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Fomesafen impacts bacterial communities and enzyme activities in the rhizosphere☆

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ABSTRACT

Fomesafen, a long-lived protoporphyrinogen-oxidase inhibitor, specially developed for post-emergence control of broad-leaf weeds, is used widely in soybean fields in northern China (Dayan and Duke, 2010). The impact of fomesafen on microbial communities in rhizosphere soils, however, is unknown. In this study we examined fomesafen degradation as well as its effects in the rhizosphere of soybean plants grown in a greenhouse. Fomesafen had shorter half-life in rhizosphere soil than previously reported for bulk soil from the same location (87 vs 120 days). The enzyme activity of soil extracts and the microbial community composition of 16S rRNA genes (16S) amplified from soil DNA were also investigated. Although not immediately apparent, both the high (37.5 mg kg^{-1}) and low (18.75 mg kg^{-1}) doses of fomesafen significantly decreased urease and invertase activities in the rhizosphere soil from days 30 and 45 respectively until the end of the experiment (90 days). Analysis of 16S amplicons demonstrated that fomesafen had a dose dependent effect, decreasing alpha diversity and altering beta diversity. Significant phylum level decreases were observed in five of the ten phyla that were most abundant in the control. Proteobacteria was the only phylum whose relative abundance increased in the presence of fomesafen, driven by increases in the genera *Methylophilacaea, Dyella,* and *Sphingomonas*. The functional implications of changes in 16S abundance as predicted using PICRUSt suggested that fomesafen enriched for enzymes involved in xenobiotic metabolism and detoxification (cytochrome P450s and glutathione metabolism). Our data suggest that, despite being degraded more rapidly in the rhizosphere than in bulk soil, fomesafen had long-lasting functional impacts on the soil microbial community.

1. Introduction

The diphenyl ether herbicide fomesafen (5-[2-chloro-4 (trifluoromethyl) phenoxy]-N-[methyl sulfonyl]-2-nitrobenzamide) is widely applied for the selective post-emergent control of broadleaf weeds in soybeans and some other legumes (Kleifeld et al., 1988; Dayan and Duke, 2010). Since being introduced into China, fomesafen quickly became one of the most popular herbicides in soybean and peanut fields because of its high herbicidal activity at low application dosage (Liang et al., 2009). The half-life of Fomesafen ranges from 100 to 240 days and thus there are concerns that residual herbicide may cause phytotoxicity and injury if sensitive crops are planted in successive years (Cobucci et al., 1998; Guo et al., 2003; Rauch et al., 2007). The continuous use of this herbicide may also lead to the contamination of food stuffs, thereby threatening human health (Potter et al., 2011). Residual herbicide could also have adverse impacts on soil health and biological processes by changing microbial metabolic activity, community structure, and enzyme activity (Zhang et al., 2014). Recent studies reported that addition of fomesafen can alter microbial community structure and functional diversity of soil in laboratory microcosms, and in field-

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