

Project Title: **The influence of secondary plant metabolites on pesticide degradation in agricultural soils**

Can plant-derived compounds help clean pesticides from soil?

Pesticides are chemical substances used in agriculture to protect crops from pests, diseases, and weeds. They are essential for ensuring high yields and food security. However, their intensive and long-term use leads to the accumulation of pesticide residues in soil, posing a serious threat to the health of soil ecosystems. These residues can persist for months or even years, contaminating soil and groundwater, and negatively affecting the diversity and activity of microorganisms and soil-dwelling organisms such as earthworms and springtails. Disrupting these natural processes can weaken soil fertility and its ability to support life, which is particularly concerning given global environmental challenges and the need for sustainable agriculture.

In the soil environment, there are also naturally occurring organic compounds called secondary plant metabolites (SPMs). These arise from the decomposition of plant residues, root exudates, and microbial activity. A particularly important group among them are phenolic compounds such as p-hydroxybenzoic acid, p-coumaric acid, vanillic acid, and syringaldehyde. These compounds are found in various soils, especially in the root zone, and influence many biological soil processes including microbial activity, redox balance, and enzyme functions. Although their role in regulating soil microbiology and interactions with plants is increasingly understood, their impact on pesticide degradation remains largely unknown.

Until now, studies on the effect of SPMs on pesticide breakdown have focused only on a single, widely used herbicide—MCPA. These studies showed that syringic acid can stimulate the degradation of this herbicide by supporting the microorganisms responsible for its breakdown, suggesting the potential of natural plant metabolites in bioremediation, which is a natural method of cleaning polluted environments. However, it remains unclear whether similar effects occur with other commonly used pesticides, especially insecticides and fungicides, which also pose a serious risk to soil health.

To fill this knowledge gap, this project aims to investigate how four natural phenolic compounds influence the biodegradation of five commonly used pesticides: the herbicide fluroxypyr, the insecticides acetamiprid and pirimicarb, and the fungicides tebuconazole and azoxystrobin. The research will be conducted under controlled laboratory conditions using soil microcosms with common Polish soil textures—loamy sand, loam, and silty loam. Field trials will also be carried out to better simulate real soil environment conditions. Changes in soil enzyme activity, microbial community composition, and pesticide toxicity to soil organisms in the presence of phenolic compounds will be assessed to determine if these substances have a beneficial effect on ecosystem functioning.

The results will improve our understanding of whether natural compounds produced by plants can accelerate or modify pesticide degradation processes, reducing their harmful impact on soil. This knowledge will support the development of new, eco-friendly soil protection strategies and sustainable agriculture practices, aligned with European Union policies such as the European Green Deal and the Farm to Fork strategy, which aim to reduce pesticide use and improve environmental health. Ultimately, this project will contribute to protecting the valuable resource of soil and preserving its ecological functions for future generations.