

At last count, around 27 million golfers in the United States have been teeing up for rounds on approximately 16,000 golf courses. Each golf course has either 9 or 18 holes, so well over 100,000 fairways—which typically make up a third of a golf course—are carefully tended and pampered.

Golf courses are often close to ponds, streams, and lakes, and the chemicals used to maintain the grounds have been found in surface waters of urban watersheds. Now, studies by Agricultural Research Service chemist Pamela Rice on pesticide and nutrient losses from fairways have given landscape crews some environmentally friendly ideas for maintaining the popular green playgrounds.

“Our research indicates that there are management practices you can use as a preventative measure to protect water resources around golf courses,” says Rice, who works at the ARS Soil and Water Management Research Unit in St. Paul, Minnesota.

#### **Cultivation Method Affects Pesticide Fate**

Rice worked with University of Minnesota professor Brian Horgan to design a series of studies at the University of Minnesota Turf Research, Outreach, and Education Center in St. Paul. One project simply measured the quantity of pesticides in runoff from creeping bentgrass (*Agrostis palustris*) turf managed as a golf course fairway.

The scientists applied the pesticides chlorpyrifos; flutolanil; mecoprop-p; 2,4-D; and dicamba to the experimental fairways and then measured the amount of the pesticides in runoff from simulated rain events that occurred within 33 hours of the applications. Samples taken from edge-of-plot runoff contained less than 1 to 23 percent of the total amount of pesticides



At the University of Minnesota Turf Research, Outreach, and Education Center in St. Paul, Minnesota, a rainfall simulator is used to generate runoff. Plots were equipped with rain gauges and automated runoff samplers to measure precipitation, runoff, and flow rates, and to collect periodic runoff samples.

applied. With the exception of chlorpyrifos, all the other chemicals were detected in the initial runoff samples and in samples taken throughout the runoff events.

Rice and Horgan also evaluated the effects of different types of core cultivation on pesticide concentrations in runoff. In hollow-tine cultivation, soil cores are removed from the turf, air dried, and then brushed back into the open holes. Solid-tine core cultivation uses less labor and is less disruptive to the turf surface, but can cause soil compaction. Core cultivation on golf fairways controls thatch, alleviates surface compaction, improves water infiltration, and stimulates root and shoot growth.

Studying the same group of pesticides 63 days after the plots were cultivated and within 39 hours of chemical application, the scientists measured a 10-percent reduction in runoff volume and a 15- to 24-percent reduction in pesticide transport in runoff from plots receiving hollow-tine core cultivation compared to those receiving solid-tine core cultivation. Samples taken 2 days after the plots were cultivated a second time and within 39 hours of a subsequent

chemical application showed a 55-percent reduction in runoff volume and a 35- to 57-percent reduction in pesticide transport.

Rice and Horgan calculated the environmental concentrations of these pesticides in surface water receiving runoff from turf managed with solid-tine core cultivation and found that they would exceed levels that are harmful to nine sensitive aquatic organisms. But hollow-tine core cultivation reduced surface-water concentrations of the pesticides to levels below these for most of these aquatic fauna.

#### **Models: Room For Improvement**

Along with ARS agricultural engineer Kevin King, who works at the ARS Soil Drainage Research Unit in Columbus, Ohio, the researchers used the data they collected to evaluate a turfgrass runoff model called “TurfPQ.” This model estimates pesticide levels in runoff associated with moderate rainfall, and they wanted to see how accurately TurfPQ predicted pesticide transport in runoff associated with more intense rainfall. They compared runoff data from 13 artificial

## ARS Scientists Tee Up To Tackle Golf Course Pesticide Runoff

rainfall events to estimates provided by TurfPQ for the same conditions.

The scientists found that the model's estimates were lower than the actual measurements for transport of dicamba; 2,4-D; flutolanil; and chlorpyrifos. The model predicted that runoff would begin later than it actually did, which in turn increased error estimates for the amount of pesticides available for offsite transport via runoff. As a result of these findings, they concluded that with some tweaking, TurfPQ could provide better pesticide-loss estimates during intense storm events.

#### What About Fertilizers?

Rice and Horgan also used their experimental plots to study differences between how hollow-tine cultivation and solid-tine cultivation affected nitrogen and phosphorus retention on fertilized fairways. In surface waters, these two nutrients feed the growth of algae, and when the algae die, their decomposition depletes oxygen levels in the water. These conditions contribute to deterioration of local waterways and downstream aquatic environments. The U.S. Environmental Protection Agency (EPA) has established phosphorus limits for lakes and streams and nitrate nitrogen limits for our drinking water.

Using the same experimental turfgrass fairways that were used for the pesticide studies, the researchers measured runoff volume and amounts of soluble phosphorus, ammonium nitrogen, and nitrate nitrogen that were lost via runoff.

As with their pesticide studies, Rice and Horgan found lower nutrient concentrations in runoff from fairway plots that received



Pesticides being applied to experimental turf plots maintained at a golf course fairway. Following a simulated rain event, runoff was collected from the plots and analyzed for five different pesticides.

hollow-core cultivation compared to solid-core cultivation—up to 77 percent less 2 days after the plots were cultivated and up to 27 percent lower 63 days after cultivation.

They also estimated the environmental concentrations of nitrogen and phosphorus in surface water receiving runoff from the experimental plots. They found that with one exception, phosphorus concentrations usually remained above EPA water-quality criteria established to limit eutrophication, which can occur when water bodies receive excess nutrients that stimulate excessive plant growth. (The exception was observed in phosphorus concentrations

found in runoff 2 days after hollow-tine core cultivation.) However, all estimated environmental concentrations of nitrogen were below levels associated with increased algal growth, and nitrate levels in runoff from plots receiving either type of core cultivation were not high enough to threaten human health.

“We’ve seen that the total amount of applied chemicals lost from golf courses is more a function of the volume of runoff than the concentrations of chemicals in the runoff,” Rice con-

cludes. “Our studies also show that, even though it is more labor intensive, hollow-tine core cultivation can help reduce the loss of applied nutrients and pesticides from fairways, which helps protect nearby surface waters.”—By **Ann Perry**, ARS.

*This research is part of Water Availability and Watershed Management (#211), an ARS national program described at [www.nps.ars.usda.gov](http://www.nps.ars.usda.gov).*

*Pamela Rice is in the USDA-ARS Soil and Water Management Research Unit, 1991 Upper Buford Circle, St. Paul, MN 55108; (612) 624-9210, [pamela.rice@ars.usda.gov](mailto:pamela.rice@ars.usda.gov).* ✿

Core cultivation of plots. Some plots were cultivated with solid tines, others with hollow tines. Runoff was collected from plots cultivated by each method and analyzed for pesticide and fertilizer (nitrogen and phosphorus) content.



JENNIFER RITTENHOUSE (D2562-1)