KTURF: A Pesticide and Nitrogen Leaching Model

A computer model available on the Internet and World Wide Web helps turfgrass managers predict pesticide and nitrogen leaching.

by DR. STEVE STARRETT, DR. SHELLI STARRETT, JUDY HILL, and GREG ADAMS

Research lysimeters generate data to form the basis of the KTURF model.

THE USE OF PESTICIDES on golf courses may have some potential negative impacts, including groundwater contamination. As the golf industry continues to grow, the proper management of pesticides grows in importance. KTURF is a computer model, developed at Kansas State University and funded by the USGA, that estimates the percentage of applied nitrogen or pesticide that leaches through 50cm (20 inches) of turfgrass-covered soil in specific circumstances. KTURF was developed to allow golf course superintendents access to these models on the internet. KTURF models are available via the internet and the world wide web (www) at the following URL:

http://www.eece.ksu.edu/~starret/KTURF/

Because KTURF is located on the www, any superintendent with internet access can use the latest version of the model and the mathematical software required by the models. The models can be accessed at any time of day and do not require that the software be downloaded to the user's computer. The user simply enters the conditions that pertain to the situation and clicks a button. Within a minute or so, the results appear on the screen.

The KTURF Models

The KTURF models were developed using artificial neural networks (ANNs), a form of artificial intelligence. ANNs are *trained* using experimental data from lab tests. The ANN *learns* the relationships between the inputs and the output. Once the models are developed (trained), those relationships can be applied to other sites to make predictions about the output, in this case the percentage of nitrogen or pesticide leached. The KTURF models were trained using data from USGA-funded projects.

Although completely accurate, useable models for turfgrass-covered soil have yet to be developed. KTURF does a very good job of predicting pesticide and fertilizer leaching based upon the results of USGA research. The actual results will vary from site to site, but KTURF provides an approximation of the nitrogen or pesticide leached based on four readily determined input variables. Figures 1 and 2 are KTURF's pesticide leaching predictions compared to measured values. The results from 16 test cases for the nitrogen model are shown in Figures 3 and 4. KTURF did a good job of estimating the percentage of applied pesticide and nitrogen leached for the test cases. For more information about the methodology used to obtain the training data for the ANNs, refer to Starrett et al. 1996, 1995a, 1995b, and 1995c.

Developing the KTURF Website

The web files were written in HyperText Markup Language (HTML), a programming language specific to the world wide web to be accessible by web browers such as Netscape Navigator, Mosaic, or Internet Explorer. Combining text with tags that indicate format changes, the web browser presents the documents in the desired format. HTML tutorials and examples are available via the world wide web, and several books are also available about this subject (National Center for Supercomputing Applications 1996a, Smith 1995).

At the KTURF website, programming scripts written in languages other than HTML were needed to perform the interactive data processing and calculation. HTML is used to execute the scripts that do the calculations. The user inputs data about a golf course's pesticide or nitrogen use on an HTML form, and the HTML script executes an intermediate script using the data input.

The intermediate programming script that KTURF uses is written in Practical Extraction and Report Language (PERL). PERL, a useful language for Common Gateway Interface (CGI) programming or interactive web programming, processes data submitted by a remote user. Some of PERL's web applications include guest books where users can leave comments about a site, access counters that count the number of times a web page is displayed, and shopping carts that allow users to buy objects for sale. The KTURF PERL script assigns the submitted data from the HTML form to variables, opens MATLAB=AE (the mathematical software used to write the ANN model), receives the data back from MATLAB=AE, and creates another form using embedded HTML to display the results.

Several informative websites about PERL are available via the internet (NCSA 1996b), and several books have

also been written that describe the basics of PERL scripting (Schwartz 1993).

Using the KTURF Website

Two interactive models are currently available at the KTURF website: one predicting the nitrogen leaching and the other predicting pesticide leaching through 20 inches of turfgrass-covered soil.

The nitrogen model predicts the percentage of applied nitrogen leaching through 20 inches of turfgrass-covered soil. It is applicable to conditions on both fairways and greens. The user must supply four input variables to compute the predicted result: the sand content of the soil, the irrigation applied to the soil, the form of nitrogen applied, and the period of time after the nitrogen application that the leached output is calculated.

To illustrate the use of the interactive nitrogen model, the following data set was entered into the input form:

Sand content of the soil: 65%.

Irrigation rate: two .5" applications per week.

Nitrogen form: liquid urea.

Time (in days): 14.

The submit button, located at the bottom of the form, is pressed and, after approximately one minute, the resulting web page should appear.

The predicted percentage of nitrogen leached during the 14 days after application for this case is approximately 2%. The exact nitrogen leached will vary from site to site depending on the conditions present.

The pesticide model currently available is applicable only to fairway conditions. It predicts the percentage of applied pesticide that leaches through 20 inches of turfgrass-covered soil. The irrigation rate and the time (in days after pesticide applications) are necessary input variables. In addition, two characteristics of the pesticide — the water solubility and the sorption coefficient — must be input. Because the water solubility and sorption coefficient may be unknown, a table of common pesticides used is provided and accessed with the click of a button. However, if a pesticide used is not listed, your pesticide sales representative can provide this information.

As an example of the interactive pesticide model, the following data were input into the pesticide form:

Pesticide name: Dicamba.

Water solubility of pesticide: 400,000 mg/L.

Sorption coefficient of the pesticide: 2.

Irrigation rate: two .5" waterings per week.

Time (in days): 14.

After submitting the data, the following result was calculated:

Output: 2%.

The output forms also display the variables entered to ensure the submitted data were correct. The output value provided is an estimated percentage of how much of the applied pesticide leached.

A model applicable for pesticide leaching under green conditions is currently under development.

Range of Application

KTURF was developed from experimental data collected primarily in

Figure 1
Comparing KTURF with Measured Pesticide Leaching Values

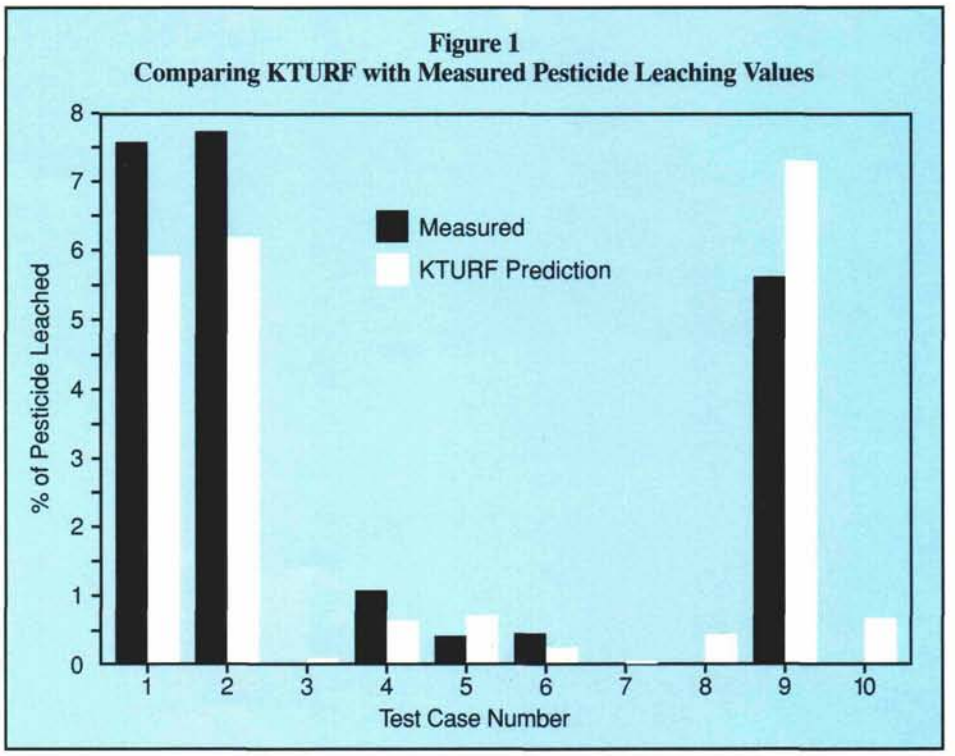
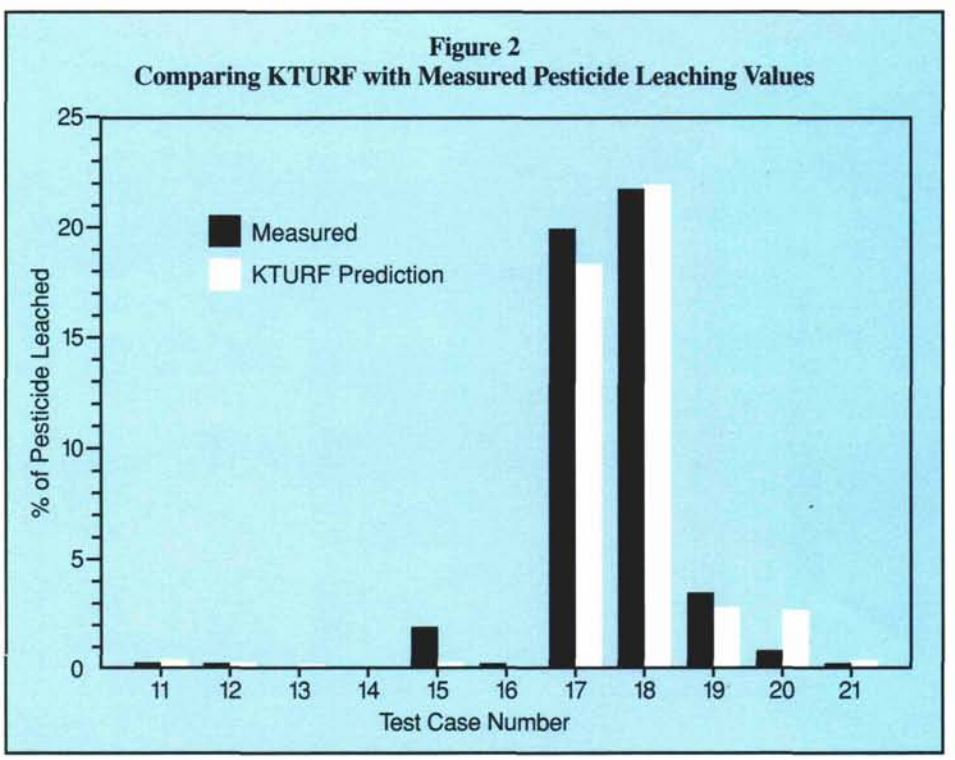


Figure 2
Comparing KTURF with Measured Pesticide Leaching Values



Iowa. The soil used was in an undisturbed condition; therefore, many macropores (earthworm burrows, soil cracks, etc.) existed. The soil moisture content was at field capacity. If your soil moisture conditions are extremely dry, then little of the applied irrigation will leach below 50cm. If your soil moisture conditions are near saturation, then most of your applied irrigation will leach below the rootzone. KTURF was not developed with these extreme conditions; therefore, its predictions will not be realistic for those conditions.

Conclusion

Using the interactive version of KTURF is advantageous compared to other more traditional distribution methods that are available. Accessing KTURF via the internet allows the user to use the most up-to-date versions available. Program changes are available instantaneously, rather than waiting for a diskette to be mailed. Also, responses to user feedback will be provided more quickly by e-mail than by postal letter or telephone.

The KTURF model is an accurate, reliable method to approximate the percentage of applied pesticide and nitrogen that will leach through turfgrass-covered soil. Used as an assessment tool, KTURF can help to reduce pesticide leaching by allowing users to experiment with different pesticide/irrigation schemes. Turfgrass managers can thus optimize their practices to reduce the likelihood of pesticide leaching beyond the rootzone. The KTURF site is located at:

http://www.eece.ksu.edu/~starret/KTURF/

Figure 3
Comparing KTURF with Anticipated Nitrogen Leaching Values

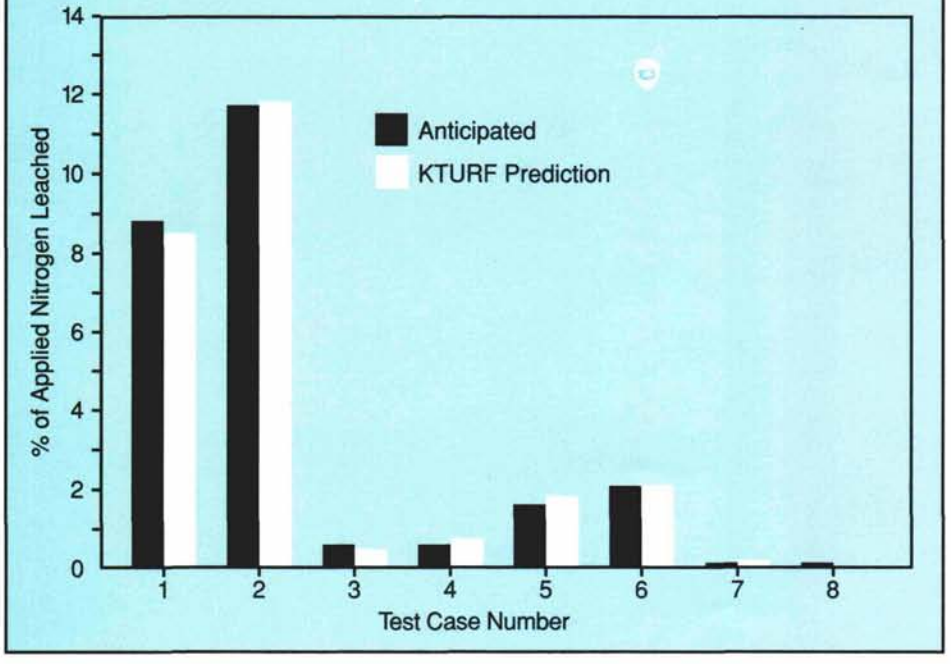
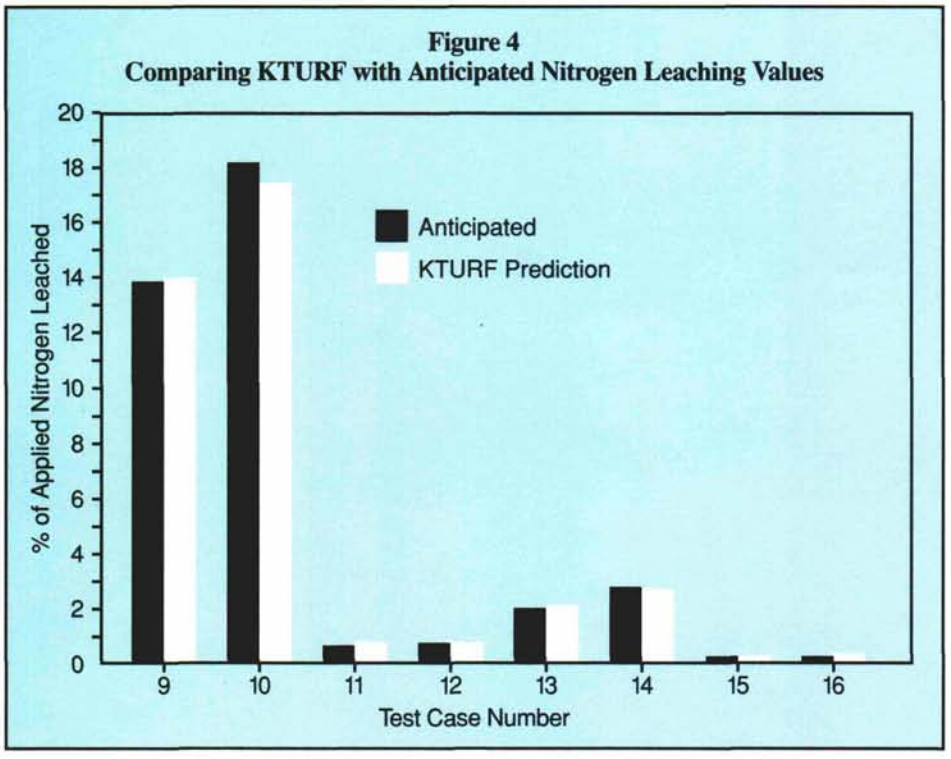


Figure 4
Comparing KTURF with Anticipated Nitrogen Leaching Values



References

National Center for Supercomputing Applications. 1996a. *http://ncsa.uiuc.edu/General/Internet/WWW/HTMLPrimer.html.*

National Center for Supercomputing Applications. 1996b. *http://ncsa/uiuc.edu/General/Training/PerlIntro/.*

Randal L. Schwartz. 1993. Learning Perl. O'Reilly and Associates.

Mike Smith. 1995. *http://snowwhite.it.brighton.ac.uk/-mas/mas/courses/html/html.html.*

S. K. Starrett, N. E. Christians, and T. Al Austin. 1996. Comparing Dispersivities and Soil Chloride Concentrations of Turfgrass-Covered Undisturbed and Disturbed Soil Columns. J. of Hydrology. 180:21-29.

S. K. Starrett, N. E. Christians, and T. Al Austin. 1996. Movement of Pesticides Under Two Irrigation Regimes. J. Environ. Qual. 25:566-571.

S. K. Starrett, N. E. Christians, and T. Al Austin. 1995. Fate of Nitrogen Applied to Turfgrass-Covered Soil Columns. J. Irr. and Drain. Engg. 121:390-395.

S. K. Starrett, N. E. Christians, and T. Al Austin. 1995. Fate of Amended Urea in Turfgrass Biosystems. Commun. Soil Sci. Plant Anal. 26:1595-1606.

S. K. Starrett, N. E. Christians, and T. Al Austin. 1995. Comparing Chloride Transport in Undisturbed and Disturbed Soil Columns Under Turfgrass Conditions. Commun. Soil Sci. Plant Anal. 26:1283-1290.

DR. STEVE STARRETT *is Assistant Professor in the Kansas State University Civil Engineering Department. He guides the scholastic efforts of civil engineering students Judy Hill and Greg Adams. Dr. Shelli Starrett is an Assistant Professor in the KSU Electrical and Computer Engineering Department.*