Evaluation of Best Management Practices to Protect Surface Water from Pesticides and Fertilizer Applied to Bermudagrass Fairways

Dr. James H. Baird

Oklahoma State University

Goal:

- *Develop effective and practical management practices that protect surface water from runoff of pesticides and fertilizer applied to golf course fairways and other turf areas*

Cooperators:

Raymond Huhnke
Nicholas Basta
Gordon Johnson
Daniel Storm
Mark Payton
Michael Smolen
Dennis Martin
James Cole

The potential for runoff of pesticides and nutrients from turf, especially on golf courses, is the subject of increasing environmental concern. Consequently, a project was initiated in 1995 under the joint sponsorship of the United States Golf Association and the Oklahoma Agricultural Experiment Station. The primary objective was to evaluate the use of buffers as a best management practice for reducing pesticide and nutrient runoff from golf courses and other turf areas.

Studies were conducted in 1995 and 1996 on a three-acre sloped field of bermudagrass [*Cynodon dactylon* (L.) Pers.] located at the Oklahoma State University Agronomy in Stillwater, OK. The soil is a Kirkland silt loam. The area was surveyed to determine suitable locations for eight rainfall simulator set-ups, each containing four plots. The average slope of the plots was 6 percent. A portable rainfall simulator was used to apply controlled precipitation to a 50-foot diameter area containing the four plots (6 feet wide by 32 feet long). Each area of the plot receiving pesticide and fertilizer was 6 feet by 16 feet and mowed at 0.5 inches to represent a golf course fairway. The buffer area was considered to represent a golf course rough or the area between the treated area (fairway) and collection point (surface water). The following fertilizers and pesticides were applied to the treated area:

1. Nitrogen (N) at 1.0 lb ai 1000 ft^{-2} from urea (46% N) or S-coated urea (39% N);

2. Phosphorous (P) at 1.0 lb ai 1000 ft^{-2} from triple superphosphate (20% P);
3. Chlorpyrifos (0.5% granular or 50% wettable powder) at 2.0 lb ai A^{-1};
4. 2,4-D at 1.0 lb ai A^{-1}, mecoprop at 0.5 lb ai A^{-1}, and dicamba at 0.1 lb ai A^{-1} formulated as dimethylamine salts.

In most experiments, simulated rainfall (2.5 in h^{-1}) was applied for 75 minutes within 24 hours following application of chemicals. Start of surface runoff was recorded when a continuous trickle of water was first observed at the collection pit. Samples were collected at preset times after the start of runoff for individual plots using a nominal sampling schedule. Most plots were sampled 10 times during the simulated rainfall period. In most experiments, a single volume-weighted composite was prepared for chemical analysis from runoff samples for each plot.

In 1995, buffer length (0, 8, and 16 feet), mowing height (0.5 and 1.5 inches), and solid-tine aerification were evaluated to reduce pesticide and nutrient runoff. Soil moisture before simulated rainfall in July 1995 was low and pesticide and nutrient loss to surface runoff was less than 3 and 2 percent of applied, respectively. Highest concentrations of pesticides and nutrients in runoff water were 314 ppb for 2,4-D and 9.57 ppm for PO_4-P from the treatment containing no buffer. In August 1995, 6.5 inches of natural rainfall fell seven days before simulated rainfall. Pesticide and nutrient loss to surface runoff was increased to 15 and 10 percent of applied, respectively. Highest concentrations of pesticides and nutrients in runoff water were 174 ppb for 2,4-D and 8.14 ppm for PO_4-P from the treatment containing no buffer.

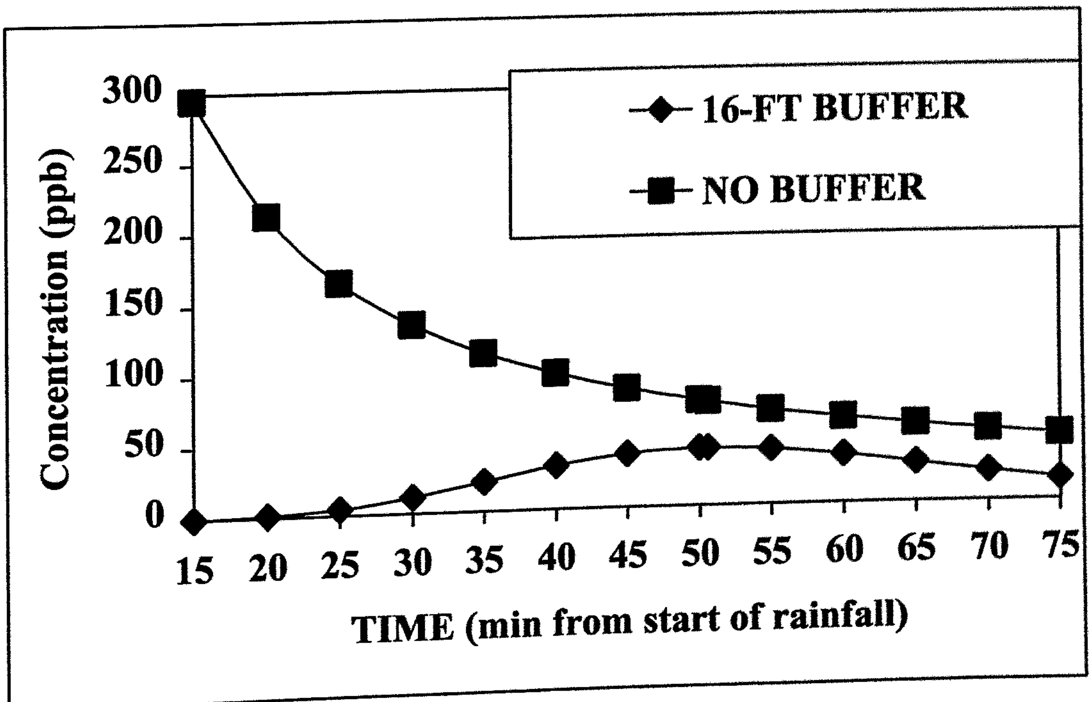

Figure 9. Plot of the predicted concentration of 2,4-D in surface runoff versus time in the 1996 buffer length experiment. *, ** Significant at alpha levels 0.05 and 0.01, respectively.

Overall, buffers were effective in reducing pesticide and nutrient runoff due, in part, to dilution. In most instances, buffer mowing height, length (8 vs. 16 ft), and aerification did not significantly affect pesticide and nutrient runoff. A paper describing research conducted in 1995 is published in the *Journal of Environmental Quality* Vol. 26 (1997).

In 1996, the portable rainfall simulator was used to evaluate the effects of: 1) buffer length (0, 4, 8, and 16 feet) at a 1.5 inches mowing height; and 2) mowing height (0.5, 1.5, and 3.0 inches) over a 16-foot long buffer on pesticide and nutrient runoff from bermudagrass turf. In the buffer length experiment, buffers reduced surface runoff losses of the pesticides and PO_4-P compared to no buffer. No differences in surface runoff were observed between buffer lengths of 4 and 8 feet. In the mowing height experiment, the buffer mowed at 3.0 inches was most effective in reducing surface runoff of pesticides and nutrients. No differences in surface runoff were observed between buffers mowed at 0.5 and 1.5 inches. Overall, effectiveness of buffers was dependent upon soil moisture content prior to simulated rainfall.

In 1995 and 1996, estimated concentrations of each contaminant for each plot were computed from a single volume-weighted composite of samples taken in a time series throughout the course of a simulated rainfall event. The focus of an ancillary investigation in 1996 was the manner in which buffers affect contaminant transport over the course of the simulation. For this purpose, samples taken in time series from no-buffer and 16-ft buffer treatments were individually analyzed for pesticide and nutrient content. Significant ratios for 2,4-D ranged from 2079 times higher for non-buffered plots at 15 min to 3 times larger at 40 minutes (see Figure 9).

Overall, the buffer was found to reduce and delay the onset of 2,4-D concentration in runoff, with a peak contamination of 41 ppb occurring approximately 51 minutes after the start of rainfall, according to the fitted model. Similar results were found for other pesticides and nutrients. For the conditions studied, significant ratios over the first half of the experiment suggest that the buffer takes an even more important role in reducing contaminant transport when rain events are expected to be shorter than 40 minutes. An analysis of estimated total runoff losses were not conclusive but suggests a buffer effect on runoff quality.

In addition to evaluating the effects of buffers on surface runoff of chemicals from turf, the time series data were used to evaluate the effectiveness of surface runoff sampling techniques for rainfall simulation studies. Volume-weighted composite samples are useful for determining if a management practice (e.g., buffer) affects the runoff quantity or quality. The data were used to predict the volume-weighted concentration of pesticides and nutrients in the surface runoff for samples taken at various times after the start of runoff. For the conditions studied, it was found that the difference in volume-weighted concentration between buffered and non-buffered plots had the lowest statistical significance 15 to 25 minutes after the start of runoff. Therefore, sampling 40 to 50 minutes after the start of runoff is recommended.

Time series data is desirable for predicting off-site environmental impacts from pesticides and nutrients in surface runoff. An optimal sampling scheme requires the smallest number of chemical analyses while still representing the actual time series accurately. For the data analyzed, the sampled data best represented the actual time series when sampling intervals were shorter at the start of runoff. The two schemes that worked best were: 1) sample every two minutes for the first 10 minutes after runoff and every 10 minutes thereafter; or 2) sample at 0, 2.5, 5, 10 minutes and every 10 minutes thereafter. The 2 to 10 minute scheme was more accurate, but requires two additional samples. Which scheme to select depends on the economics and objective of the study.

Based upon this investigation, chemical losses in surface runoff from turf can be reduced by the following:

- Install buffers between surface water and areas treated with chemicals;
- Effective buffer length is dependent upon site conditions (longer buffers are safer);
- A 3-in buffer mowing height is more effective than 0.5 or 1.5 in.;
- Avoid chemical application following heavy irrigation or rainfall events; and
- Choose pesticides and nutrients with low runoff potential.