**Session C: Turf and Ornamentals**
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# Landscape Herbicides: What Happens after Application?

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## Abstract

Recent monitoring studies show that the majority of urban streams in the U.S. are contaminated by pesticides, and the contamination is primarily a result of urban runoff. Implementation of risk-reduction measures, however, is hampered by the lack of an understanding of the interaction of urban landscape planting systems with pesticide behavior. We investigated the effect of landscape plantings on the persistence of two commonly used herbicides, 2,4-D and dicamba. The herbicides exhibited greatly different persistence in the different planting systems. In the 0-10 cm surface layer, the half-life of 2,4-D was 31 days in soil under trees, which was about 20 times longer than in soil planted with turfgrass (1.6 days). The half-life of dicamba was much longer in soil under a tree canopy (149 days) than in a mulched soil (7.9 days).

This study suggests that landscape planting practices can modify the chemical and biological activities of soil, which in turn may affect pesticide persistence and hence the runoff potential. Such information may be used for developing landscape systems that are resistant to pesticide runoff, thus alleviating water quality impact by pesticides used by homeowners.

## Introduction

In the United States home lawns occupy 20-25 million acres. The total area of environmental horticulture in California was estimated to be 1.4 million acres. Residential landscapes serve as the direct target of pesticides applied to home lawns and gardens and the first-tier buffer for pesticides applied to structures. However, pesticide use in residential settings has apparently led to contamination of urban streams. For example, surveys by the U.S. Geological Survey (USGS) have shown that 99% of the tested urban streams contain at least one pesticide, with 70% containing 5 or more pesticides (*1*). The presence of pesticides at trace levels may cause short or long-term impairments to aquatic ecosystems, such as toxicity to aquatic organisms (*2*). Runoff of pesticides resulted in the establishment of diazinon and chlorpyrifos TMDLs for San Diego Creek in Orange County, CA (*3*).

Currently little is known about the behavior of pesticides in the heterogeneous residential landscapes. Because pesticide movement in urban settings is driven by stormflow, the runoff potential is related to pesticide persistence. Planting practices can modify a soil's chemical and biological properties. The objectives of this study were to evaluate the interaction of planting with soil chemical and microbial reactivity, and the effect on the persistence of two common herbicides, 2.4-D and dicamba. The results from this study may be used for identifying high-risk landscape systems, and for developing practices to reduce pesticide runoff to urban streams.

**Experimental Procedures**

***Soils:*** Soil samples were collected from a field located at the Agricultural Experiment Station on the campus of University of California in Riverside, CA. The field consisted of plots with different planting covers that were established in 1995. The soil was a Hanford fine sandy loam. The planting systems included Bradford pear tree, "shortcut" tall fescue grass, mulches (chipped tree branches and leaves), and a low growing ground cover. Soil was collected from the 0-10 cm layer using a hand auger. Chemical and physical properties of these soils are shown in **Table 1**.

**Table 1. Selected properties of soils for the various landscape systems**

| Soil | OM (%) | Clay (%) | Silt (%) | Sand (%) | CEC (meg/100g) | pH |
|---|---|---|---|---|---|---|
| | Surface soil (0-10 cm) | | | | | |
| **Tree** | 0.35 | 10 | 24 | 66 | 6.3 | 5.4 |
| **Grass** | 0.82 | 9 | 24 | 67 | 7.7 | 6.7 |
| **Ground cover** | 1.16 | 8 | 26 | 66 | 8.4 | 6.3 |
| **Mulch** | 1.95 | 8 | 24 | 68 | 10.7 | 6.9 |

***Degradation Experiments:*** Degradation of 2,4-D and dicamba in the different landscape soils was determined by incubating spiked soil samples at 20ºC. The initial soil water content was 8% (w/w). The initial herbicide concentration was 2.0 ppm. At different times after treatment, replicate samples were removed and extracted with methanol. Analysis of 2,4-D and dicamba was carried out by HPLC.

***Enumeration of Herbicide Degraders:*** In a separate experiment, the population density of 2,4-D degrading microorganisms was determined in the surface soils using the most probable number (MPN) method (*4*).

**Results and Discussion**

***Effect of Planting on Soil Organic Matter Content:*** The different planting covers over a period of about six years caused significant differences in soil organic matter content (OM) (**Table 1**). While the OM in the soil from the tree plots remained essentially unchanged, soils from the turfgrass, ground cover, and mulch plots showed 170, 280, and 550% increases over the original level, respectively. Because soil organic matter plays a critical role in soil microbial ecology and hence in the degradation of many contaminants, it may be expected that 2,4-D and dicamba would be degraded at different rates in the different soils.

***2,4-D Persistence:*** Significantly different degradation patterns were observed among the different soils (**Table 2**). The most rapid degradation occurred in the turfgrass soil, the half-life of 2,4-D was only 1.6 days (d). The half-life in the ground cover (3.9 d) or mulched soil (3.7 d) was slightly longer. The half-life of 2,4-D in the tree soil, at 30 d, was the longest among all the soils. The persistence of 2,4-D therefore followed an order of tree soil > ground cover soil ≈ mulch soil > turfgrass soil. It may be envisioned that if a rain storm occurred following 2,4-D treatment, the potential for the herbicide to move in storm runoff would increase in the order of turfgrass soil < mulch soil ≈ ground cover soil < tree soil.

**Table 2. Rate constants and half-lives of 2,4-D in various landscape soils**

| **Soil** | **k (day$^{-1}$)** | **$T_{1/2}$ (day)** | **R** |
|---|---|---|---|
| | **Surface (0-10 cm)** | | |
| **Tree** | 0.0226 | 30.7 | 0.97 |
| **Grass** | 0.4256 | 1.6 | 0.97 |
| **Mulch** | 0.1851 | 3.7 | 0.96 |
| **Ground cover** | 0.1798 | 3.9 | 0.99 |

- *Mitigation implication* 1: With its large biomass and dense, fibrous root system and its ability to quickly degrade 2,4-D, turfgrass may likely act as a "filter" for 2,4-D and similar pesticides. Grassed strips may therefore be placed on the border of residential landscapes to reduce pesticide runoff.
- *Mitigation implication 2:* Conversely, 2,4-D applied to exposed soil surfaces such as in areas around trees or bushes may be highly susceptible to runoff, and pesticide application in these areas should be avoided when possible.

***Dicamba Persistence:*** In the surface soils, the fastest degradation occurred in the mulched soil, which was followed by the ground cover soil and then the turfgrass soil (**Table 3**). The half-life of dicamba in the turfgrass, mulch and ground cover soils ranged from 7.9 to 19.6 d, which was much longer than that for 2,4-D in the same soils (1.6-3.9 d). The overall ranking of dicamba persistence was tree soil > turfgrass soil > ground cover soil > mulch soil. This order was different from that for 2,4-D, indicating that there were different predominant factors in the degradation of 2,4-D and dicamba in the landscape soils.

**Table 3. Rate constants and half-lives of dicamba in various landscape soils**

| **Soil** | **K (day$^{-1}$)** | **$T_{1/2}$ (day)** | **R** |
|---|---|---|---|
| | **Surface (0-10 cm)** | | |
| **Tree** | 0.0047 | 147 | 0.95 |
| **Grass** | 0.0354 | 19.6 | 0.99 |
| **Mulch** | 0.0873 | 7.9 | 0.98 |
| **Ground cover** | 0.0620 | 11.2 | 0.98 |

- *Mitigation implication 3:* The much longer persistence in the tree soil suggests again that dicamba applied on exposed soil such as in the area around trees or bushes may represent an increased runoff risk and such applications should be discouraged.

- *Mitigation implication 4:* The overall longer persistence of dicamba than 2,4-D implies that different pesticides may have different runoff risks. The use of persistent products should be reduced or avoided during the raining season when surface runoff is more frequent.

***Role of Soil Chemical and Microbial Reactivity:*** Excellent correlation was found between the degradation rate of dicamba and soil OM (R = 0.98). This dependence suggests that the different plant covers altered soil OM and hence the degradability of dicamba. The population of 2,4-D degrading microorganisms was estimated to be 2,300, 230,000, 49,000, and 13,000 cells $g^{-1}$ soil. Regression analysis showed that there was a linear relationship between the number of 2,4-D degraders in the soil and the degradation rate constant k ($d^{-1}$) (R = 0.94). This suggests that the different plant practices played a selective role in soil microbial ecology, which led to the different degradability of 2,4-D.

## Conclusions

Different planting types or practices drastically modified soil chemical and microbial properties. These changes consequently caused the landscaped soils to degrade these herbicides at different rates. Of all the landscape systems tested, herbicide persistence was consistently prolonged in the soil around trees that was low in both organic matter content and herbicide-degraders. Therefore, high runoff risks may be expected in such landscape systems.

The knowledge of high or low-risk planting systems or practices may be used by city planners, developers, landscape architects, and professional landscapers for designing landscapes that are resistant to pesticide runoff. The same information may be also used for education of the general public (e.g., homeowners) that may lead to reduced or guided pesticide use in residential landscapes.

## References


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