

Effects of Landscape Variability on the Rate and Maximum 2,4-D Mineralization

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Objective

To quantify the spatial distribution of soil properties in a landscape and assess their impact on the rate and maximum amount of 2,4-D mineralization.

Introduction

The herbicide 2,4-D [2,4-(dichlorophenoxy) acetic acid] (Fig. 1) is the most widely used pesticide in Canada for the post-emergent control of broadleaf weeds. Accurate information on 2,4-D mineralization is a critical component in maintaining environmental integrity within the Canadian agricultural ecosystem. The heterogeneous nature of agricultural fields necessitates further investigation into the behavior of 2,4-D in agricultural soils in which the physical, chemical, and agrometeorological conditions vary spatially. Physical and chemical properties of soil, soil organic matter, moisture, temperature, and pH vary with respect to slope position, and thus are integral components in modeling the behavior of 2,4-D in a topographically diverse landscape.

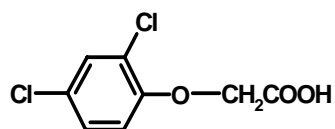


Figure 1. 2,4-D Molecule.

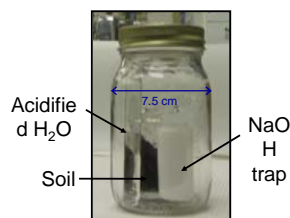


Figure 2. Microcosm setup.

Materials and Methods

Mineralization was assessed in laboratory microcosm incubations (Fig. 2), using (¹⁴C)-labeled 2,4-D. A 2.5 km² sampling area was set up in a field near Deerwood, Manitoba, Canada and 100 soil samples (Ap-horizon) were obtained in October 2002 (Fig. 3).

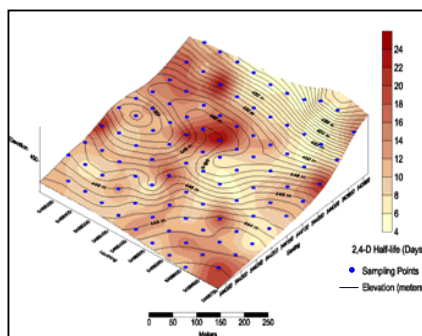


Figure 3. Topography, sampling points, and 2,4-D half-life.

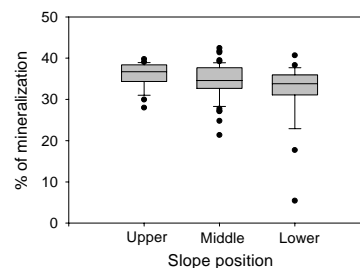


Figure 4. Percent of mineralization as affected by slope position, 130 days after application.

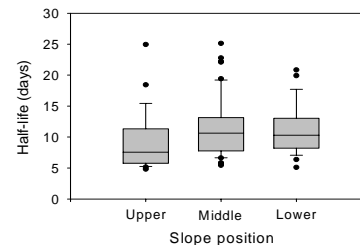


Figure 5. Half-life (days) as affected by slope position.

Results and Discussion

Herbicide mineralization (¹⁴CO₂ production) was variable across the landscape (Fig. 4). At 130 days after herbicide application, the minimum and maximum total mineralization within the landscape was 5 and 40% respectively.

The amount of 2,4-D mineralized varied widely within each slope position. The variation in the amount mineralized increased from lower to middle to upper slope positions (Fig. 4).

The half-life of readily mineralizable 2,4-D varied from 4 to 25 days (Fig. 3). The half-life of 2,4-D was smallest in the upper slope and largest in the lower slope position (Fig. 5). Variation in 2,4-D half-lives within slope positions was also present and was similar for upper, middle and lower slope positions.

The differences in soil organic carbon (SOC) content among slope positions may explain the differences in the rate and maximum amount of 2,4-D mineralized. For example, greater SOC content in the lower slope position could increase sorption and therefore decrease mineralization rate and increase half-life. In addition, microbial populations and activity, as well as 2,4-D relative sorption strengths may vary across the landscape, and further explain the measured differences in 2,4-D mineralization rates.

Conclusions

Landscape position has an effect on the rate of 2,4-D mineralization. Preliminary results of this study showed that the amount of 2,4-D mineralized at 130 days varied from as little as 5% to as much as 40%, depending on the slope position. Similarly, half-life of 2,4-D varied across this topographically variable landscape, ranging from 4 to 25 days.