Does preserving soil structure combined with on-demand moisture maintenance enhance degradation rates of Plant Protection Products?

Dougan, C.1*, Hand, L.1, Nichols, C.1 and Oliver, R.1

1 Product Metabolism, Product Safety, Syngenta, Jealott’s Hill International Research Centre Bracknell, Berkshire, RG42 6EY, UK
*christine.dougan@syngenta.com

Introduction

Degradation rates of plant protection products (PPP) are frequently faster under field conditions than in laboratory studies. Field trials are often carried out on relatively undisturbed soil, whereas for laboratory studies, regulations dictate that soil is sieved to <2 mm and maintained under controlled conditions (constant temperature and moisture). These soil preparation processes disrupt the soil pore structure, therefore changing the habitat of many microbes, possibly altering populations, and affecting solute transport processes within the soil. These practices may contribute to deviations in degradation behaviour from those observed under field conditions.

A higher tier laboratory study was designed, utilising intact soil cores with on-demand watering, and comparing degradation rates in these against the standard regulatory study. The following conditions were examined: constant moisture vs. variable moisture (mimicking rainfall and evaporation) and dark vs. light/dark cycle.

Materials and Methods

All studies were conducted using 14C-labelled compounds to ensure full mass balance was measured where feasible (OECD307 studies only). All study designs were run for duration of 70 days.

The initial study design, using Azoxystrobin, Paclobutrazol and Fomesafen was:

- Standard regulatory OECD307 study at pF2,
- Intact soil cores at constant moisture (ca. pF2) in the dark,
- Intact soil cores in the dark with a variable moisture regime to mimic rainfall and evaporation,
- Intact soil cores at constant moisture (ca. pF2, complex dynamic I: without artificial moisture variation, variations seen in the moisture were due to temperature fluctuations during the light dark cycle) in a light/dark cycle,
- Intact soil cores in a light/dark cycle with a variable moisture regime (complex dynamic II).

An extended study design was used for Paclobutrazol which included:

- A repetition of the standard regulatory OECD307 and intact soil core studies, at constant moisture (ca. pF2) in the dark, to act as references,
- Intact soil cores, with the top 1 cm removed, at constant moisture (ca. pF2) in the dark (to examine the impact of altering the surface microbial community),
- Cores with <10 mm sieved soil, repacked to same bulk density as the intact cores, at constant moisture (ca. pF2) in the dark,
- Cores with <2 mm sieved soil, repacked to same bulk density as the intact cores, at constant moisture (ca. pF2) in the dark (both examining the effect of varying soil structure).
Results

Three PPPs (Azoxystrobin, Paclobutrazol and Fomesafen) were tested. For Azoxystrobin and Fomesafen, degradation rates were similar regardless of design; fairly rapid for Azoxystrobin (DT$_{50}$: 35-45 days) and slow for Fomesafen (DT$_{50}$: >1 year). However, Paclobutrazol degradation was significantly faster in the intact cores than the regulatory design (>2x), indicating that disruption of soil structure, and its subsequent impact on microbial communities and solute transport properties, impaired degradation. Neither the variable moisture content nor a light-dark cycle enhanced the degradation further (slight variation due to temperature).

An extended study was conducted to investigate the effect further for Paclobutrazol. Degradation rates in these modified designs were compared to undisturbed cores and the regulatory design. However, none of these designs showed the same degree of enhanced degradation, implying that the entire soil structure had some role to play.

Conclusions

The data provides support for the hypothesis that active ingredients can be classified in terms of their degradation behaviour as follows:

Type A: Compounds that are readily degraded using biochemical pathways that exist in a broad range of soil microbes, for which the regulatory study is a reasonable model (exemplified by Azoxystrobin).

Type B: Compounds that are degraded using biochemical pathways that exist in a smaller range of soil microbes, which may be negatively impacted by the sieving process. These could include heterotrophic and phototropic surface communities. A higher tier study in intact cores would be a better model for these compounds (exemplified by Paclobutrazol).

Type C: Compounds that are more resistant to degradation by soil microbes and may be more persistent depending on the significance of other degradation processes (exemplified by Fomesafen).