Non-UV light influences the rate of crop protection degradation in soil

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Introduction

The first point of contact of a Crop Protection Product (CPP) with the soil environment is the soil surface. Therefore, regulatory tests assessing CPP degradation should aim to include the physical, chemical and biological properties of the soil surface. In an agricultural field, the surface is exposed to light, which stimulates the development of photo-trophs that have been shown to degrade CPPs in pure culture. However, OECD guideline 307 is conducted under dark conditions, which prevents photo-trophs from developing. This work investigated the effect of non-UV light, which stimulates the development of photo-trophs without photodegrading CPPs, on CPP degradation.

Materials and Methods

The top 15 cm of Gartenacker soil (silty loam) was sourced from Switzerland (CH-1896 Vouvy) and sieved to 2 mm. Degradation studies were performed using [14C] labelled chlorotoluuron, cinosulfuron, prometryn, propiconazole, fludioxonil, benzovindiflupyr, lufenuron, and imidacloprid. CPPs were applied to 100 g dry weight equivalent of Gartenacker soil at 35% moisture content and setup under a flow-through system at 20±0.2°C according to OECD guideline 307. The light treatment was simulated using a Sanyo Gallenkamp Environmental Chamber and fluorescent lights (>360 nm) on a 16 h light:8 h dark cycle to reflect maximal diurnal light cycles during summer. A timecourse of benzovindiflupyr and chlorotoluuron degradation were taken. Degradation of the remaining six CPPs were assessed by comparing degradation rates at a single time point. Taken at the approximate DegT50 (50% degradation) of the CPP. At sampling points, CPPs were extracted by multiple solvent extractions prior to analysis by high performance liquid chromatography. 14CO2 mineralisation and non-extractable residues (NER) were also quantified by liquid scintillation counting. Chlorophyll a was measured to estimate phototroph growth. Bacterial (16S rRNA), archaeal (16S rRNA), and fungal (ITS) copy number were also assessed, in addition to pH, along the timecourse of benzovindiflupyr and chlorotoluuron degradation.

Results

Phototrophs proliferated under light conditions for all CPPs tested, with the exception of cinosulfuron (p≤0.05). The DegT50 of benzovindiflupyr was approximately halved under light from 373 d to 183 d. Chlorotoluuron DegT50 values were similar under light and dark conditions at 10 d and 15 d, respectively. The DegT90 (90% degradation) of chlorotoluuron was approximately halved from 79 d in the dark to 35 d under light. Significant reductions in extractable parent compound occurred under light conditions for prometryn (4%), imidacloprid (8%), and fludioxonil (24%) compared to dark controls (p≤0.05) (Figure 1a). However, a significantly slower rate of cinosulfuron (14%) transformation was observed under light compared to dark conditions (p≤0.05) (Figure 1a). There was no effect of light on the degradation rates of propiconazole and lufenuron (Figure 1a). Under light conditions,
NER were significantly higher for all CPPs except cinosulfuron, compared to dark conditions (Figure 1b). There was a significant increase in pH under light compared to dark conditions during benzoquinone degradation (p≤0.001). Bacterial, archaeal, and fungal copy numbers were not significantly different between light and dark conditions during the degradation of benzoquinone and chlorotoluene. There were no correlations between differences in degradation between light and dark conditions and DegT_50, K_oc, water solubility or chlorophyll a content.

![Graphs a) and b) showing extractable parent compound and non-extractable residues for different CPPs under light and dark conditions.](image)

Figure 1. Degradation (a) and formation of non-extractable residues (b) for a range of crop protection products in Gartenacker soil in an aerobic flow-through incubation system under light and dark conditions. An asterisk (*) indicates a significant difference between treatments (p≤0.05).

**Conclusions**

This is the first study to investigate the effect of non-UV light on the degradation of CPPs in soil. The inclusion of non-UV light to standard laboratory studies increased the rate of CPP transformation for five CPPs, and formation of NER for seven out of the eight CPPs tested (Figure 1). This effect may have been driven by the presence of soil phototrophs, which could directly degrade CPPs or indirectly impact heterotroph community composition and/or alter soil chemical properties such as pH. Phototrophs represent the first point of contact for CPPs applied to the soil surface, and therefore the results have potential implications for pesticide regulatory studies. It is important to further investigate the mechanisms responsible, test if the ‘light effect’ is soil-specific and if natural light also has a similar effect. Future studies should assess the effect of additional variables on CPP biodegradation, with the ultimate aim of bridging the gap between laboratory studies and field-applications, and improving the risk assessment of CPPs.

**References**
