The Fate of Your Fungicides

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Every golf course superintendent goes to great pains to develop their pesticide program. Part of that program should include proper inspection of equipment and calculation of proper travel speed and pressure to ensure the proper amount of pesticide is leaving the nozzles. But once it leaves the nozzle, its activity is largely out of the superintendent's control. This activity is important for golf course superintendents for environmental and human health considerations, as well as obtaining proper disease control.

The fate of our fungicide applications on the environment and human health varies immensely with application method and environmental conditions. Despite this variability, two important points consistent amongst most turfgrass sites are (a) pesticide exposure to golfers is very low if proper drying time on the plant is allowed and (b) movement of pesticides or pesticide metabolites away from the target site as either runoff or leaching into groundwater is rarely seen when pesticides are properly applied (Cisar and Snyder, 2000; Clark and Doherty, 2006; Watschke et al., 2000). Two significant reasons for this lack of movement in the turfgrass profile is the hydrophobic nature of thatch and the dense vegetation cover that turfgrass provides. The same chemical reactions in the thatch layer that turn portions of the soil hydrophobic in dry conditions also cause thatch to bind very tightly to most turfgrass chemicals. While this might make location of pesticides to the root zone more difficult for the control of root diseases (and nearly impossible in a home lawn), it does lessen the turf system's susceptibility to contaminate surrounding environments (Figure 1). The dense vegetation cover provided by healthy turfgrass also prevents pesticide runoff by preventing soil runoff, which is the number one cause of non-point pesticide contamination of surface waterways. This in no way means turfgrass chemicals are "safe" or have no negative effect on the environment, but it does suggest that the impact of turfgrass pesticides on the environment and human health is minimal and often over stated in the popular press.

Turning specifically to fungicides and disease control, most would assume that the majority of the pesticide leaving the nozzle reaches the turfgrass a mere couple feet below. But fungicides (and other pesticides) can adhere to plastic or rubber sprayer components, and drift or volatization can prevent the pesticide from reaching its intended target. Most of us also assume that once it reaches the turf, most of it goes toward protecting the plant. According to Sigler et al., 2000 there are six major physical and chemical processes that affect fungicide fate in a turfgrass system (Table 1). Most of these processes will decrease the activity of the fungicide.

Figure 1. The thatch layer can provide a nearly impenetrable barrier for pesticides to pass through. This may negatively affect control of root-inhabiting pathogens, but has a positive environmental effect as pesticides rarely escape the turfgrass system in large quantities. Photo courtesy Dr. John Stier.

In contrast to row crop agriculture where one or two fungicide applications are required for proper disease control, repeated applications are necessary in turfgrass to control certain diseases throughout the entire growing season (or the entire off season in the case of snow molds). Current fungicide labels use a calendar method for the reapplication interval, but that doesn't take into consideration varying conditions that could vary the rate of fungicide degradation and the rate at which a fungicide needs to be applied. The examples of possible degradation variability are seemingly infinite, but two are proposed here. One example would be from varying microbial activity. We know from Table 1 that microbial populations can degrade fungicides, and we also know that temperature, moisture, pH, and a range of other factors all can have a large effect on microbial activity. Could fungicides last longer, and provide extended control, under certain temperature or moisture conditions that decrease microbial activity? Another example is the power of the sun, which uses powerful ultraviolet and infrared radiation to stimulate degradation of fungicides into non-reactive metabolites. Is it possible that fungicides last longer, and provide extended disease control, in shaded areas of the golf course because of the less intense light? These are both complex questions that require a complex answer that is not currently available. But the next time you can't figure out why disease broke through on hole #1 but not hole #11, be aware that the fungicide applied to hole 1 might not react the same as the same fungicide applied to hole 11.

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Research undertaken by myself, along with Dr. John Stier and Dr. Jim Kerns from the departments of Horticulture and Plant Pathology, respectively are trying to answer some of these pesticide fate questions as they pertain to snow mold control. Snow mold control in Wisconsin and much of the Midwest is important for many reasons. First off, snow molds can cause serious damage to maintained turfgrass under extended periods of snow cover. Second, the snow mold fungicide application(s) is the single largest chemical expenditure at many facilities. Lack of disease control with such a costly application can provide a serious blow to the finances of the club, not to mention to the long term job status of the superintendent.

Most golf course superintendents put their snow mold fungicides down well before snow cover arrives, a practice supported by most turfgrass pathologists. But what if several weeks, or even months go by until snow cover arrives? What if an early winter snowstorm melts and leaves weeks of open ground before more snow arrives? Is there any fungicide remaining for protection? Should the superintendent attempt to reapply fungicide in January? These are all scenarios that have plagued Wisconsin and Midwestern superintendents the past couple of winters, and were the impetus behind our research. In brief, our research is investigating the rate of fungicide degradation on snow-covered turf compared to the rate of degradation on turf lacking any kind of cover. Iprodione and chlorothalonil were applied alone and in a tank mix on creeping bentgrass grown at fairway height at the OJ Noer center in early December, after which an initial fungicide concentration reading was obtained. Snow was applied to the snow covered and removed from the uncovered plots shortly after the fungicide application, and subsequent samplings are being undertaken every seven days for five weeks.

From this research we hope to obtain more information about the activity of fungicides in a winter environment and how it affects snow mold control. Stay tuned in the coming months for more updates on the project's progress, and for any early recommendations resulting from the data. Special thanks to the Golf Course Superintendents Association of America, Wisconsin Golf Course Superintendents Association, and Northern Great Lakes Golf Course Superintendents Association for critical funding of this project.

Table 1. The six physical and chemical processes that affect fungicide fate in a turfgrass system (adapted from Sigler et al., 2000).

1)	Solubility-based movement in water -Just like fertilizers, different fungicides are more soluble in water and can be moved several directions in the turfgrass system.
2)	Sorption/desorption to surfaces -Adsorption refers to the pesticide binding to soil particles and/or organic matter, and soils with high adsorptive potential (ie high clay content) can tightly bind pesticides and make them unavailable to the plant.
3)	Abiotic degradation -Primarily this means photodegradation stimulated by sunlight, but some fungicides are susceptible of converting to inactive forms via alkyl hydrolysis in high pH environments.
4)	Biotic degradation -Both fungi and bacteria can be highly active in fungicide degradation. Activity depends on temperature, pH, moisture, and previous fungicide exposure.
5)	Volatization -Volatization refers to the ability of a pesticide (or other compound) in solid or liquid form to turn into a gas, decreasing its pesticide activity. Air temperature, droplet size, and the chemistry of the pesticide all affect the ability to volatize.
6)	Plant uptake -Uptake of the fungicide can lead to further metabolization by enzymes present within the plant, in addition to performing its desired function.

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