MODELING PESTICIDE TRANSPORT

In

TURFGRASS THATCH AND FOLIAGE

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GREEN SECTION RESEARCH

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Executive Summary

Pesticides applied to mature turf move into the soil only after being washed off foliage and moving through turfgrass thatch. Any attempt to predict the movement of pesticides applied to turf requires that the retention characteristics of the pesticide to foliage and thatch be known. Research evaluating the washoff of pesticides from Southshore creeping bentgrass foliage was conducted in the summer of 1995 and 1996. The turf was mowed to 5/8" prior to the application of each pesticide and approximately 1.25" of simulated rainfall applied 1, 8, 24 and 72 hours after pesticide application. Pesticide washoff from the foliage was determined by mowing strips of turf at a 3/8" height immediately before and after simulated rainfall. The strips were located adjacent to one another inside 6 X 7' plots. Three formulations of chlorothalonil, Daconil 2787 4F, Daconil Ultrex (WDG), and Daconil 2787 5G were applied at a target rate of 9 lb chlorothalonil/acre on four dates in 1995, and on two dates in 1996. Each formulation was applied to a separate block of turf on each of the six dates, and a single plot within each block sampled at one of the four designated residence time intervals. Similarly, four replicate blocks of Southshore creeping bentgrass were treated with target rates of 0.5 lb dicamba/acre or 7.7 lbs/acre carbaryl on a single date in 1995, using Banvel or Chipco Sevin 4SL.

Chlorothalonil was more resistance to washoff than carbaryl or dicamba. Over the 72 hour evaluation period, foliar levels of chlorothalonil were 20 to 46% higher in turf treated with Daconil 2787 5G, than in turf treated with F or WDG formulated Daconil 2787. There was, however, no difference among the three formulations in the fraction of chlorothalonil that was removed by rainfall. When averaged over the 3 formulations, only about 35% of the chlorothalonil was removed from the foliage when rainfall occurred 1 hour after application. At longer residence times no more than 15% of the chlorothalonil was removed from the foliage with rainfall.

Rainfall that occurred within 8 hours of the application of Banvel removed 70% of the dicamba present on the foliage. Dicamba became more resistant to washoff at longer residence times. Only 44% of the dicamba present on bentgrass foliage was removed when rainfall first occurred 72 hours after application of Banvel. Replicate measurements of the fraction of carbaryl retained on bentgrass foliage were variable. The amount of carbaryl washoff, however, did not vary much with residence time. Washoff of carbaryl from bentgrass foliage ranged from 64 to 79% over the 72 hour residence time evaluation period.

Research in 1997 will focus on conducting sorption and transport studies aimed at obtaining the transport parameters needed to model 2,4-D, carbaryl and chlorothalonil movement using equilibrium and non-equilibrium forms of the convection dispersion equation. Our initial transport study conducted in 1996 revealed that the presence of a surface thatch layer reduced the transport of 2,4-D through shallow (ie., 6" deep) soil cores by at least 50%. Cores having a 3.5 year old 0.7" surface layer of Southshore creeping bentgrass thatch were more effective in reducing 2,4-D transport than cores having a 6 year old 1.3" surface layer of Meyer zoysiagrass thatch.

From November 1995 to November 1996, the two principal investigators, Drs. Carroll and Hill devoted 25% and 15%, of their professional time, respectively, to this project. As of 29

September 1996 the following expenses have been incurred related to this project: Wages, $36,603, Equipment and Supplies, $9,346 Indirect Costs, $15,171 Sum of all Expenses, $61,120.

Goals:

- To quantify the washoff of pesticides from bentgrass foliage as a function of time after application and pesticide formulation.
- To determine the effect of solution residence time on the sorption of pesticides to turfgrass thatch.
- To determine if the linear equilibrium form of convection/dispersion equation is able to provide accurate estimates of pesticide transport in turf.

Project Title: Modeling Pesticide Transport in Turfgrass Thatch and Foliage

Principal Investigators: Mark J. Carroll and Robert L. Hill

Project Overview- Pesticides applied to mature turf move into the soil only after being washed off foliage and moving through turfgrass thatch. Any attempt to predict the movement of pesticides applied to turf requires that the retention characteristics of the pesticide to foliage and thatch be known.

Pesticide movement from foliage to underlying porus media layers is usually modeled using foliar washoff algorithms. The use of foliar washoff algorithms requires that accurate estimates of the fraction of applied pesticide that is deposited on the foliage, and of the fraction of pesticide removed from the foliage as a function of rainfall amount be known. In the case of the latter, the amount of time elapsed between pesticide application and the first rainfall event can significantly affect the fraction of pesticide removed from foliage. One of the objectives of this research project is to quantify the washoff behavior of pesticides from turfgrass foliage as a function of time after application.

Many pesticide transport models, such as PRZM and LEACHM, use the linear equilibrium form of the convection-dispersion equation to predict pesticide movement in porus media. A major assumption inherent in use of this form of the convection-dispersion equation is that the residence time of solution containing the pesticide is of sufficient duration that sorption equilbium between the solution and porus media is achieved. It has been hypothesized that turfgrass thatch differs from soil in that it exhibits non-equilibrium pesticide sorption. In such cases, pesticide movement within the media may be predicted with greater accuracy when a non-equilibrium form of the convection-dispersion equation is used to model pesticide transport. The primary objectives of this project are to determine the pesticide sorption characteristics of turfgrass thatch, and to use that information to evaluate linear equilibrium and non-equilibrium forms of the convection-dispersion equation to predict pesticide transport in soils containing a turfgrass thatch surface layer. Our work in this area should result in improved prediction methods for modeling the transport of pesticides applied to turf.

Progress to date

Washoff: Research evaluating the washoff of pesticides from Southshore creeping bentgrass foliage was conducted in the summer of 1995 and 1996. The turf was mowed to 5/8", 1 to 4 hours prior to the application of each pesticide and approximately 1.25" of simulated rainfall applied 1, 8, 24 and 72 hours after pesticide application. Pesticide washoff from the foliage was determined by mowing strips of turf at a 3/8" height immediately before, and after simulated rainfall. The strips were located adjacent to one another inside 6 X 7' plots. Three formulations of chlorothalonil, Daconil 2787 4F, Daconil Ultrex (WDG), and Daconil 2787 5G were applied at a target rate of 9 lb chlorothalonil/acre (10 kg chlorothalonil/ha) on 10, 19, 26 and 31 July 1995, and on 25 June and 2 July 1996. Each formulation was applied to a separate block of turf on each of the six dates, and a single plot within each block sampled at one of the four designated residence time intervals. Similarly, four replicate blocks of Southshore creeping bentgrass were treated with target rates of 0.5 lb dicamba/acre (0.56 kg dicamba/ha) on 7 August 1995, and with 7.7 lbs/acre carbaryl (8.6 kg carbaryl/ha) on 14 August 1995, using Banvel and Chipco Sevin

4SL respectively. Individual plots were sampled for dicamba and carbaryl pesticide washoff at the four prescribed residence times. All samples were stored in a freezer until analysis.

Actual application rates for each pesticide were determined by collecting tank mix samples of the pesticide upon completion of pesticide application in the field. Samples of Daconil 2787 5G were also collected for analysis. All pesticide analysis was conducted by the USDA Environmental Chemistry Laboratory in Beltsville, Maryland.

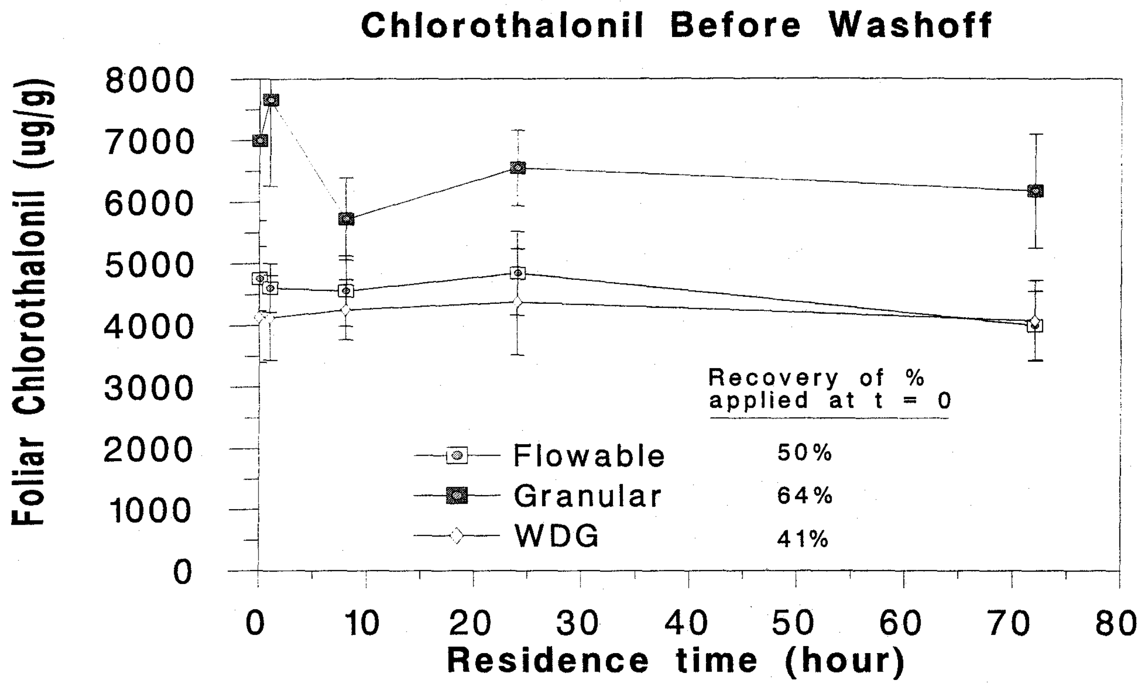
Figures 1, 2 and 3 summarize the results of our washoff work by providing the initial pesticide concentration present on bentgrass foliage as a function of residence time, and the portion of pesticide remaining on the foliage after subjecting the turf to simulated rainfall. The percent of applied pesticide that was recovered from the foliage within 1 hour of application (ie., T = 0) is also presented. The percent of applied pesticide that was recovered in the foliage is based on the measured delivery rate of the sprayer and the actual amount of pesticide detected in the tank mix at the time of application. The recovery percentage for Daconil 2787 G is based on the concentration of chlorothalonil in the granules (g /g) and the mass of Daconil 2787 G applied to each plot. No rainfall was applied at T = 0. This permitted the T = 0 retention data to serve as a untreated check, where the expected retention fraction value should be close to 1.

Although the target A.I. application rate was the same for all three formulations of Daconil 2787, bentgrass treated with the G formulation had higher foliar levels of chlorothalonil than bentgrass treated with the F or WDG formulation. Little to no decline in chlorothalonil was observed during the initial 72 hours following application of each formulation. Moreover, there was no difference in the fraction of chlorothalonil retained on the foliage among the three formulations of Daconil 2787. When averaged over all 3 formulations, approximately 35% of the chlorothalonil was removed from foliage when rainfall occurred 1 hour after application. After this time washoff of chlorothalonil was relatively constant. Only 10 to 15% of the chlorothalonil present on the foliage could be removed with 1.27 inches of rainfall once the residence time was ≥ 8 hours.

Foliar levels of dicamba declined 57% over the first 24 hours following application of Banvel. Little decline in dicamba was observed over the next 48 hours. Rainfall that occurred during the first 8 hours following the application removed about 70% of the dicamba present on the foliage. After this time dicamba became more resistant to washoff, however, 44% of the dicamba present on the foliage could be removed with 1.3 inches of rain 72 hours after application.

No clear pattern of carbaryl dissipation in the foliage was apparent during the first 72 hours following application of this insecticide. In addition, the fraction of carbaryl retained on the foliage did not vary much with residence time. In general, carbaryl appeared to be more susceptible to washoff than did dicamba. Carbaryl washoff from bentgrass foliage ranged from 64% to 79% over the 72 hour residence time period.

Sorption: Studies to determine the effect of solution residence time on the sorption of pesticides to soil and turfgrass thatch have been delayed pending the completion of preliminary studies aimed at identifying the extent of pesticide absorption to experimental material other than thatch and soil. In our initial attempt to determine the sorption of chlorothalonil to zoysiagrass thatch



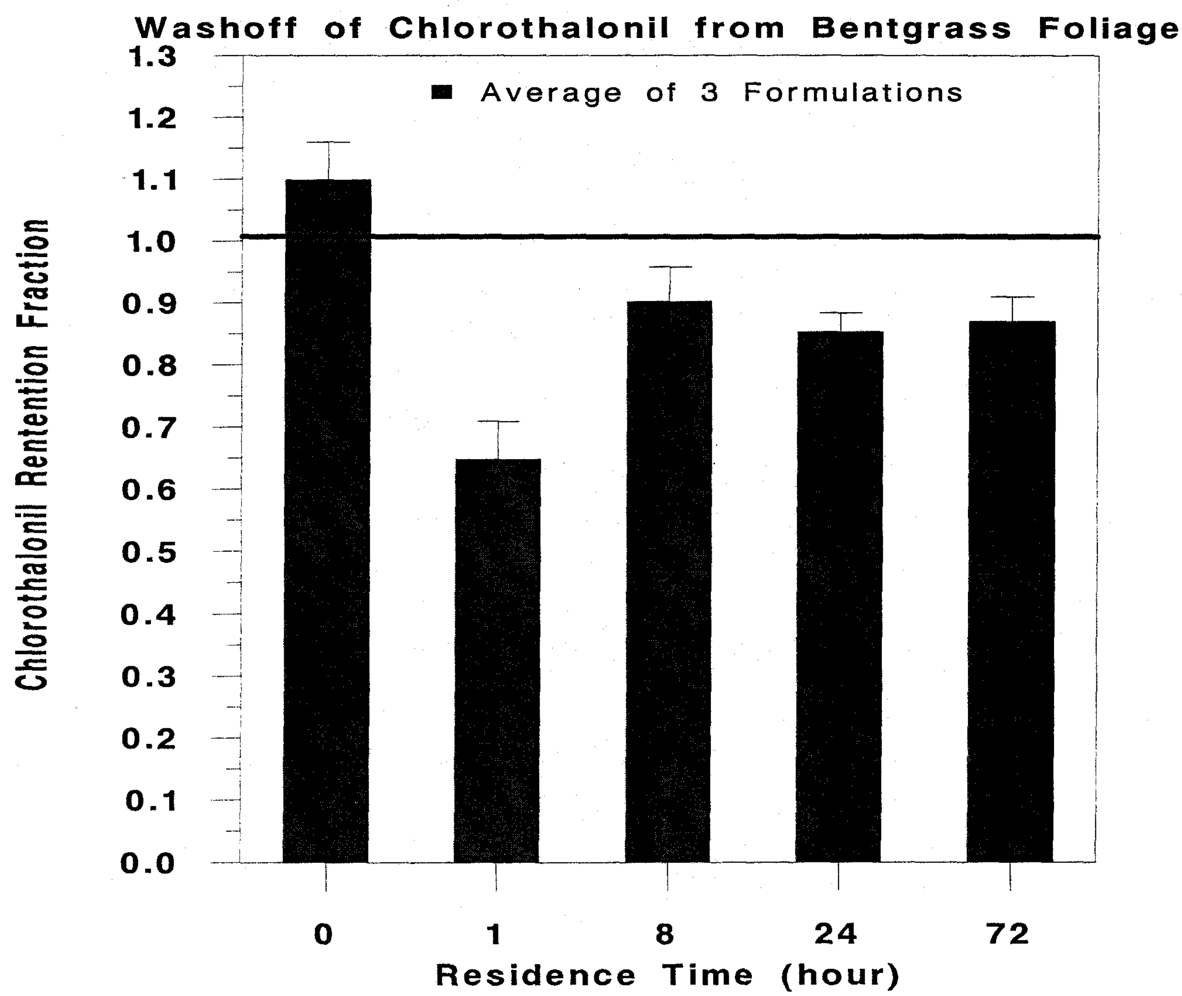


Figure 1. Means and standard errors are based on six replicates. 1.27 (± 0.01) inches of simulated rainfall was applied at the prescribed residence time.

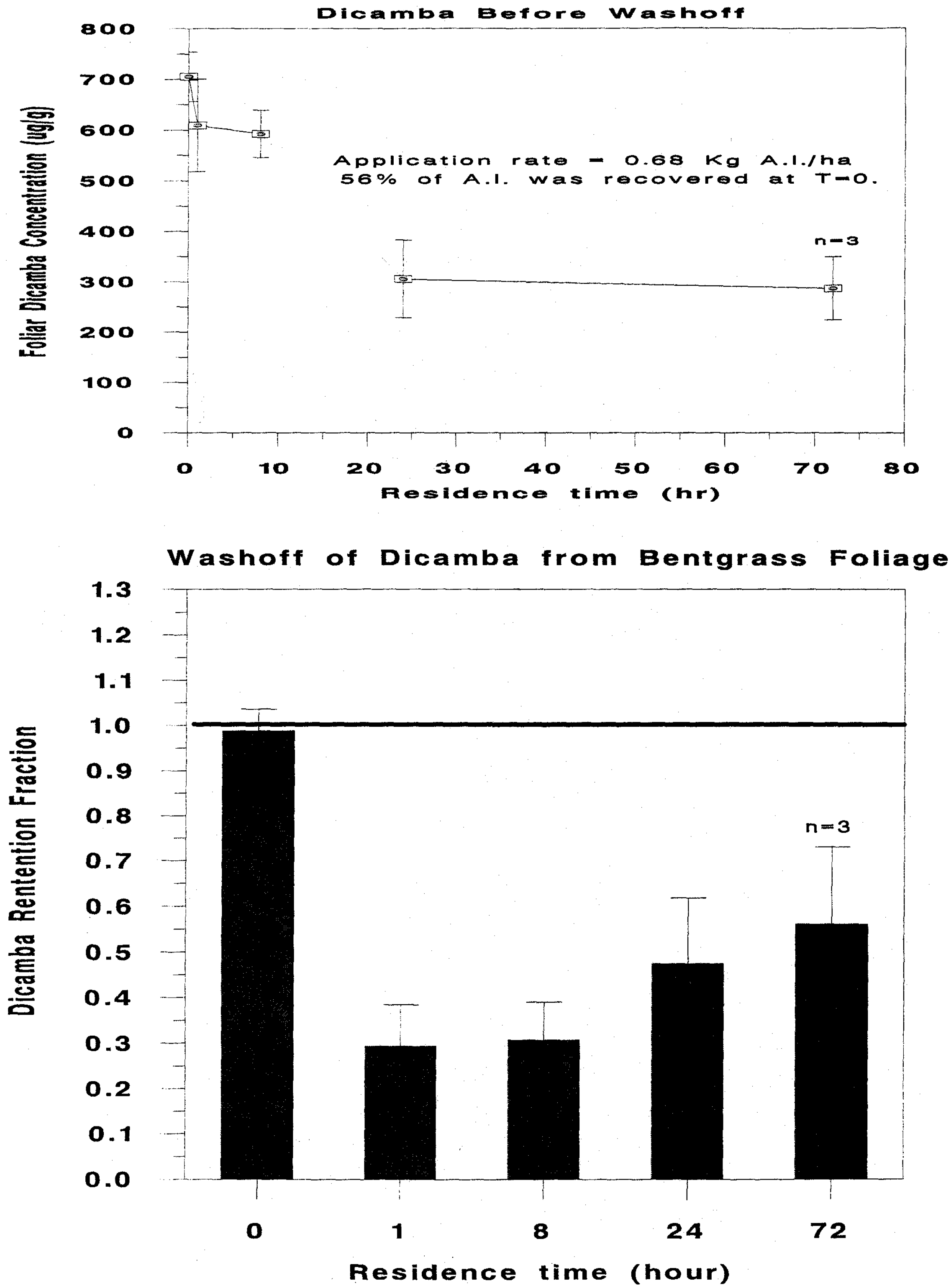
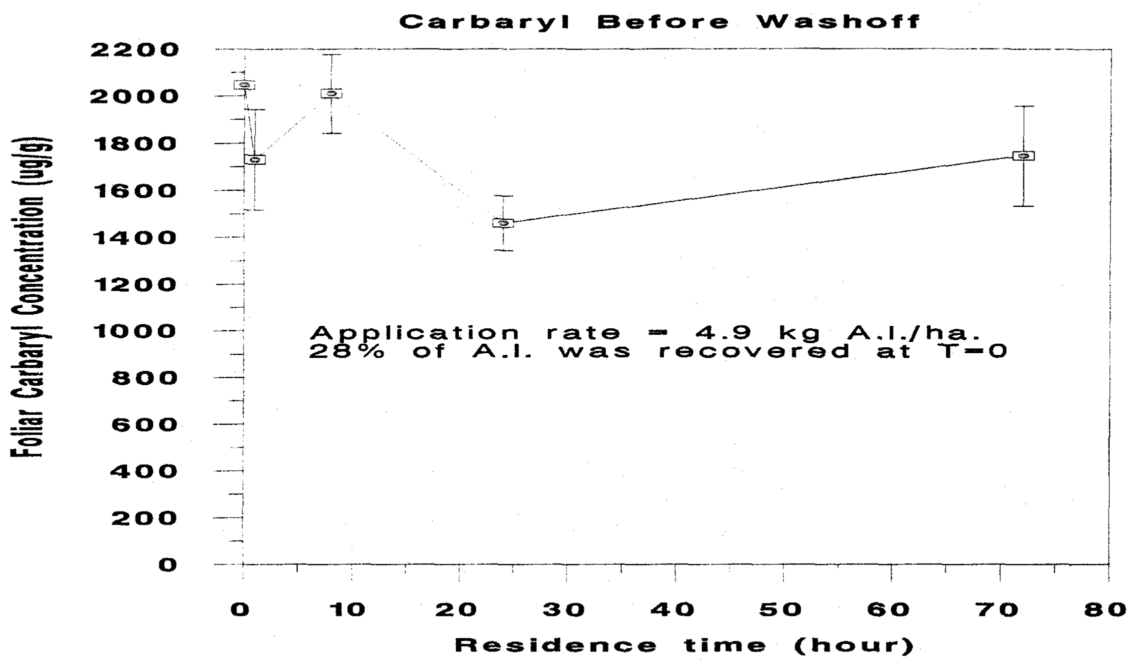


Figure 2. 1.30 (±0.02) inches of simulated rainfall was applied at the prescribed residence time. Means and standard errors are based on four replicates except were noted.



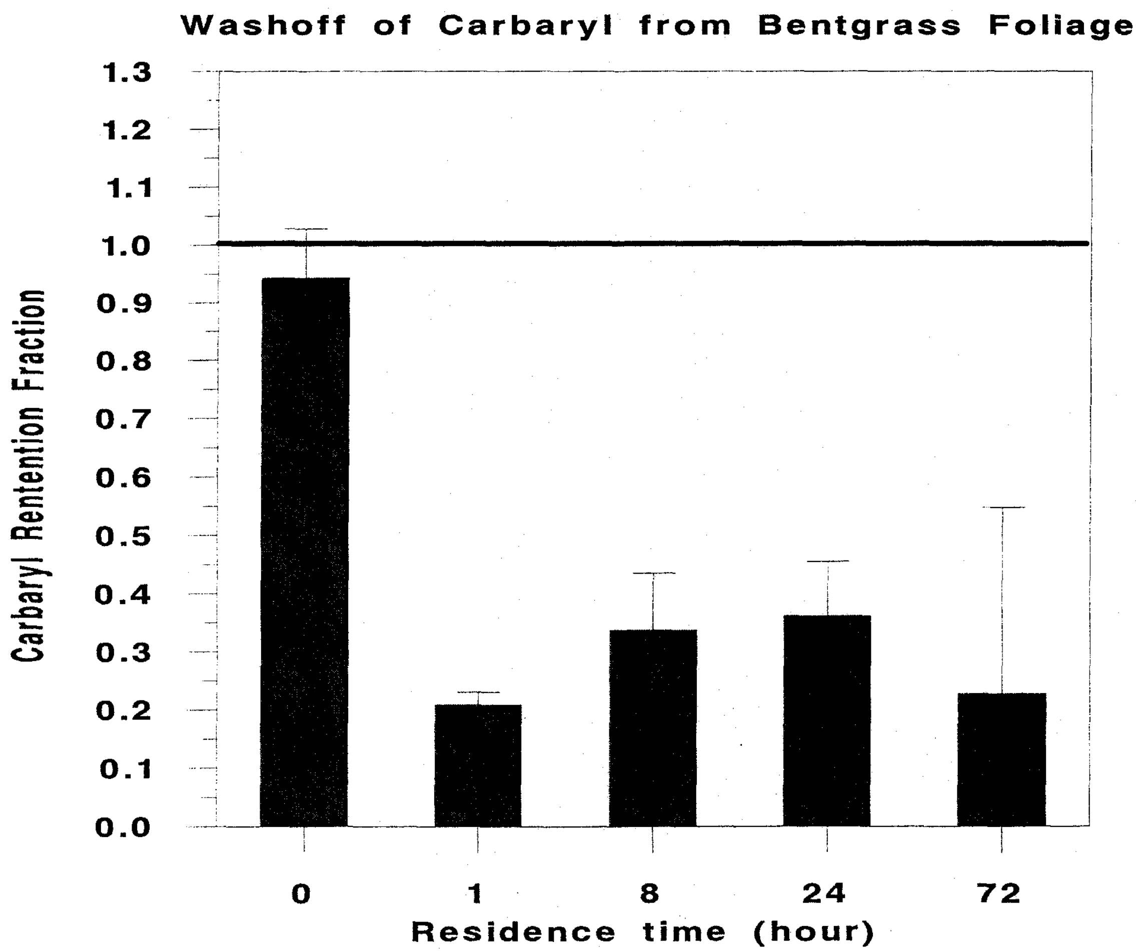


Figure 3. 1.24 (±0.01) inches of simulated rainfall was applied at the prescribed residence time. Means and standard errors are based on four replications.

using standard vacuum extraction methodology, we found that most of the chlorothalonil was adsorbed to a foam plug used to distribute the initial pesticide solution over the surface of the thatch sample. Apparently, the plug readily sorbs hydrophobic compounds such as chlorothalonil. In a previous study involving highly water soluble dicamba, no dicamba absorption to this plug was detected. The bentgrass and zoysiagrass thatch needed for the sorption studies were collected in the spring of 1996 and are currently being stored at 4 °C pending completion of the preliminary studies. The bentgrass thatch was collected from a 3.5 year old stand of Southshore creeping bentgrass. The zoysiagrass thatch was collected from a 6 year old stand of Meyer zoysiagrass.

Transport: The transport of 2,4-D through undisturbed cores of soil or soil plus a surface layer of thatch were examined in 1996. Each core contained approximately 5.5 inches of soil. The bentgrass site cores had a sandy loam texture while the zoysiagrass site cores had a loamy sand soil texture. The average thatch depth of the cores containing a surface layer of thatch was 0.7" for the bentgrass thatch cores and 1.3" for zoysiagrass thatch cores. A constant rate of simulated rainfall (0.4"/hr) was applied to the cores using a specially designed emitter. Once steady state flow conditions were achieved in each core, a pulse of bromide was added and leachate samples collected for the next 12 hours. The bromide leachate data (data not shown) will be used to derive the convective dispersive parameters needed to model 2,4-D transport. Analytical grade 2,4-D acid was added to the surface of each core 12 hours after adding the pulse of bromide. The emitters were removed from the cores at this time and the 2,4-D allowed to sorb to the thatch and soil for 24 hours. Simulated rainfall was then re-initiated and leachate samples collected at regular intervals until the concentration 2,4-D in the leachate approached the lower limits detection.

The 2,4-D breakthrough curves for each thatch-soil combination are shown in Figures 4 through 7. The individual diagrams within each figure represent the results from a single core, hence each thatch-soil combination was replicated four times. In the discussion that follows, core BS4 has been removed from the data set because leachate sampling of this core was terminated before the concentration of 2,4-D in leachate approached the lower limits of 2,4-D detection.

Our experimental conditions probably represent a "worst case scenario" for pesticide leaching from turf. Even under such conditions the data clearly show that the presence of thatch reduces 2,4-D transport through the cores. When averaged over the 3 soil and 4 thatch cores, the presence of bentgrass thatch reduced the amount of applied 2,4-D that was leached from the soil from 5.7% to 0.8% (a > 7 fold reduction). Similarly, the presence of zoysiagrass thatch reduced the percent of applied 2,4-D that was leached from 5.3% to 2.4% (a > 2 fold reduction). Visual comparison of the two thatch sources revealed that the thinner diameter of the creeping bentgrass stolons resulted in this thatch being much finer than zoysiagrass thatch. The lower amount of 2,4-D leaching observed in the cores containing bentgrass thatch, may be the result of more organic matter surface area, (ie., more exchange sites) being available for sorption in the bentgrass thatch than in the zoysiagrass thatch.

Work Planned for Nov. 1 1996 - Nov. 1 1997 Period

Ms. Sanju Raturi, will be completing her Ph.D. course work requirements at the end of this fall semester. With her course work behind her, we anticipate that collection of the remaining sorption and transport data will proceed quickly over the next 12 months. Sanju plans

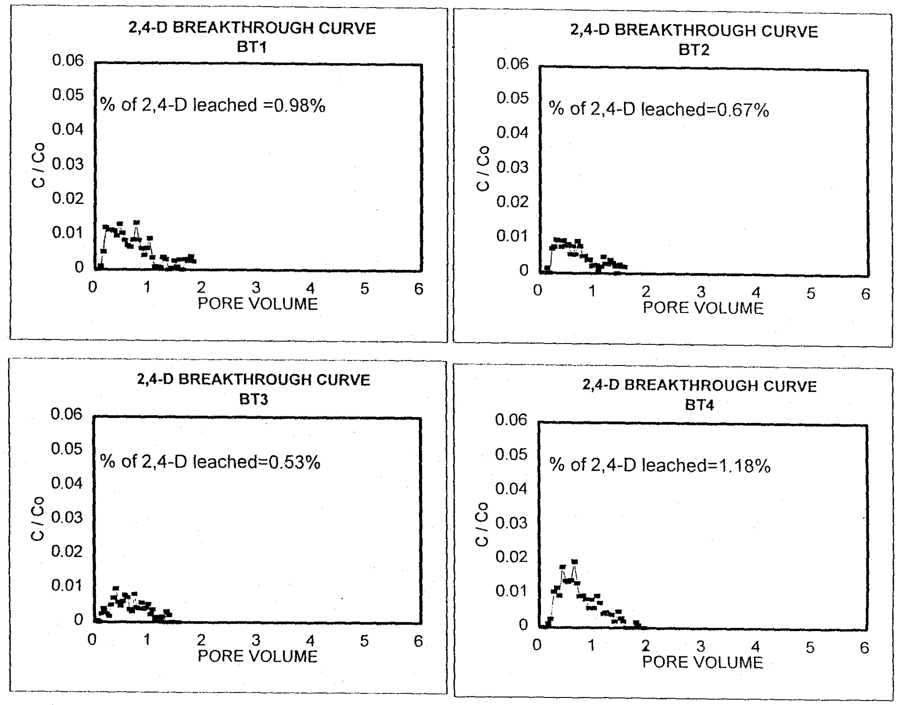


Figure 4. Creeping bentgrass site (B) 2,4-D breakthrough curves for cores containing a surface layer of thatch (T).

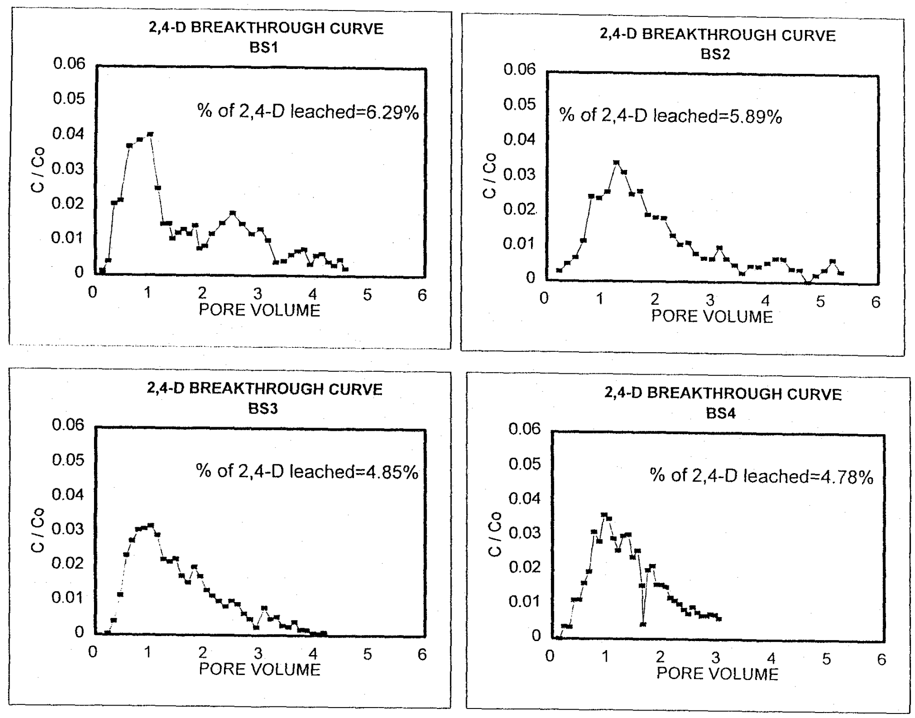


Figure 5. Creeping bentgrass site (B) 2,4-D breakthrough curves for cores containing soil only (S).

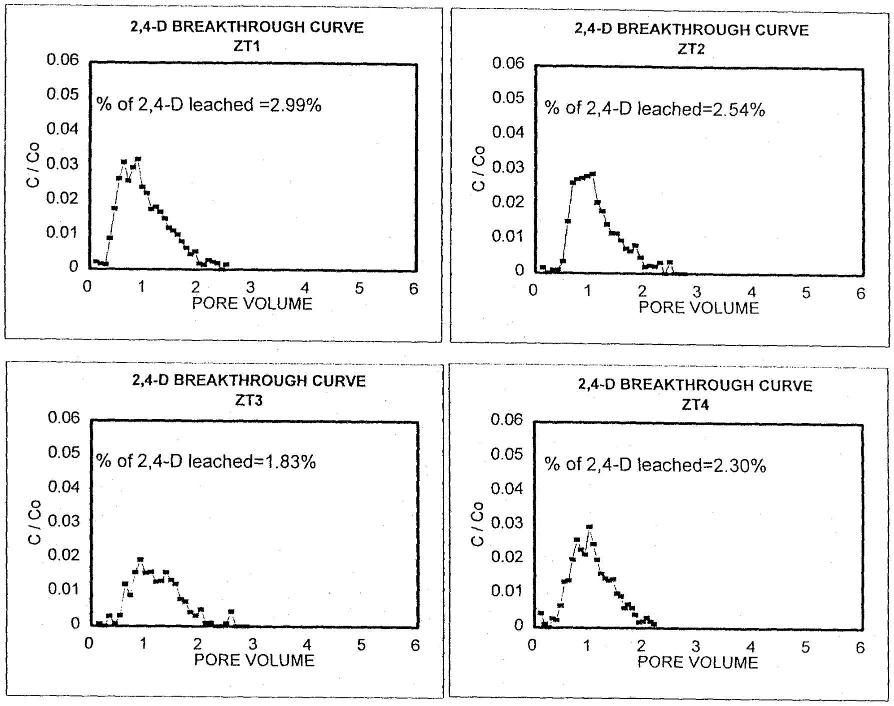


Figure 6. Zoysiagrass site (Z) 2,4-D breakthrough curves for cores containing a surface layer of thatch (T).

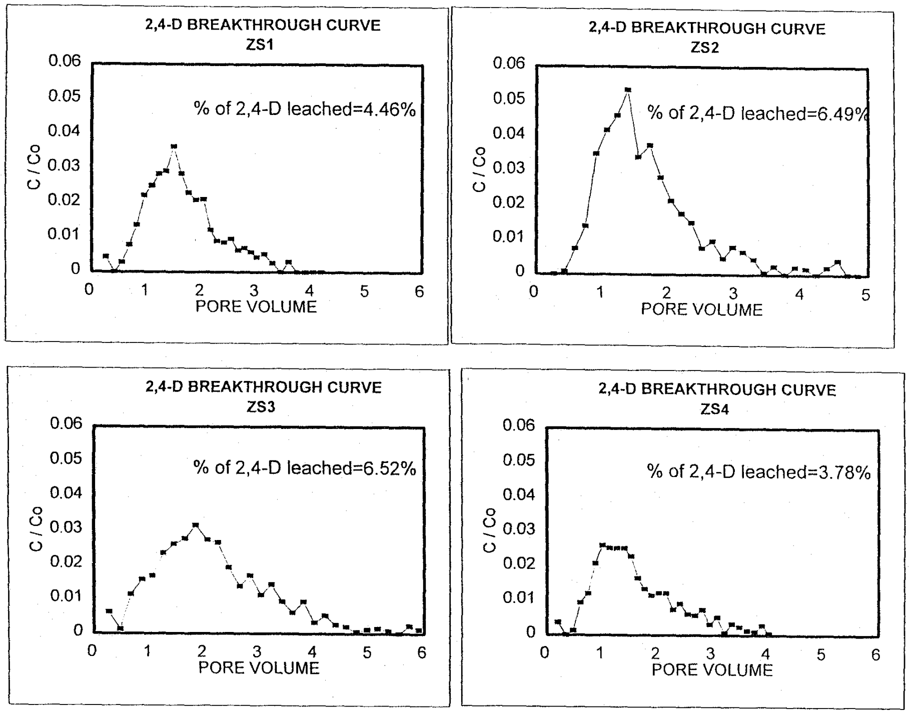


Figure 7. Zoysiagrass site (Z) 2,4-D breakthrough curves for cores containing soil only (S).

on completing her preliminary sorption work by the end of this year. During the first six months of 1997 she plans on conducting all laboratory work needed to characterize the sorption of 2,4-D, carbaryl and chlorothalonil to both species of turfgrass thatch. She will also complete the 2,4-D transport study by determining the amount of bound 2,4-D present in the soil and thatch of cores used to generate the data shown in Figures 4 through 7. The cores from the 2,4-D transport study were placed into a freezer immediately after terminating the leachate sampling portion of the study. She has been working with Dr. Scott Glenn, (Department of Agronomy Weed Scientist) during the Fall 1996 semester to develop a technique to extract bound 2,4-D from the transport study thatch and soil cores. This information is needed in order to determine the amount of 2,4-D that can be accounted for by only considering the processes of sorption and leaching. After completing the 2,4-D transport study and the three pesticide sorption studies, Sanju will began investigating the transport of carbaryl and chlorothalonil. We hope to began the carbaryl and chlorothalonil transport studies, early next summer 1997. Evaluation of various forms of the convective/dispersive equation will commence once all three transport studies have been completed.