THE FATE OF CHEMICALS AND FERTILIZERS IN A TURFGRASS ENVIRONMENT
UNIVERSITY OF CALIFORNIA RIVERSIDE
M. V. YATES, PRINCIPAL INVESTIGATOR

PURPOSE

The purpose of this research project is to study the fate of pesticides and fertilizers applied to turfgrass in an environment which closely resembles golf course conditions. The goal is to obtain information on management practices that will result in healthy, high quality turfgrass while minimizing detrimental environmental impacts. The proposed integrated research project has been designed so that all combinations of all treatments can be statistically analyzed. By simultaneously looking at interactions between soils, turfgrasses, irrigation amounts, pesticides, and fertilizers; questions about "best management practices" for turfgrass growth and maintenance will be able to be answered.

OBJECTIVES

1) Compare the leaching characteristics of pesticides and fertilizers applied to two turfgrass treatments.
2) Study the effects of the soil type and irrigation regime on the leaching of pesticides, nitrates and phosphorus.
3) Compare the leaching characteristics of nitrates from different fertilizers.
4) Measure the volatilization rate of pesticides from turfgrasses into the atmosphere as a function of time since application.
5) Monitor the effects of different irrigation regimes, fertilizers, and soil types on the quality of the turfgrass.

PROGRESS

Irrigation

The two irrigation treatments that were initiated on the plots on March 23, 1992 (100% ET_c and 130% ET_c) were continued. ET_c (crop evapotranspiration) is calculated from the following equation:

$$ET_c = (ET_o \times K_c)/(\text{application rate} \times \text{distribution uniformity})$$

ET_o is the reference evapotranspiration rate of 4-6" tall fescue. This information is obtained weekly from a CIMIS (California Irrigation Management Information System) weather station located on the turf plots. K_c is the crop coefficient for the particular crop of interest, in this case turfgrass. Crop coefficients have been determined for cool season (bentgrass) and warm season (bermudagrass) grasses as a result of extensive research at the UCR turf plots over the years. The crop coefficient used in the above equation changes monthly. The irrigation timing is being determined by allowing a 50% moisture depletion in the soil before irrigating to replace the moisture.

Fertilization

Two fertilizer treatments have been established for the plots. The green plots are fertilized at a rate of 1 lb N/1000 ft^2/month, and the fairway plots at a rate of 0.5 lb N/1000 ft^2/month. The two fertilizer sources are urea and sulfur-coated urea (SCU). The SCU applied to the green plots is in the form of miniprills to minimize losses during mowing operations. Fertilizer is applied twice per month to each plot individually to ensure even distribution of the fertilizer. Green plots receive 358.8 g N and fairway plots receive 179.4 g N per application. Fertilizer treatments were initiated on April 17, 1992.

Pesticide Application and Monitoring

Trimec® Bentgrass Formulation (pbi/Gordon Corporation, Kansas City, MO) was applied to all plots in May and August, 1993. The herbicide was applied at a rate of 1.8 oz. and 3.2 oz. per 1000 ft^2 for the green and fairway plots, respectively. Sevin® brand XLR plus (Rhone-Poulenc Ag company) was applied to the plots in August, 1993 at a rate of 6.1 oz. and 10.7 oz. per 1000 ft^2 for the green and fairway plots, respectively.

Twelve of the plots were designated as pesticide plots; these included 4 of the green plots (two of each irrigation treatment) and eight fairway plots (two of each soil-irrigation treatment combination). The pesticide plots have been designated with a "P" on the attached plot map. In the pesticide plots, the drainage is collected from two of the lysimeters. The drainage tubes have been fitted with teflon tubing to avoid pesticide adsorption to the sample collection devices. Soil-water sampling devices have been installed in two of the lysimeters in these plots. One of the devices has a ceramic tip attached to a PVC tube, the other has a porous stainless steel cup attached to a teflon tube. Soil-water samples are collected from each of the lysimeters on a weekly basis. This will allow an assessment of any adsorption of pesticides to the ceramic and PVC materials.

Drainage Water Quality

Samples of drainage water were collected from each of the 36 plots on a weekly basis. Drain volumes are measured and recorded several times per week, allowing a calculation of the mass of N, P, and pesticides leaching from the plots. The average volume of drainage water from the plots is shown in Figures 1-3.

Drain samples are analyzed to determine nitrate-N and phosphate-P concentrations. The average weekly masses of nitrate-N leached from the green plots receiving 100%ETc and 130%ETc are shown in Figures 4 and 5, respectively. The average weekly masses of nitrate-N leached from the fairway loamy sand plots receiving urea and the sandy loam plots receiving SCU are shown in Figures 6 and 7, respectively. Note that the y-axis on Figures 4-7 are on a logarithmic scale to accommodate the extreme differences in mass of N from week to week.

The drain samples from the pesticide plots were also analyzed for carbaryl and 2,4-D. Pesticide analyses were performed using an ELISA (enzyme-linked immunosorbent assay) technique (RaPID Assays, Ohmicron, Newtown, PA) that allows us to detect pesticides at very low levels. The detection limit using this technique is 0.7 ppb for 2,4-D and 0.25 ppb for carbaryl. Data from the treatments that should represent the extremes in leaching behavior (sandy loam, 100%ETc and green sand, 130%ETc) are shown. Weekly concentrations of 2,4-D and carbaryl measured in the drain samples are shown in Figures 8 and 9, respectively.

Pesticide Volatilization

The volatilization of 2,4-D and carbaryl was measured during an experiment conducted in August, 1993. Six of the pesticide plots, designated with a "V" on the plot map were used for this experiment. Immediately after pesticide application, a volatilization flux chamber was placed directly on the turf in each of the designated plots. The chambers measure approximately 18"x18" and have a volume of approximately 40 liters. The air above the surface of the turfgrass is pulled out of the chamber at a very low rate (approximately 10 liters/minute). As it is removed, the air is passed through a polyurethane foam plug (PUF) that adsorbs any pesticides present in the air. Air from outside the chamber is drawn into the chamber to replace the air that is removed. Any pesticides in the outside air are removed as the air is drawn into the chamber. The PUFs were replaced every four hours. The position of the flux chamber was rotated between two marked spots on the plots to minimize damage to the turfgrass. The pesticides were extracted from the PUFs using organic solvents. The volatilization experiment was conducted for 7 days. The data from this experiment are in the process of being analyzed.

Data Summary

All data collected during this research project will be summarized and discussed in the final project report. This will include: 1) a statistical analysis of the effects of the different treatments (i.e., soil type, fertilizer type, irrigation amount) on the mass of nitrate, phosphate, and pesticides leached; 2) the percent of applied pesticides that volatilized into the atmosphere; 3) the effects of the treatments on the quality of the turfgrass; 4) an analysis of the differences between concentrations measured in soil-water samples vs. drainage water samples; and 5) an analysis of the effects of using stainless steel-teflon vs. ceramic-PVC sampling devices on pesticide results.

USGA TURF PLOT--UC RIVERSIDE

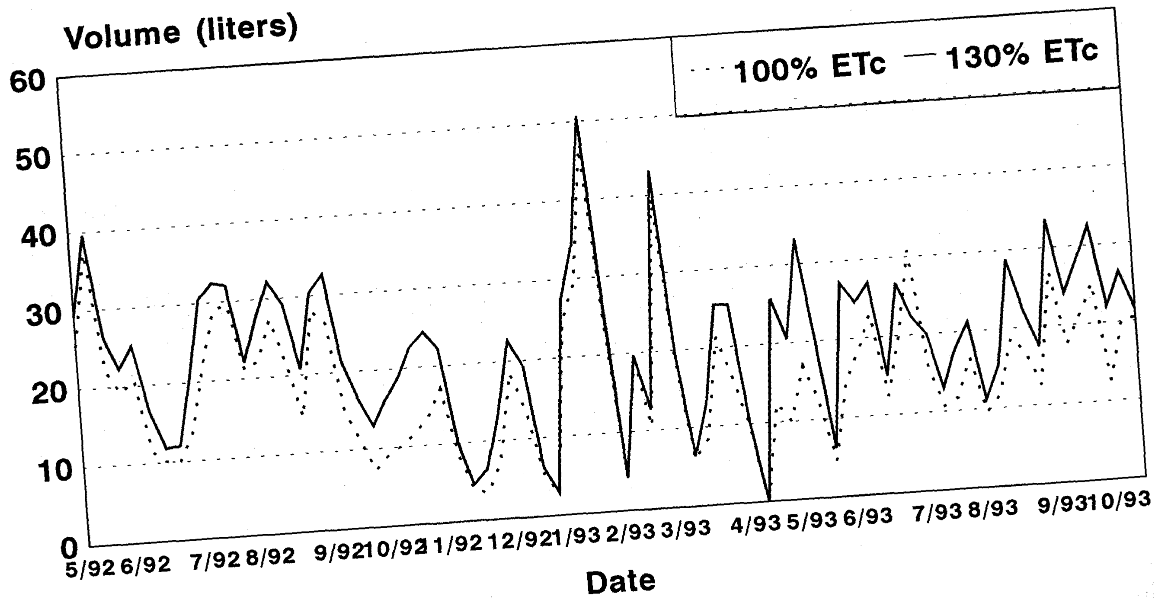
Rep 1	01G F1 I1 S3	04G F2 I1 S3	07G F2 I2 S3	10G F1 I2 S3
Rep 2	02G F1 I2 S3 P, V	05G F1 I1 S3	08G F2 I1 S3	11G F2 I2 S3 P
Rep 3	03G F2 I2 S3	06G F1 I1 S3 P,V	09G F1 I2 S3	12G F2 I1 S3 P

Rep 1	01F F1 I1 S1 P,V	04F F1 I1 S2	07F F2 I2 S1 P	10F F1 I2 S1	13F F2 I1 S2	16F F2 I2 S2	19F F1 I2 S2	22F F2 I1 S1
Rep 2	02F F1 I2 S1	05F F2 I1 S2 P	08F F2 I2 S2 P	11F F1 I1 S2 P,V	14F F1 I1 S1	17F F2 I1 S1 P	20F F1 I2 S2 P,V	23F F2 I2 S1
Rep 3	03F F1 I2 S2	06F F1 I1 S2	09F F2 I1 S2	12F F1 I2 S1 P,V	15F F2 I2 S2	18F F1 I1 S1	21F F2 I1 S1	24F F2 I2 S1

00126

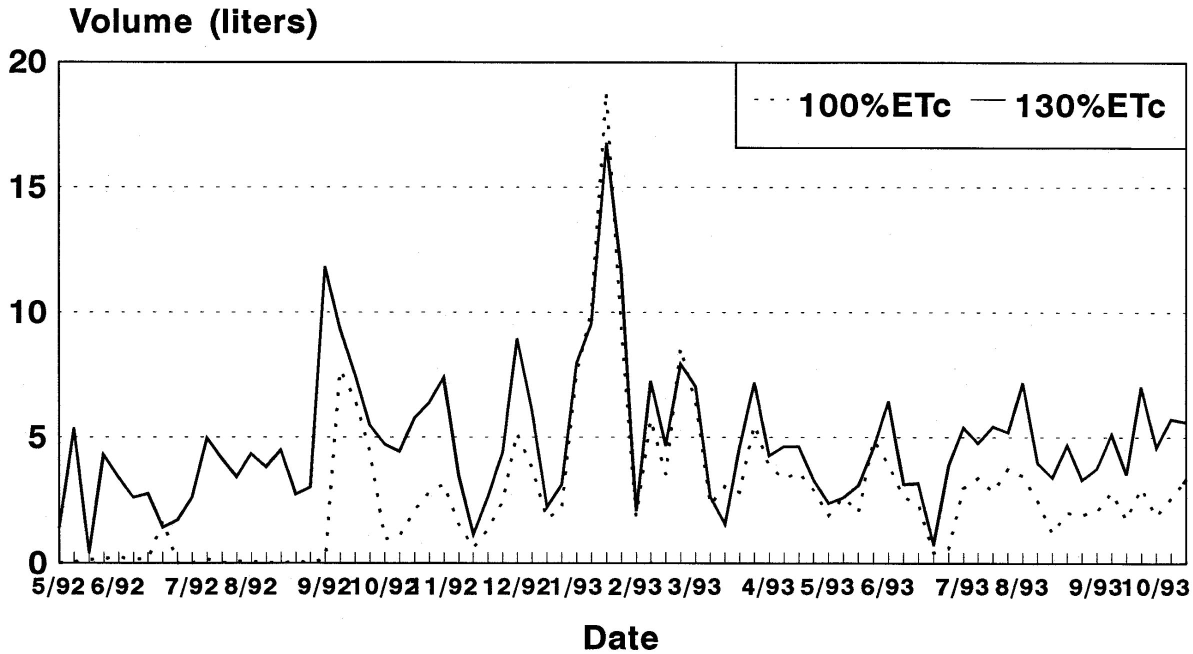
Key: F1 = SCU, F2 = urea
I1 = 100% ET_c, I2 = 130% ET_c
S1 = loamy sand, S2 = sandy loam, S3 = green sand
P = pesticide plot; V = volatilization plot

Figure 1. Drain Volumes
Green Plots



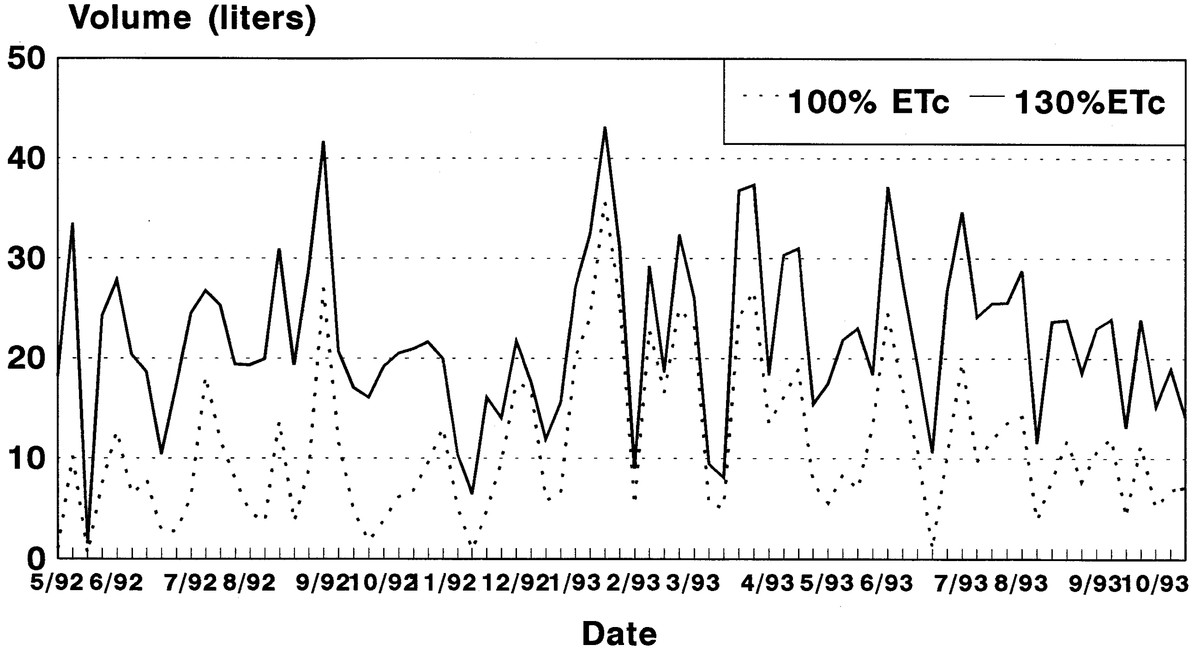
00127

Figure 2. Drain Volumes
Fairway Sandy Loam Plots



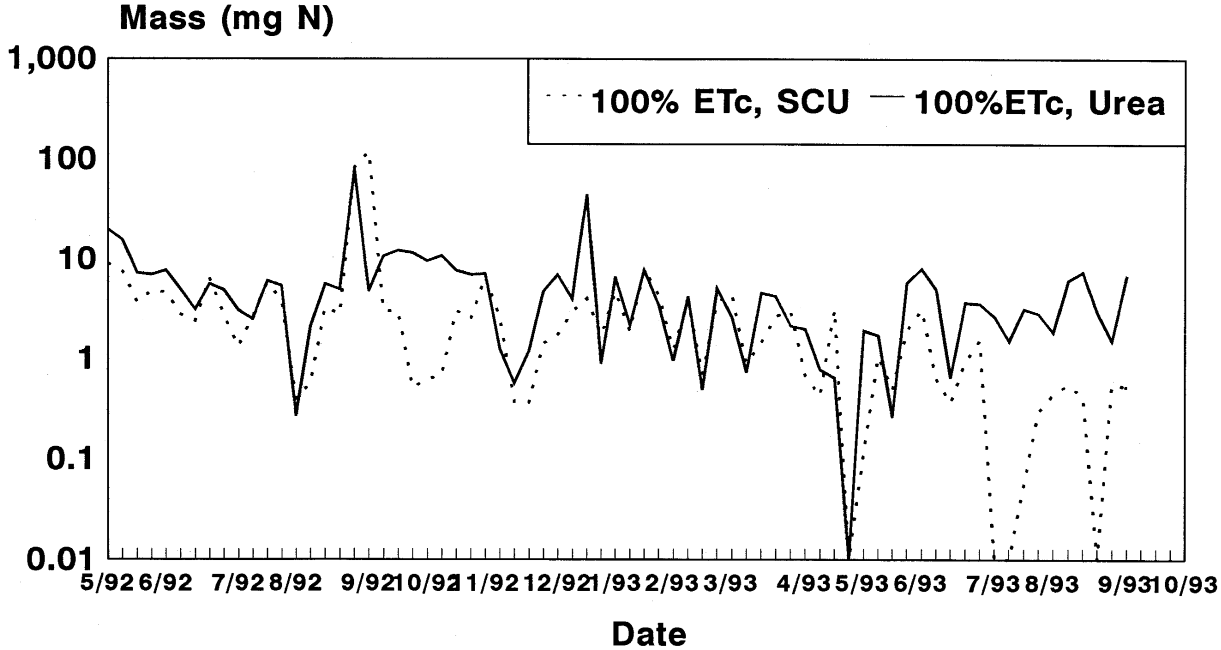
00128

Figure 3. Drain Volumes
Fairway Loamy Sand Plots



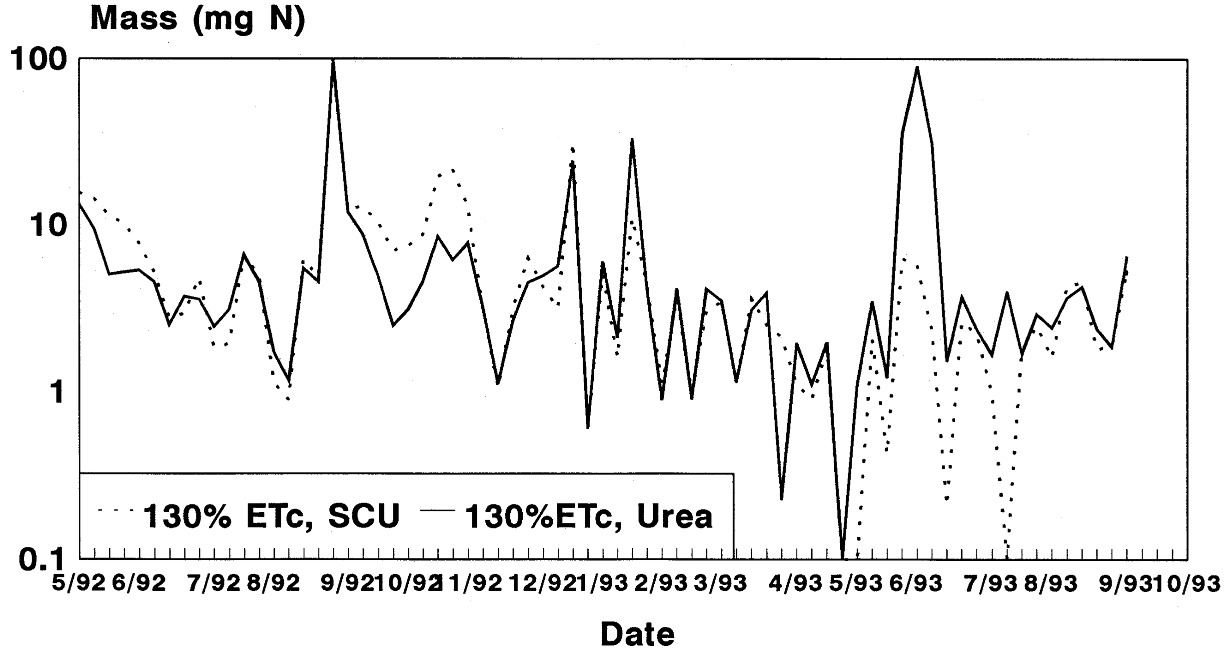
00129

Figure 4. Nitrate Leaching
Green Plots



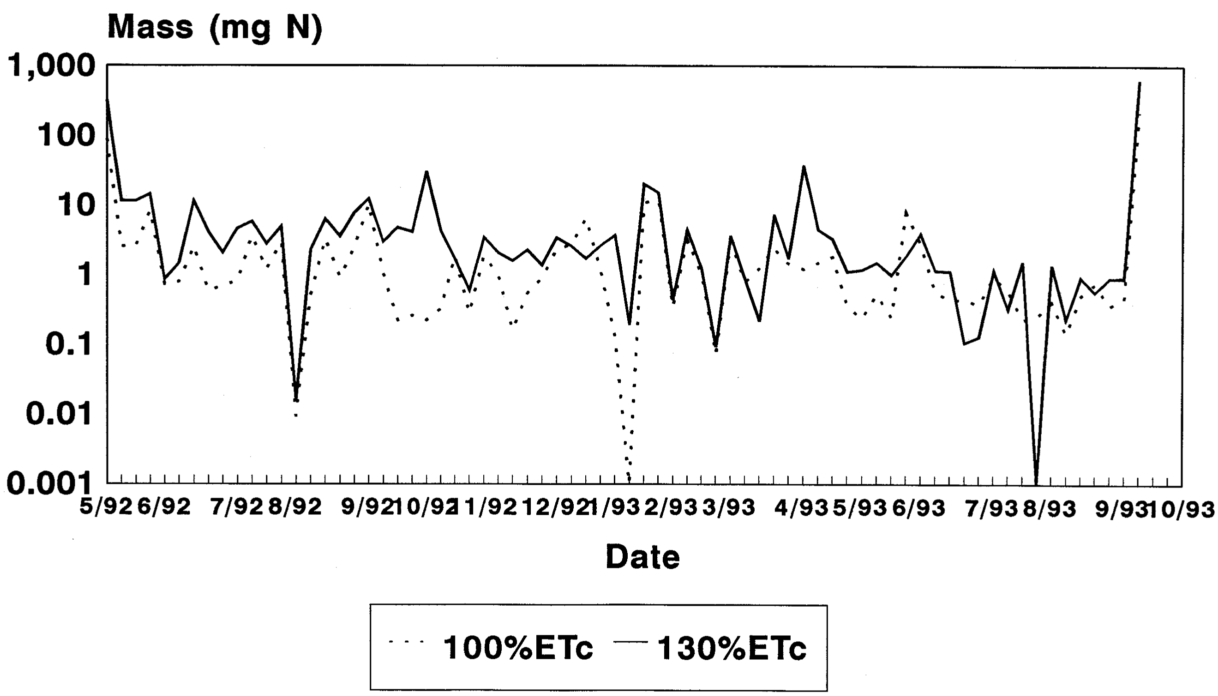
00130

Figure 5. Nitrate Leaching
Green Plots



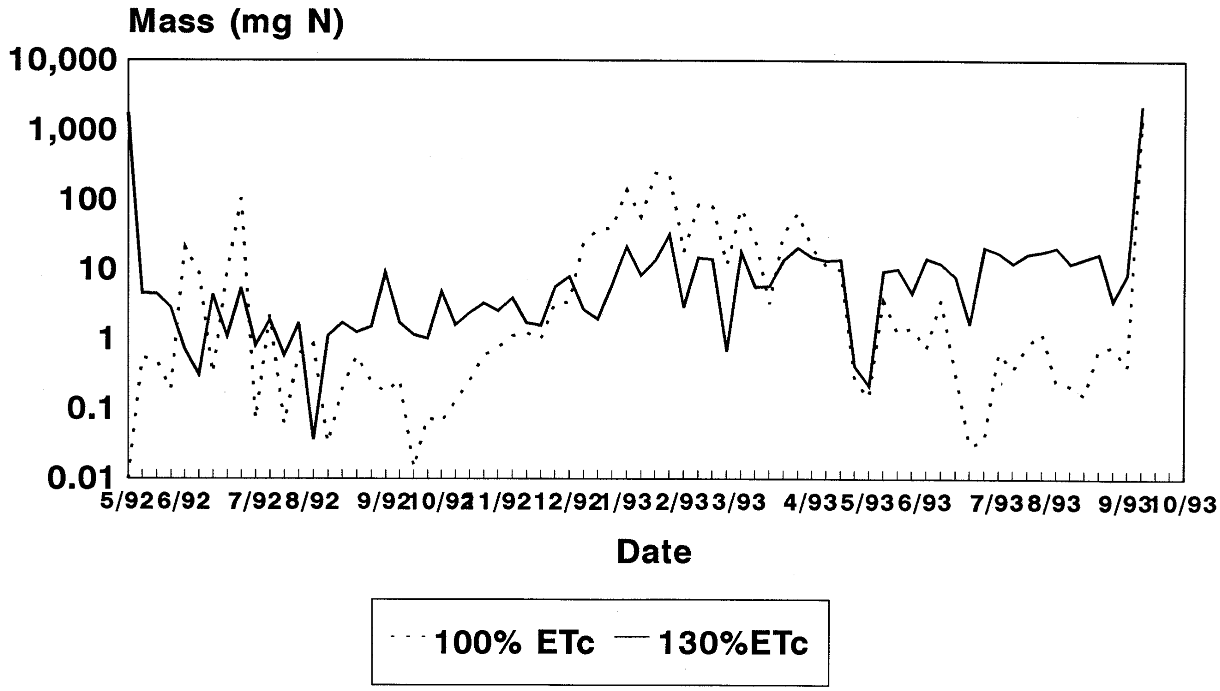
00131

Figure 6. Nitrate Leached Fairway Loamy Sand Plots (Urea)



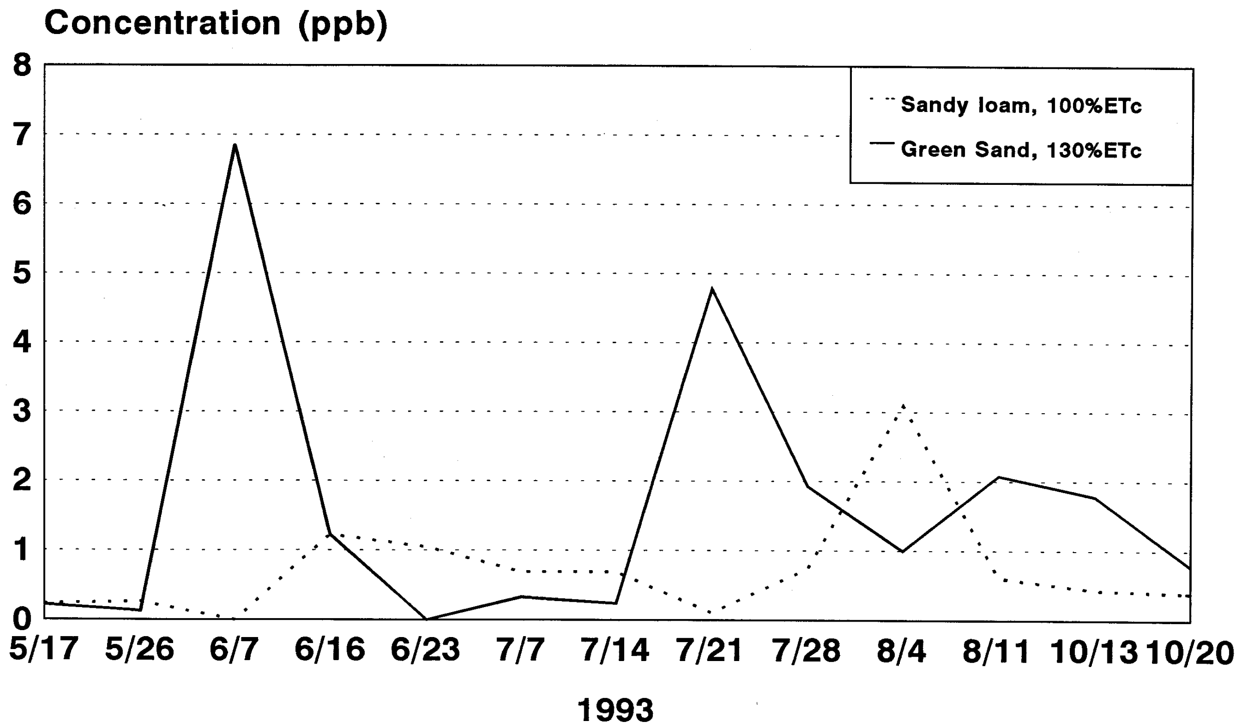
00132

Figure 7. Nitrate Leached Fairway Sandy Loam Plots (SCU)



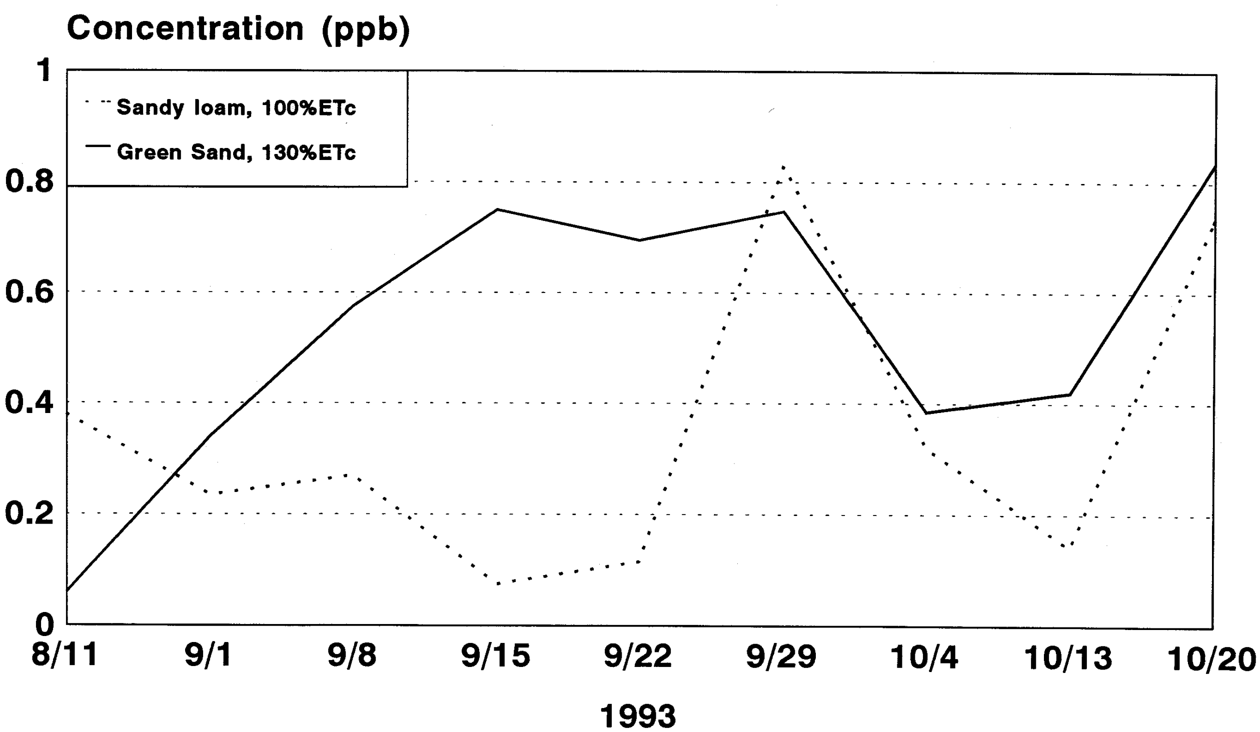
00133

Figure 8. Leaching of 2,4-D



00134

Figure 9. Leaching of Carbaryl



00135

THE FATE OF PESTICIDES AND FERTILIZERS IN A TURFGRASS ENVIRONMENT

M.V. Yates, Principal Investigator, Department of Soil & Environmental Sciences, University of California, Riverside.

The purpose of this research project is to study the fate of pesticides and fertilizers applied to turfgrass in an environment which closely resembles golf course conditions. The goal is to obtain information on management practices that will result in healthy, high quality turfgrass while minimizing detrimental environmental impacts. The proposed integrated research project has been designed so that all combinations of all treatments can be statistically analyzed. By simultaneously looking at interactions between soils, turfgrasses, irrigation amounts, pesticides, and fertilizers; questions about "best management practices" for turfgrass growth and maintenance will be able to be answered.

The specific objectives of the project are: 1) Compare the leaching characteristics of pesticides and fertilizers applied to two turfgrass treatments; 2) Study the effects of the soil type and irrigation regime on the leaching of pesticides, nitrates and phosphorus; 3) Compare the leaching and volatilization characteristics of nitrates from different fertilizers; 4) Measure the volatilization rate of pesticides from turfgrasses into the atmosphere as a function of time since application; 5) Monitor the effects of different irrigation regimes, fertilizers, and soil types on the quality of the turfgrass.

The site consists of 36 plots, each of which measures 12' x 12'. The fairway area consists of 24 plots, 12 each of two different soil types that have been located randomly in the fairway area. A lysimeter assembly, consisting of 5 metal cylinders was placed in the center of each of the 36 plots. The lysimeter assembly and drain system has been fabricated using only metal so that there is no potential for pesticide adsorption. All turfgrass-soil type combinations are subjected to two irrigation regimes: 100% crop evapotranspiration (ET_c) and 130% ET_c. Two different fertilizers are used on the plots. One-half of the plots are fertilized with a urea, the other half are fertilized with sulfur-coated urea. The green and fairway plots receive 1 and 0.5 lb N per 1000 ft^2 per month.

Weekly samples are collected from the drains from and soil-water samplers in each of the 36 plots and analyzed to determine the concentrations of nitrate-N, phosphate-P, 2,4-D, and carbaryl. The volume of water draining from each plot is measured to enable a calculation of the mass of pesticides and nutrients leached. The volatilization of two pesticides, carbaryl and 2,4-D from the turfgrass surface into the air was also determined using volatilization flux chambers.

The final report on this project will include: 1) a statistical analysis of the effects of the different treatments (i.e., soil type, fertilizer type, irrigation amount) on the mass of nitrate, phosphate, and pesticides leached; 2) the percent of applied pesticides that volatilized into the atmosphere; 3) the effects of the treatments on the quality of the turfgrass; 4) an analysis of the differences between concentrations measured in soil-water samples vs. drainage water samples; and 5) an analysis of the effects of using stainless steel-teflon vs. ceramic-PVC sampling devices on pesticide results.

PESTICIDE AND FERTILIZER FATE IN TURFGRASSES MANAGED UNDER GOLF COURSE CONDITIONS IN THE MIDWESTERN REGION

Executive Summary

Research addressing fertilizer and pesticide fate in turfgrass managed under golf course conditions is in progress at the University of Nebraska and Iowa State University. The research objective is to determine the influence of pesticide, fertilizer and irrigation management practices on the persistence and mobility of nitrogen and selected pesticides in turfgrass systems.

Research sites with established stands of Kentucky Bluegrass include the John Seaton Anderson Turfgrass Research Facility at the Agricultural Research and Development Center near Mead, Nebraska and at the Iowa State University (Ames) Horticulture Farm. Experimental areas were treated with recommended rates of urea fertilizer, TRIMEC (2,4-D, mecoprop, and dicamba) and pendimethalin herbicides, isazophos and chlorpyrifos insecticides, and the fungicide metalaxyl in 1991 and 1992. Turf/soil cores periodically were excavated to 60 cm depth and sectioned into verdure, thatch, and multiple soil depths for residue analysis.

While the verdure contained high concentrations of the pesticides immediately after application, irrigation, rainfall and clipping reduced the amount of pesticide recovered from the plant material with time. The thatch layer was highly retentive of the pesticide residues, and generally contained the greatest amount of residue throughout the monitoring period. Relatively little chlorpyrifos, and very low amounts of pendimethalin moved through the thatch layer into the underlying soil. Isazofos residues were lower in soil at the Iowa site where more thatch was present. Pesticide concentrations were much lower in soil than in thatch at all sampling times during the study. Soil concentrations were highly skewed in the profile, and, with the exception of metalaxyl, generally were highest at the 0-5 and 5-10 cm depths throughout the monitoring period. Metalaxyl concentrations in soil were much higher than those of isazofos, which generally were higher than those of chlorpyrifos and pendimethalin, and metalaxyl moved through the entire soil column. The lack of increase in isazofos in soil after 1 DAT suggested rapid degradation in soil in addition to limited mobility. Little chlorpyrifos or pendimethalin was found below a depth of 5 cm, and concentrations remained slightly higher in the top 2.5 cm throughout the sampling period. There was a trend toward higher metalaxyl, chlorpyrifos and pendimethalin concentrations in the Nebraska soil. Greater pesticide residue availability in the Iowa soil could result in greater plant uptake and higher verdure concentrations of metalaxyl and possibly chlorpyrifos. However, pendimethalin has very limited translocation in plants, suggesting that less of the herbicide was displaced from the verdure after application due to differences in the timing and amount of irrigation and rainfall received at the two sites. Pesticide dissipation in the turf/soil profile appeared to fit the kinetics of first order or 3/2 order decay, with an exponential or hyperbolic loss of pesticide residue with time. Based on an R^2 value ≥ 0.81, first-order decay estimated DT_{50} values of 14, 14, 15, and 19 days for isazofos, chlorpyrifos, pendimethalin, and metalaxyl in the turf/soil profile. All four pesticides appeared to degrade more rapidly in the turfgrass environment than typically reported for other agronomic crop systems. Variability in pesticide residue concentrations for each soil depth among the turf/soil cores was consistent with similar studies in non-turf systems, indicating non-uniform and preferential pathways of movement in soil.