



# *Turfgrass and Environmental Research Online*

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...Using Science to Benefit Golf



Dr. Joe Massey presents quality control approaches that have proven helpful in conducting runoff studies at Mississippi State University.

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The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 350 projects at a cost of \$29 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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# Considerations When Conducting Pesticide Runoff Experiments from Turfgrass

Joe Massey

## SUMMARY

This paper is to assist researchers, and perhaps those charged with evaluating/interpreting runoff study designs/results, by highlighting certain quality control considerations important to the conduct of a plot-scale turf runoff experiment. These considerations include:

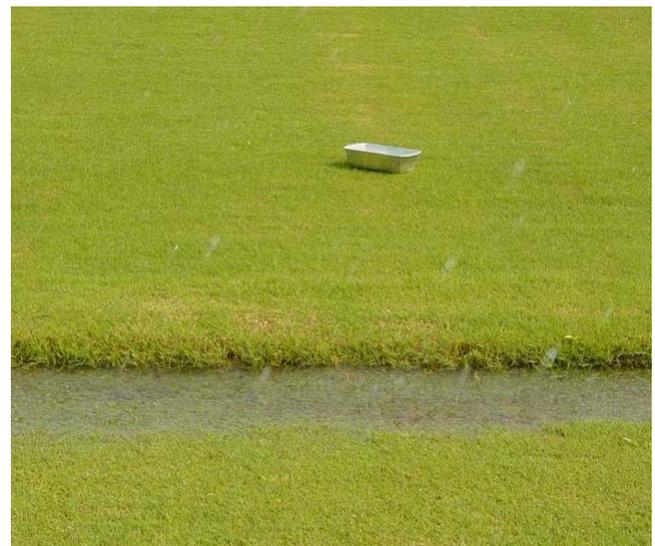
- A well-designed protocol serves as an invaluable reference throughout a study as many construction and study conduct activities build upon one another.
- Consultation with the chemical manufacturer, other researchers, and the targeted end-user of the information generated by the study can help in addressing important aspects of study design.
- To prevent extraneous water from entering the plot, the plot must be hydrologically isolated from surrounding area.
- One of the most important considerations in plot construction and maintenance is the interface that exists between the down-slope edge of the plot and the runoff collection apparatus since it represents a potential point of loss for surface runoff.
- The delivery rate and uniformity of the rainfall simulator must be verified under field conditions.
- One must know the actual amount of pesticide applied to turf rather than assuming the nominal rate was applied in order to (a) accurately calculate the percentage of chemical that occurs in runoff and (b) ensure that the pesticide concentrations measured in runoff reflect those that would occur with labeled applications.
- The application monitors and runoff samples must be properly labeled, handled, and stored in order to preserve the scientific integrity of study results.

Surface runoff is one of the largest loss mechanisms for pesticides applied to turfgrasses (7, 12). Owing to the importance of turfgrass to urban environments and the need to protect water quality, there exists an on-going need to perform turf runoff experiments to (a) assess the behaviors of new chemicals or products, (b) refine best man-

agement practices, and (c) calibrate/validate runoff prediction models for turfgrass. Field studies indicate that surface runoff from creeping bentgrass (3) and bermudagrass (8) is 'scalable' across a range of plot areas. Thus, there is solid scientific justification for using plot-scale experiments to study the surface runoff of turf chemicals.

Conceptually, conducting a turf runoff experiment is simple: a chemical(s) is applied to grass and runoff, generated by natural or simulated rainfall, is collected and analyzed for the chemical(s). In practice, a runoff study involves a number of steps that must be carefully performed to ensure that scientifically valid, representative data are produced. Seemingly small oversights in study design or conduct may compromise data from a scientific or regulatory perspective. The goal of this paper is to assist researchers, and perhaps those charged with evaluating or interpreting runoff study designs or results, by highlighting certain quality control considerations important to the conduct of a plot-scale turf runoff experiment.

This paper is not comprehensive but presents quality control approaches that have proven



**Figure 1.** Water pools at top of runoff plot that has been hydrologically isolated by use of turf-covered berms.

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**Figure 2.** Installation of runoff diverter and collection trough.

helpful in studies conducted at Mississippi State University. For a review of technical considerations important to the conduct of a runoff study, the reader is directed to Wauchope et al. (14). The phases addressed here are study planning, plot construction and maintenance, rainfall simulator verification, application monitoring, and sample handling.

## **Study Planning**

### Quality Control Principle

A detailed study protocol that addresses all aspects of study conduct is critical to success of any study. Moreover, an approved protocol is required for a study to be submitted to support pesticide registration. A well-designed protocol serves as an invaluable reference through out a study as many construction and study conduct activities build upon one another.

### Basis of Concern

There are certain study details that should not be left to chance or addressed as an after thought once the study is underway. Particular attention should be paid to methods used to control and account for water movement in test plots and methods used to account for pesticide application and fate in the turf system. Some pesticides present special considerations, such as those with a propensity to strongly adsorb to plastic and other surfaces (water solubility = 1 mg/L at 25°C), rapidly degraded (soil  $T_{1/2}$  = 2 days), or those that are relatively volatile (vapor pressure >  $10^{-4}$  mm Hg at 25°C). Thus, the researcher must take into account the properties and environmental behavior of the pesticide during protocol development. Sample handling and storage practices are also critical and often compound-dependent.

### Approach

A thorough literature review is an appropriate place to begin a study of this scale. Unfortunately, quality control programs are not always explicitly reported in published works. Consultation with the chemical manufacturer, other researchers, and the targeted end-user of the

information generated by the study can help in addressing important aspects of study design. In the end, attempting to account for as much of the rainwater and applied pesticide as possible is a good guiding practice in study design and conduct.

## Turf Plot Construction & Maintenance

### Quality Control Principle

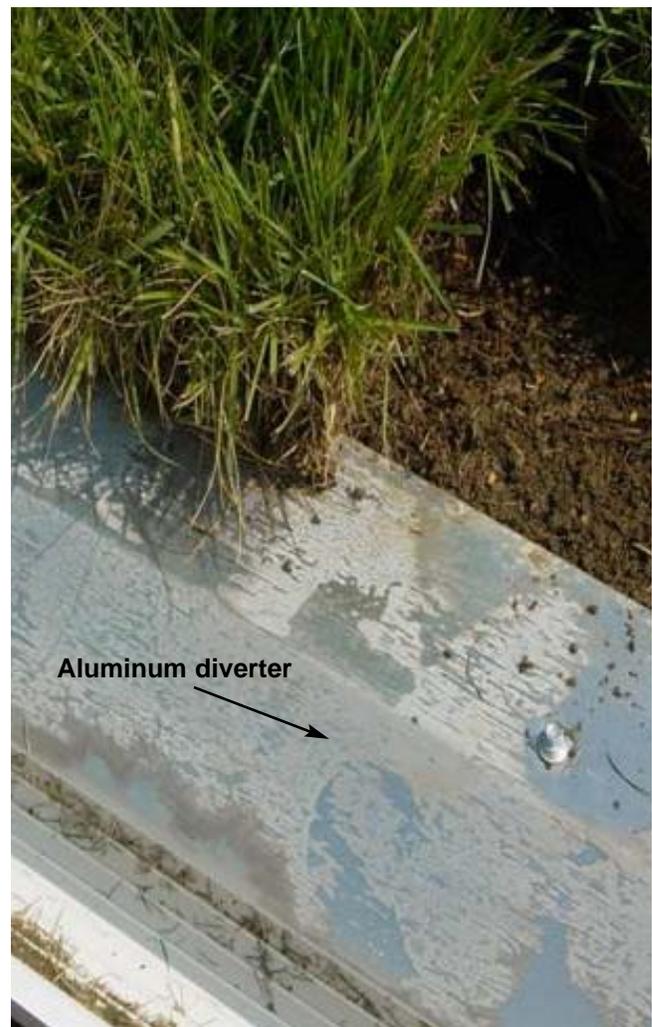
The runoff plot should be constructed to capture no more and no less than the actual runoff occurring from the treated plot. Water external to the plot borders should not be allowed to run onto the treated plot, just as the runoff collection apparatus must capture all surface runoff and not leak.

### Basis of Concern

If water external to the treated plot is allowed to run onto the plot, pesticide concentrations in runoff will be diluted. Runoff that completely by-passes or leaks from the runoff collection apparatus before measurement will reduce the total runoff volume and pesticide load measured during the study. Both of these scenarios will not accurately reflect the actual amount of runoff that occurred.

### Approach

To prevent extraneous water from entering the plot, the plot must be hydrologically isolated from surrounding area using metal dykes (13), landscape timbers (6, 12), or flexible plastic discharge hoses filled with masonry sand (5). For multiple plots, however, it may be better to use permanent turf-covered soil berms (Figure 1) as these are easy to maintain by mowing when less than 2 inches high. Plot spacing is also important and dependent on overall experimental design and configuration of spray equipment and rainfall simulator to be used. Wide plot spacing prevents over-spray during pesticide application and rainfall simulation and allows movement of equipment between multiple plots. Knowledge of the



**Figure 3.** Installation of runoff diverter showing overlapping sod on diverter.



**Figure 4.** Rainfall simulator audit using cups placed on 12-inch centers (Image courtesy of Dr. Mark Carroll).

distance of throw of the rainfall simulator is needed to determine appropriate plot spacing.

One of the most important considerations in plot construction and maintenance is the interface that exists between the down-slope edge of the plot and the runoff collection apparatus. This interface between the runoff diverter and turf is critical because it represents a potential point of loss for surface runoff. Wauchope et al. (14) note that construction of the diverter-turf interface requires creativity and skill. Several approaches may be used but in each case the system must ensure against runoff bypass and potential leaks.

At Mississippi State, we thought it best to minimize the transition between the sod and diverter by minimizing the thickness of the diverter. Our diverter consisted of 20-gauge aluminum metal bent to a 140 degree angle. The diverter was designed such that it extended into the plot by about 2 inches and into the runoff collection trough by about 3 inches (Figure 2). The soil underneath the diverter was sieved, carefully leveled, and tamped so that no air space existed under the diverter.

The diverter was next attached to a wooden box lining the collection trench using silicone sealant and screws with rubber grommets. Prior

to installing the diverter, sod close to the interface was removed using a sod cutter (Figure 2). Once the diverter was installed, the original sod was placed so that it overlapped the diverter by about one inch (Figure 3). The diverter-sod interface was allowed to heal for six to eight weeks before leak testing the remaining portion of the runoff collection system using marker dye.

## **Verification of Rainfall Application Rate**

### Quality Control Principle

The delivery rate and uniformity of the rainfall simulator must be verified under field conditions.

### Basis of Concern

Rainfall application rates significantly less or greater than the target rate and/or lacking in uniformity may cause non-representative and/or highly variable results that complicate results.

### Approach

Prior to conducting actual runoff studies, the performance of the rainfall simulator must be verified. This is accomplished using a formal audit procedure (14). For example, Carroll (2005) used paper cups spaced on approximately 12-inch centers (Figure 4). Plastic tarps placed over the entire plot area may be used to determine total rainfall delivery. This approach provides a visual assessment of uniformity but does not yield a quantitative measure of rainfall uniformity. The operating pressure of the simulator should be noted during audits and checked periodically during the study to ensure the system is operating properly. During actual runoff events, pan-type rain gauges should be used to record actual rainfall amounts and uniformity. Note that tall, narrow-top rain gauges may not accurately measure rainfall owing to the steep descent of the artificial raindrops.

## **Pesticide Application Monitoring**

### Quality Control Principle

One must know the actual amount of pes-



**Figure 5.** Pesticide application verification using Petri dish monitors (A) and recording pass-times (B).

pesticide applied to turf rather than assuming the nominal rate was applied in order to (a) accurately calculate the percentage of chemical that occurs in runoff and (b) ensure that the pesticide concentrations measured in runoff reflect those that would occur with labeled applications.

*Basis of Concern*

In field experiments involving pesticide application, it is not uncommon for actual application rates to differ by  $\pm 15\%$  or more from nominal rates, even after careful calculation, calibration of spray equipment, and application by experienced persons (1, 11). In an analysis of over 1,600 pesticide applications, improper boom height (60% of errors), miscalculation of application rate (26%), and variation in pass time (14%) were most responsible for inaccurate application rates (2).

*Approach*

Three main approaches are used to verify

pesticide application rates (10). Two indirect measures are the catch-back method and the pass-time method. The catch-back method involves measuring the spray solution volume before and after application to determine if the desired volume of test solution was applied to the test plots. The pass-time method involves measuring the time that it takes the applicator to pass over the test plot having known length and comparing this time to the speed used in calculation (Figure 5, B).

Experienced applicators are able to apply within  $\pm 2\%$  of the targeted spray volume or pass time. Making several practice runs before each pesticide application improves overall accuracy. Field protocols written for regulatory purposes typically require that the application be within  $\pm 5\%$  of the target spray volume or pass time value. Variances exceeding these criteria should be closely scrutinized and the cause of the misapplication determined before proceeding with additional applications.

A direct measure of deposited residues



**Figure 6.** Collection of application monitors using catwalk to minimize plot disturbance after pesticide application.

uses application verification (AV) monitors. These are paper discs, polyurethane foam plugs, Petri dishes, etc. placed in the test plot to collect actual spray deposition that occurs during application (Figure 5, A). The AV monitors are collected and chemically analyzed for the test chemical(s) being applied. Pre-labeled monitors are positioned before application in an arrangement spanning the length and width of the plot to allow a representative sample of the spray pattern (Figure 5). We used approximately one AV monitor per 100 ft<sup>2</sup> of plot area.

Immediately after application, the monitors are carefully collected and handled so as to not lose pesticide content, wrapped in aluminum foil, and immediately frozen until analyzed. Care must also be taken not to walk on or otherwise disturb treated turf surfaces after application. A 'cat-walk' may be helpful in preventing plot disturbance when retrieving the monitors (Figure 6). If after analysis the pesticide contents of the individual AV monitors are found to vary by more than 20% for an application, the source(s) of the variability should be determined and reduced to ensure uniform pesticide treatment in future studies (9).

## Sample Handling & Storage

### Quality Control Principle

The application monitors and runoff samples must be properly labeled, handled, and stored in order to preserve the scientific integrity of study results.

### Basis of Concern

Improper handling and storage of samples can result in unacceptable degradation losses and compromise the integrity of the samples and, thus, the scientific validity of the overall study.

### Approach

Collection of application monitors should begin immediately after application and the samples stored frozen to stabilize residues and solidify liquid spray droplets to prevent spills. Provisions should be made to have ample help to collect the application monitors, recognizing that labor requirements rise with plot size and number of monitors used. A 'dry run' in collecting the AV monitors helps in assessing the time needed to collect, wrap, and store the monitors.

Runoff samples should be placed on ice during or immediately after collection and transported on ice back to the laboratory. Ideally, a robust, sensitive analytical method would be in place before initiating the field-conduct phase of a runoff study as this assures timely analysis of samples. However, if the samples can not be analyzed soon after collection, it is best to analyze at least a subset of the initial runoff samples. These samples would then be frozen along with the remaining unanalyzed samples and reanalyzed when the remainder of samples is analyzed. By comparing the initial and final analyses of these samples, the storage stability of pesticide residues in the later-analyzed samples can be determined.

## Summary

Much planning, effort, and expense are associated with the conduct of a pesticide runoff

experiment. While all aspects of the study are important, several are of critical importance to overall outcome of the study. Perhaps the best way to summarize the approach encouraged here is to strive to account for as much of the rainwater and applied pesticide as possible.

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