Oryzalin, pendimethalin, and oxyfluorfen are the components of the two preemergence herbicides (Rout and OH-2) applied at both nurseries. Nursery records documented amounts and dates of herbicide application and correlated applications to residue levels detected .

Nursery runoff studies were conducted on one growing area encompassing over 3 acres and isolated from the rest of a commercial nursery. The beds sloped uniformly and unidirectionally so that runoff water could easily be channeled and directed into a gravel drainage ditch. All of the runoff water from this bed entered a single containment pond through a pipe [61 cm (24 in.)]. Runoff water was sampled before and after herbicide application from the drainage pipe, and water/sediment samples were taken from the containment pond to determine herbicide dissipation. Three studies were conducted on this site from 1992 to 1995 determining the nature of herbicide loss in runoff water and the dissipation in the pond.

In 1994, the drainage ditch was reconfigured to evaluate the effects of vegetation on pesticide concentration in runoff water. Hybrid Bermuda grass *(Cynodon dactylon × C. transvaalensis)* was sodded in the drainage area [91 m × 1.8 m (300 ft × 6 ft)] that received runoff from half of the site. A 91-m-long (300 ft) planting of cattails (*Typha latifolia*) was installed to further filter the runoff which drained through the grass waterway. The remaining growing area drained across a gravel and clay road bed (reference ditch). Weirs were installed at the termination of all waterways to facilitate sampling and to allow for quantification of runoff volumes. Commonly used pesticides, an insecticide—Dursban, a fungicide—Clearys 3336, and a herbicide—Snapshot TG (isoxaben + trifluralin), were applied at recommended rates in two applications, 6 weeks apart, 1 year after establishment of the waterways. Runoff water samples were taken after irrigation events to determine the movement of the pesticides in runoff water and the influence of vegetation on the movement of these pesticides.

RESULTS AND DISCUSSION

Results of the 2-year survey from the piedmont nursery indicated concentrations of pendimethalin, oryzalin, and oxyfluorfen from either OH-2 or Rout applications in sediment and water. Low herbicide levels (highest level detected was 13 ppb in water and 12 ppm in sediment) were documented compared to the quantities of herbicides applied (26 to 110 lb ai per year). Results also indicated that herbicides did not accumulate in containment ponds following repeated applications, and there was no correlation between herbicide levels detected and amount or timing of herbicide application (Camper et al., 1994).

At the coastal nursery, herbicide levels found in pond water and sediment were approximately two-fold greater during the second year, corresponding to an increase in herbicides applied. The highest concentrations of oxyflurofen found in water and sediment were 40 ppb and 4 ppm, respectively. The highest concentration of pendimethalin found in water and sediment was 8 ppb and 14 ppm, respectively. In the irrigation water samples, the highest concentration of oxyfluorfen and pendimethalin detected were 5 ppb and 2 ppb, respectively. The herbicides did not accumulate in water or sediment over a 2-year period (Riley et al., 1994).

The nursery runoff studies showed maximum herbicide residue detection within the first 15 min of water runoff . Oryzalin residues were the greatest of the three herbicides evaluated (4 ppm at 15 min), and showed a rapid decreases thereafter. Herbicides detected in pond samples decreased over time until detection limit was reached 2 weeks after application. The micro plot study indicated that plastic and fabric ground covers allowed the greatest movement of oryzalin and pendimethalin while gravel significantly retained and retarded movement of all three herbicides. These results indicate bedcover composition plays a significant role in the movement of herbicide from the site of application. Release of active ingredient from granular formulations was also evaluated. Dintiroanalines (oryzalin and pendimethalin) release faster than oxyfluorfen. Oryzalin in Rout was the most rapidly released. It was the most water soluble of the investigated hebicides, and 71% of total active ingredient was accounted for after 3 weeks (Keese et al., 1994).

Nursery runoff investigations of Snapshot TG (isoxaben + trifluralin) indicated that 8.2% of the applied isoxaben moved from the application site in the first irrigation event. A total of 9% and 12.5% of the applied isoxaben moved from the application site in runoff water within 5 days after treatment during 1992 and 1993, respectively. Isoxaben concentrations in pond water were highest immediately after the first irrigation runoff event following herbicide application and decreased below detection limit at 60 days. Studies also indicated that light played an important role in the degradation of isoxaben in pond water. Micro plot studies revealed that sprayable formulations of isoxaben allowed more loss in runoff water than the granular formulations (Wilson et al., 1994).

Greenhouse studies investigated the growth and development of selected landscape species watered with various concentrations of oryzalin, isoxaben, and oxyfluorfen in the irrigation water. Liners of the woody species including dwarf gardenia (*Gardenia augusta* 'Radicans'), buccaneer azalea (*Rhododendron* 'Buccaneer'), snow azalea (*R.* 'Snow') and Heller's Japanese holly (*Ilex crenata* 'Helleri') were tolerant to 10 ppm or less of these herbicides in the irrigation water for 6 weeks. Herbaceous species of fountain grass (Bot. Ed., *Pennisetum alopecuroides* or *P. setaceum*) and daylily (*Hemerocallis*) were injured by greater than 1 ppm of these herbicides. Oryzalin was the most injurious of these herbicides. This concentration was several hundred times greater than the levels of herbicides found in the survey and runoff water studies (Bhandary and Whitwell, 1994).

The vegetated waterway experiments indicated that all four pesticides were detected on the day of application though amounts of Dursban and trifluralin were very negligible and approached the limits of detection. Isoxaben was detected through 8 days after application with amounts approaching the limit of detection. Isoxaben losses were reduced 21% by the grass waterway as compared to the reference ditch. The cattail treatment further reduced movement of the pesticide by 12%. Clearys 3336 (thiophanate-methyl) losses were reduced 25% by the grassed waterway, and 60% by traversing the grass and cattail treatments as compared to the reference waterway (Briggs et al., 1995).

Minimizing the movement of pesticides from the site of application to nontarget areas should be the goal of nursery managers. The application of pesticides to smaller areas at one time followed by less irrigation water, or the use of cycle irrigation reduces both the quantities of pesticide available to move and the amount of runoff water which may carry pesticides to irrigation ponds or drainage waterways. Avoid using plastic in the waterways or on beds. Grassed waterways and wetlands will filter some of the pesticides and remediate excess nutrients. Additional research is needed to develop information on the most efficacious vegetation system to improve runoff water .

LITERATURE CITED

Bhandary, R. and **T. Whitwell**. 1994. Response of *Gardenia* and *Pennisetum* to low concentrations of oryzalin in irrigation water. Proc. SNA 39:47-49.

Briggs, J.A., **M.B. Riley**, and **T. Whitwell**. 1995. The effect of grassed waterways in reducing pesticide levels in runoff water of a container nursery. Proc. SNA (in press).

Camper, N. D., **T. Whitwell**, **R.J. Keese**, and **M.B. Riley**. 1994. Herbicide levels in nursery containment pond water and sediments. J. Environ. Hort. 12:8-12.

Gilliam, C.H., **D.C. Fare**, and **A. Beasley**. 1992. Nontarget herbicide losses from application of granular ronstar to container nurseries. J. Environ. Hort. 10:175-176.

Keese, R.J., **T. Whitwell**, **N.D. Camper**, **M.B. Riley**, and **P.C. Wilson**. 1994. Herbicide runoff from ornamental container nurseries. J. Environ. Quality 23:320-324.

Riley, M.B., **R.J. Keese**, **N.D. Camper**, **T. Whitwell**, and **P.C. Wilson**. 1994. Pendimethalin and oxyfluorfen residues in pond water and sediment from container plant nurseries. Weed Tech. 8:299-303.

Wilson, C. , **R. Bhandary**, **T. Whitwell**, **M. Riley**, and **R. Cooper**. 1994. Movement, dissipation, and impact of isoxaben in nursery runoff water. Down to Earth 49:22-27.