Fate of Herbicides in Container Nursery Runoff

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Introduction

The 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. Overhead irrigation, typically 30% efficient, generates runoff water which may transport the pesticide off site or into ponds used for irrigation. Recycling of this 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 2 nurseries in South Carolina that frequently use preemergence herbicides and recycle their irrigation water. On site runoff studies were conducted to ascertain the quantities herbicides lost in runoff water and residual activity in ponds. Micro plot 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 non target plants and animals, efforts focused on reducing and/or eliminating herbicide movement in surface water through the use of grassed/vegetated water ways. 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 could 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 the containment pond water and sediment from February, 1991 through January 1993. Samples were taken in designated areas where runoff entered the ponds and the greatest probability of residues existed. Water was sampled from the top 6 to 12 inch depth and sediment samples were taken from the top 4 inches of the mud. Herbicide residues in samples were determined using high pressure liquid chromatography and detection limits were 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 amount 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, 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 (24 inch.). Runoff water was sampled over time 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 x C. transvaalensis)* (300' long by 6' wide) was sodded in the drainage area that receives runoff from half of the site. A 300' long 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, fungicide - Cleary's 3336, and a herbicide - Snapshot TG (isoxaben + trifluralin), were applied at recommended rates in two applications, six weeks apart, one 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 two 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). Our results also indicated that herbicides did not accumulate in containment ponds following repeated applications and there was no correlation of herbicide levels detected with amount or timing of herbicide application.

At the coastal nursery, herbicide levels found in the pond water and sediment were approximately two-fold greater during the second year corresponding to an increase in herbicides applied. The highest concentration of oxyflurofen found in water and sediment was 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 was 5 ppb and 2 ppb, respectively. The herbicides did not accumulate in water or sediment over a two year period.

The nursery run off studies indicated maximum herbicide residues were detected within the first 15 min. of water runoff and oryzalin residues were the greatest of the three herbicides evaluated (4 ppm at 15 min.) and showed rapid decreases thereafter. Herbicides detected in pond samples decreased over time until the 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 evaluated, dintiroanalines (oryzalin and pendimethalin) release faster than oxyfluorfen. Oryzalin in Rout was the most rapidly released, is the most water soluble 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 was highest

immediately after the first irrigation runoff event that followed herbicide application and decreased below detection limit at 60 days after herbicide treatment. 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.

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, Bucaneer Azalea, Snow Azalea and Hellers Japanese Holly were tolerant to less than 10 ppm of these herbicides in the irrigation water for 6 weeks. Herbaceous species of Fountain Grass and Daylily were injured by greater than 1 ppm of these herbicides. Oryzalin was the most injurious of these herbicides. The concentration of Oryzalin causing injury to these plants was several hundred times greater than the levels of herbicides found in the survey and runoff water studies (Bhandary and Whitwell, 1994).

The vegetated water way 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%. Cleary's 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).

Summary

Minimizing the movement of pesticides from the site of application to non-target areas should be the goal of nursery managers. The application of pesticides to smaller areas at one time with less irrigation water or the use of cycle irrigation reduces both the quantities of pesticide available to move and the amount of runoff water to carry pesticides to irrigation ponds or drainage waterways. Avoid using plastic in the water ways 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.