The Pesticide Matrix Project: Developing a Data-Based Tool to Guide Environmentally-Responsible Pesticide Selection

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INTRODUCTION

Golf turf managers often have many options for controlling destructive turf pests. Many factors are evaluated before choosing a particular control option. Factors such as cost, efficacy, and turf safety are often part of the knowledge base of the golf turf manager, or this information is readily obtainable from sales staff, university extension sources, magazines, trade articles, etc. The golf turf manager evaluates this information and then makes a decision regarding the choice of pesticide or biological control option for a particular pest. Information regarding the potential environmental impact of using a particular pesticide or biological control option is much more difficult to obtain, and hence most turf managers do not include information on environmental safety in their decision-making process.

The purpose of this project is to provide golf turf managers with information that will permit them to include environmental safety into their decision-making process just as they would cost, efficacy, etc. The challenge of this project is to take the enormous amount of information available regarding pesticide impact on the environment and reduce this to a level that is scientifically valid and yet can be readily used by golf turf managers. .

Several approaches have been taken by researchers to reduce data to a more usable format. One with some familiarity to the turfgrass community is the EIQ (Environmental Impact Quotient) developed by Kovach et al. (1992) to assess pesticide impact in agricultural settings. The EIQ is an algebraic model that reports a single composite number to represent the environmental impact of a pesticide. The value of the model is its simplicity; each pesticide is awarded a single numerical score. However, this simplicity has also resulted in criticism of the model for precisely this reason; i.e., it does not quantify potential risk. The model can be broken out into three components—farmworker, consumer, and ecological—which reduces some of the criticism of oversimplification.

Similarly, in the Netherlands, researchers have developed an environmental yardstick to estimate the risk associated with using a particular pesticide (Reus and Leendertse, 2000). The yardstick estimates risk for three different areas: risk of groundwater contamination, risk to soil organisms, and risk to aquatic organisms. Potential risk is estimated by impact points with the more impact points awarded a pesticide, the higher its impact on the environment. The environmental yardstick was introduced for field crops in 1994 and a separate yardstick for greenhouse crops was introduced in 1997. The yardstick is a modified risk assessment tool that calculates the expected concentration of the pesticide in the targeted area, e.g. groundwater, versus the drinking water standard for that pesticide.

Most models can be classified into two general categories, one of which uses an approach similar to the EIQ, which manipulates the physico-chemical properties, environmental toxicity data, and human health data into a numerical ranking of pesticide safety. The second approach, as exemplified by the Netherlands yardstick, is to use a simple model to estimate pesticide concentration in groundwater, surface water, foliage, or other area of interest, and then compare the estimated concentration to the concentration estimated to have an environmental impact. This ratio is then put into context for the end user. This is considered a risk assessment model and other researchers have used variations on this approach (Padovani et al.,2004; Peterson, 2006).

More in-depth, site-specific models go beyond the scope of this project. This project is aimed at developing a model that will allow turf managers across the United States to rapidly and conveniently ascertain the relative environmental risk of using specific pesticides in a turf care program. Further, the model should allow the turf manager to differentiate the relative risks on specific areas of concern such as groundwater, surface water, wildlife, and human health.

EXPERIMENTAL OBJECTIVES

This project consists of two phases. Phase one is the collection and building of a database of pesticide environmental fate, toxicological, and aquatic toxicological data that will serve as the basis for building a model that will permit turf managers to compare the relative environmental risk of using a pesticide. The second phase of the project is to use the database to build a model that will be scientifically valid and user-friendly so that turf managers will make use of the model in their pesticide-decision making process.

PROGRESS

This project is somewhat unique since it is an amalgam of four different research proposals and interests. Our first task within phase one of the project was to develop a list of pesticides for the database. We decided to be as inclusive as possible and developed a list of 107 active ingredients including herbicides, fungicides, insecticides, fumigants, and plant growth regulators. In the spring of 2006, we began a series of approximately monthly conference calls of all investigators to keep track of our progress and to discuss the evolution of this project.

Data Collection

We divided the data collection amongst the investigators on the project as follows. Bruce Branham volunteered to collect environmental fate properties (e.g. Koc, vapor pressure, water solubility, etc.) of the pesticides. Jennifer Grant volunteered to collect ecotoxicological properties (e.g. LC_{50} aquatic invertebrates and fish, LC_{50} birds, LC_{50} honeybees, etc.) of the pesticides. Stuart Cohen volunteered to collect the toxicological reference points (reference dose, carcinogenic slope/potency factor, FQPA safety factor) and to calculate drinking water health Advisory Levels and aquatic organism Maximum Allowable Concentrations for the pesticides. Tom Fermanian volunteered to assemble this information into a relational database to be hosted on a GCSAA server.

At this time, all available toxicological reference points have been gathered. The environmental fate properties data collection is 95% complete, with the remaining 5% being pesticides with special considerations. For example, we are addressing issues regarding multiple forms of some active ingredients (e.g., 2,4-D).) The ecotoxicological properties data collection was largely completed for LC_{50}s and LD_{50}s. However, we have temporarily suspended further data collection until our model is more developed and we receive feedback from other scientists as to whether we should use NOEC and NOEL values, or converted LC_{50}s and LD_{50}s.

Database Development

On February 1, 2007 Tom Fermanian discussed (via conference call) the possibility of developing a relational database from the collected pesticide matrix data with three GCSAA IT staff members: Heather Gerber, senior manager, new media products; Laura Russell, senior development team manager; and Brian Cavner, senior development team manager. It was decided that Tom Fermanian would develop several appropriate tables for a MySQL database and forward them to Heather. On February 10, 2007 he sent an e-mail to all members of the pesticide matrix development team and the three individuals at GCSAA IT staff containing the updated Excel files and SQL database.

Model Development

Several components of the final model have been selected. For risk to groundwater, we will use SCI-GROW—a screening tool developed by the U.S. EPA, Office of Pesticide Programs to estimate pesticide concentrations in vulnerable ground water. The algorithm for SCI-GROW was supplied by Stuart Cohen to Tom Fermanian and will be programmed for use with our database as a part of our final model. The team is currently recruiting a programmer to work on this aspect of the project. It should be noted that pesticide concentrations estimated by SCI-GROW represent conservative or high-end exposure values because the model is based on groundwater monitoring studies that were conducted by applying pesticides at maximum allowed rates and frequency to vulnerable sites (i.e., shallow aquifers, sandy, permeable soils, and substantial rainfall and/or irrigation to maximize leaching).

For wildlife exposure, we will use the Kenaga nomogram (Hoeger and Kenaga,1972) as modified by Pfleeger et al., (1996)This tool was developed as a simple screening tool to assess the potential exposure of wildlife to pesticide-treated crops and has been widely used in EPA risk assessments. The nomogram estimates the residues on foliage (there are estimates for short or tall grass residues) that would be available to all terrestrial species, though birds represent the wildlife species that would be most commonly expected to consume treated turf.

We intend to use honeybees as our indicator of nontarget insect exposure, and may use a simple ranking of LD_{50}s. However, this method does not account for the rate of pesticide application (potential dose)—so we may use an alternative model if appropriate. We are still discussing what model will be used to estimate risk of pesticide runoff. We will seek feedback on this topic from our colleagues at the EPA and the pesticide industry.

Our model will ultimately yield an individual risk ratio for each turfgrass pesticide in our database. These risk ratios can be compared among the various active ingredients that could potentially be used to treat a specific pest, and will thereby serve as a pesticide selection tool for superintendents to use along with their knowledge of efficacy, cost and ease of application. As noted previously, our approach is very conservative in estimating environmental risk.

Collegial Outreach and Superintendent Feedback

In order to obtain feedback on the utility and ease of use of the model for superintendents, the project was presented to a focus group at the GCSAA national meeting in Anaheim in February. The audience included 4-6 superintendents, as well as USGA and GCSAA staff, researchers and extension personnel. Superintendents did not indicate a preference on how the results were presented, and approved of the risk-ratio approach. An RCGA staffer expressed concern about the potential for the model to be used to inspire further regulation on the golf industry.

Stuart Cohen presented our project at the Chesapeake and Potomac Regional Chapter of the Society of Environmental Toxicology and Chemistry (SETAC) in May 2007 and at their national meeting in November. Audience members were pleased that the project is being undertaken, and offered specific feedback on avian risk assessment.

Three meetings were held in August 2007 to discuss our plans and get input on model development and other issues related to our project from colleagues. Two meetings were with US EPA, first with risk assessment and modeling personnel and later with regulatory and economic staff. Nobody from the health effects division attended either meeting. The other meeting was with Crop Life America (CLA) and Responsible Industry for a Sound Environment (RISE). Participants were mainly from their Environmental Risk Assessment Committee, and had expertise in risk-assessment, modeling and environmental fate. In September, Greg Lyman presented the project to a larger group from RISE at their annual meeting in New Orleans.

FUTURE

Data collections and verifications need to be completed and the final model developed. We are using feedback from the groups discussed to help formulate and finalize our model. Tom Fermanian has hired a web designer and is in the process of developing draft layouts for the initial page, data import page(s) and output page(s). We anticipate the project will be completed in 2008.

LITERATURE CITED

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