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Further Evaluation and Modeling of Pesticide Partitioning Data from the UCR Putting Green Lysimeters

University of California, Riverside

Laosheng Wu
Robert Green
Marylynn Yates

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Objectives:

1. *Measure the site-specific critical water flow and pesticide transformation;*
2. *Simulate pesticide fate using the measured hydraulic properties and pesticide parameters as model inputs; compare the model outcomes of the simulations with measured data.*
3. *Based on objectives 1 and 2, summarize the modeling predictions and measurements, produce peer-reviewed journal article(s) and a summary report.*

Undisturbed soil core samples and bulk soil samples were collected in November 1999. Core samples were taken from surface and subsoil layers and bulk samples were taken from thatch, mat, and subsoil layers. Bulk density, water retention characteristics, and saturated hydraulic conductivity were measured from the undisturbed cores. No significant difference was observed in bulk density and saturated hydraulic conductivity between the surface and bottom layers. Difference was observed in water retention characteristics between the surface and bottom layers.

A pesticide degradation experiment was conducted in the laboratory using the bench equilibrium method. Results showed that the four pesticides could be divided into two groups with respect to their degradation rates. The half-life time of dylox and chlorothalonil are much shorter than chrorpyrifos and metalaxyl. It is interesting to note that dylox degrades fastest in the subsoil layer, while chlorothalonil degrades fastest in the thatch layer. The laboratory study showed that the half-life of chrorpyrifos and metalaxyl are relatively long, which might not be applicable to the field conditions, presumably due to their difference in microbial activity.

Two models to be used for this study are CHAIN_2D and PRZM-3. The two models have been successfully installed in our computer. Runs have been conducted to test the models and their sensitivity to the input parameters. Input data have been compiled using the California Irrigation Management Information System (CIMIS) data at Riverside and soil information measured in the laboratory. A literature review showed that the degradation rate varies widely in different studies. Our next step is use the maximum, minimum, and average values reported in the literatures to conduct simulation. The simulated results will be compared to field measured data to identify the parameters most suitable for the Riverside conditions.

One of the major tasks of this study is to analyze and publish the data in a peer-reviewed technical journal. We have finished literature review, materials and methods, and most of the tables and figures for two manuscripts. We expect to submit the manuscripts to Journal of Environmental Quality in next spring.

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During 1992 to 1997, two research projects, funded by the USGA, have been carried out to study the fate of four pesticides in the turfgrass environment at the Turf Research Facility, University of California, Riverside. In the first project, results showed that less than 1% of the applied carbaryl was lost by volatilization and leaching from the putting green plots; and approximately 1% of the 2,4-D was volatilized into the atmosphere, and approximately 5% leached through the putting-green soil. In both cases, 90% of the applied compounds was not accounted for. The objective of the second project was to perform partitioning analysis of the pesticides to enable a mass balance determination. Preliminary modeling results, using literature information as inputs, showed that the trend of model predictions generally agreed with measured pesticide concentrations in the soil and in the leachate for the tested pesticides. However, further modeling work is necessary to use site-specific measurements as model inputs to improve the predictions.

Objectives:

- Measure the site-specific critical water flow and pesticide transformation parameters, specifically, soil-water retention, saturated hydraulic conductivity, and pesticide degradation and adsorption values;
- Simulate pesticide fate using the measured hydraulic properties and pesticide parameters as model inputs; compare the outcomes of the simulations from the two models with measured data.
- Based on objectives 1 and 2, summarize the modeling predictions and measurements, produce peer-reviewed journal article(s) and a summary report in a form that can be used for public education purposes and distributed among the golf industry.

Soil Sampling

Undisturbed soil core samples and bulk soil samples were collected in November 1999. Core samples were taken from two layers: surface (2 to 8 cm deep) and bottom (10 to 16 cm deep). The core samples were taken from 4 plots (reps). Bulk samples were taken from each of the 4 plots at three layers: Thatch (0 to 2 cm deep), mat (2 to 5 cm deep), and soil (5 to 10 cm deep), and they were pooled by depth.

Soil Physical and Hydraulic Properties

Bulk density, water retention characteristics, and saturated hydraulic conductivity were measured from the undisturbed cores. No significant difference was observed in bulk density between the surface and bottom layer. Saturated hydraulic conductivity was measured by constant head method. Again, no significant difference was observed between the two layers (Table 1). Water retention (0 to 15 bar) was measured in a tension table (for low suction) and pressure chambers (for high suction). At low suction, the bottom layer has higher volumetric water content than the surface layer. As suction increases, the two layers have very similar water retention characteristics (Fig. 1).

Pesticide Degradation and Adsorption Parameters

A pesticide degradation experiment was conducted in the laboratory using bench equilibrium method. The degradation experiment was replicated three times for each of the pooled samples from the layers. Results showed that the four pesticides in this laboratory study could be divided into two groups with respect to their degradation rates. The half-life time of dylox and chlorothalonil (Figs. 2 and 3) are much shorter than chrorpyrifos and metalaxyl (Figs. 4 and 5) are. It is interesting to note that dylox degrades fastest in the soil layer, while chlorothalonil degrades fastest in the thatch layer. The laboratory study showed that the half-life of chrorpyrifos and metalaxyl are relatively long. Our next step is to use the modeling approach to inversely estimate the degradation rate of the four pesticides in the field conditions.

Due to the high organic matter content of the samples and fast degradation of the pesticides, determination of adsorption coefficients of these pesticides using the 24-h shaking method will not result in meaningful data. The adsorption coefficients for the model input will be estimated from the K_{oc} values of the pesticides and fraction of organic matter measured in the samples.

Modeling Approaches

Two models to be used for this study are CHAIN_2D and PRZM-3. The two models have been successfully installed in our computer. Runs have been conducted to test the models and their sensitivity to the input parameters. Input data have been compiled using the Riverside CIMIS data, soil information measured in the laboratory. Our test simulation showed that when the laboratory measured pesticide parameters for adsorption and degradation were used as inputs, the models generally overestimate leaching. A literature review showed that the degradation rate varies widely in different studies. Our next step is to use the maximum, minimum, and average values reported in the literature to conduct simulation. The simulated results will be compared to field measured data to identify the parameters most suitable for the Riverside conditions.

Manuscript Preparation

One of the major tasks of this study is to analyze the field volatilization, clipping removal, leaching, and residual concentration of the pesticides and publish the data in a peer-reviewed technical journal. We have finished literature review, materials and methods, and most of the tables and figures for two manuscripts (except for the modeling section). As an example, Fig. 6 shows the chlorothalonil and metalaxyl volatilization as a function of time, as well as the cumulative mass loss of volatilization and fitted curve as a function of time. We have completed all similar data analysis for volatilization, clipping removal, leaching, and soil residue of the four pesticides used in this research.

We expect to submit the manuscripts to Journal of Environmental Quality in next spring.

Table 1: Bulk density and saturated hydraulic conductivity (cm/day). K_S statistics are obtained based on log-transformed data.

	n	Bulk density (g/cm^3)	P	K_s, (cm/day)	P
Surface layer	8	1.46	0.19	83.54	0.81
Bottom layer	8	1.44		74.52	
Rep I	4	1.48	0.13	44.54	0.08
Rep II	4	1.45		185.27	
Rep III	4	1.44		51.84	
Rep IV	4	1.44		90.64	

List of Figures

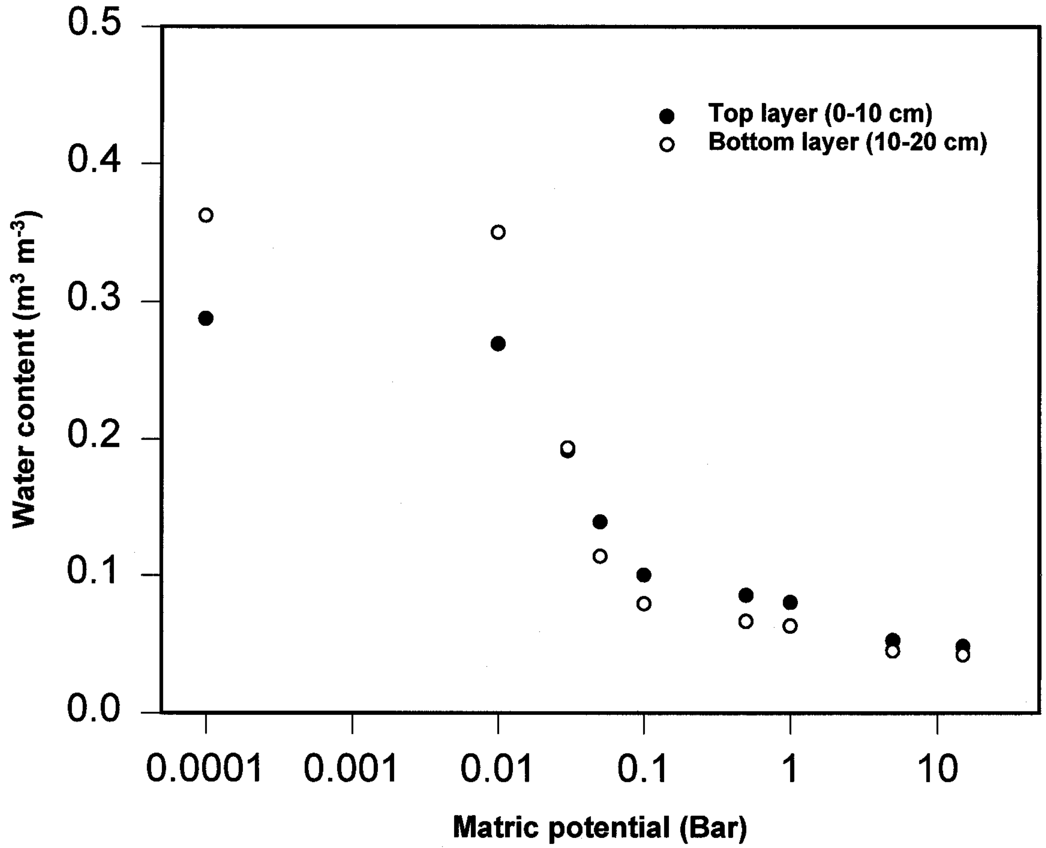

Fig. 1. Water retention characteristics of the top (0-10 cm) and bottom (10-20 cm) layers of the putting green soil at Turf Research Facility, University of California, Riverside.

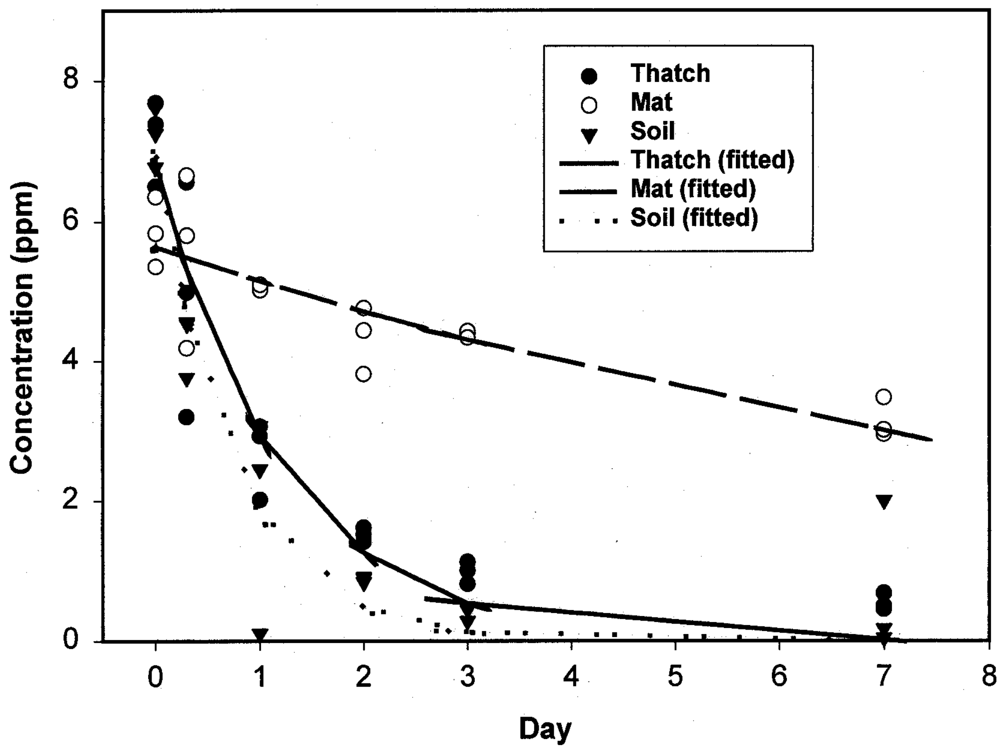

Fig. 2. Degradation (concentration as a function of time) of dylox under laboratory conditions in thatch, mat, and subsoil.

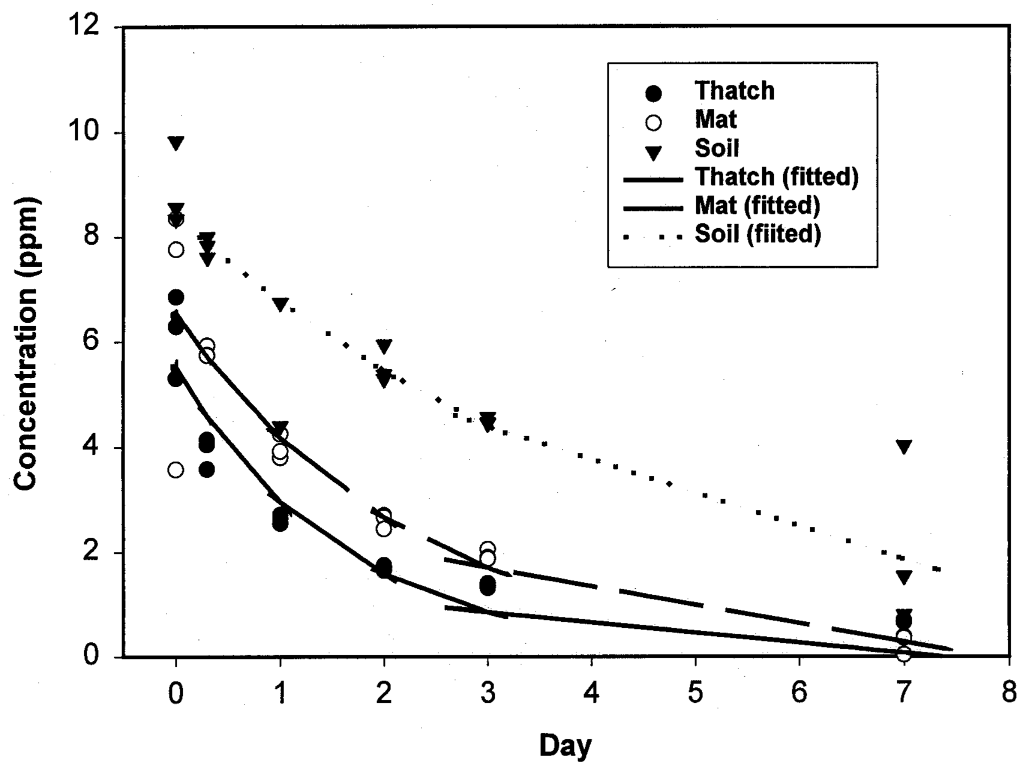

Fig. 3. Degradation (concentration as a function of time) of chlorothalonil under laboratory conditions in thatch, mat, and subsoil.

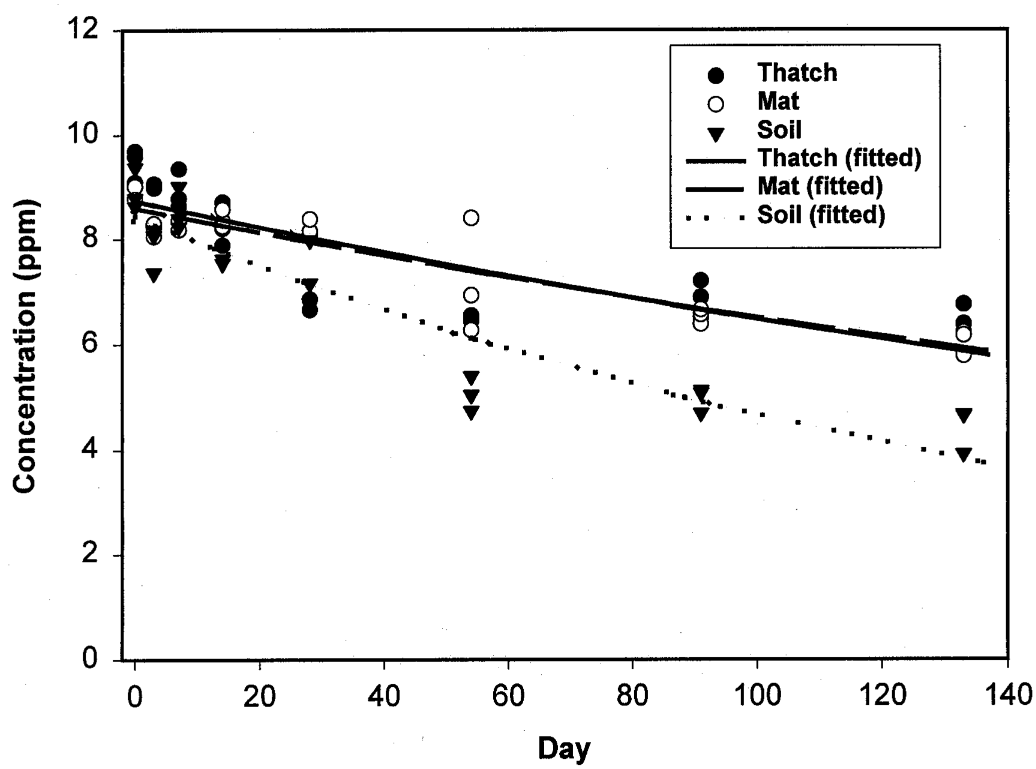

Fig. 4. Degradation (concentration as a function of time) of chlorpyrifos under laboratory conditions in thatch, mat, and subsoil.

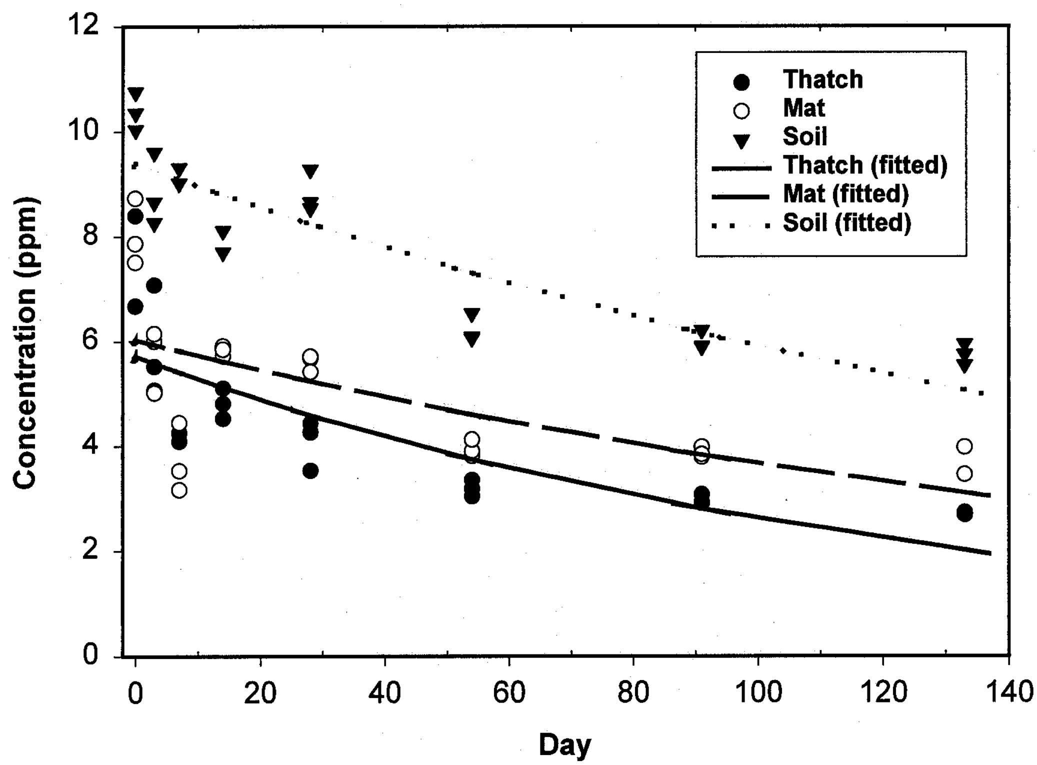

Fig. 5. Degradation (concentration as a function of time) of matalaxyl under laboratory conditions in thatch, mat, and subsoil.

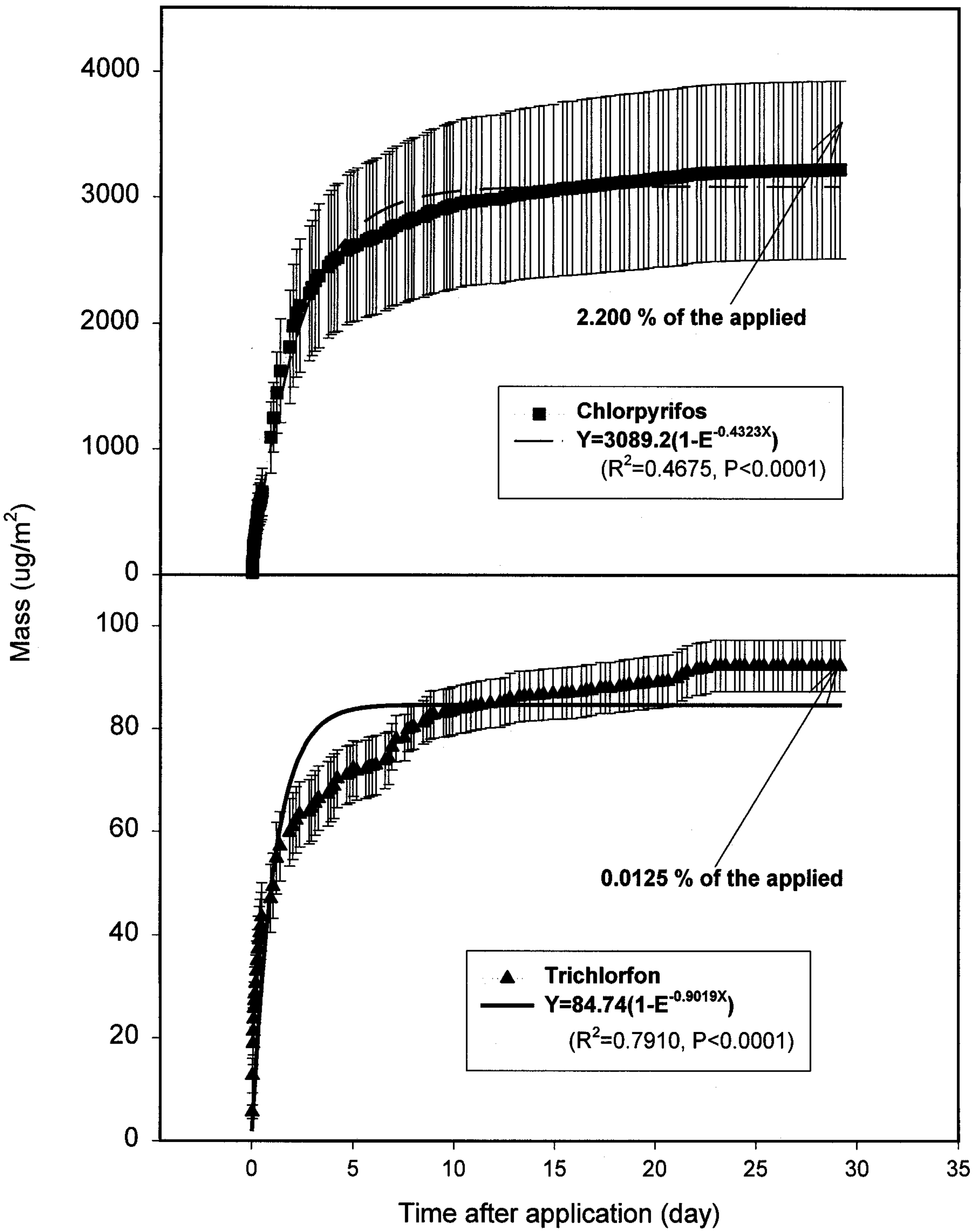

Fig. 6. Cumulative volatilization loss of chlorpyrifos and trichlorfon in 1996 (Experiment 2).