Practice abstract n°9: Examining the effects of PBAT biodegradable microplastics on plant growth and defense mechanisms

PAPILLONS consortium published a study in the journal Environmental Pollution titled *Biodegradable microplastics induce profound changes in lettuce (Lactuca sativa) […]*, which investigated the effects of relevant concentrations of PBAT (polybutylene adipate terephthalate) based biodegradable microplastics (MPs) on plant growth and defense mechanisms. The experiment was conducted in a mesocosm system: a controlled system that mimics natural conditions. Lettuce was used as a plant species to study the influence of biodegradable MPs on plant performance.

1. Aim of the study

Biodegradable plastic materials have been introduced in agricultural practices and are often positioned as a more sustainable alternative to conventional plastics. MPs from conventional plastics potentially threaten plants, soil organisms and agricultural ecosystem functioning. However, the effects of biodegradable plastic substitutes on soil ecosystems are not well studied. Therefore, this study aims at an in-depth analysis of the potential adverse effects of biodegradable MPs on plants.

2. Methodology

To do so, PAPILLONS researchers used a controlled experimental setup called CLIMECS (CLImatic Manipulation of ECosystem Samples). They prepared a series of soil columns with different concentrations of biodegradable PBAT MPs, ranging from 0.025 to 0.8% w/w, and maintained natural soil conditions to reproduce a model of terrestrial ecosystems containing plants, microorganisms and invertebrates like earthworms and springtails.

Lettuce plants were grown in these columns for 11 weeks, with samples collected at 4, 8, and 11 weeks. Various plant traits were measured, including growth parameters (leaf area, dry weight), chlorophyll content, oxidative stress markers (which indicate plant cell damage), and defense-related compounds. This setup allowed researchers to simulate real agricultural conditions and assess how biodegradable MPs interact with plant growth and physiology in soil ecosystems.

3. Main Results

The study found that **PBAT biodegradable MPs can affect lettuce plants in several ways.** First, these particles were observed to have an impact on plant growth:

- While overall growth was not significantly reduced, high biodegradable MP levels (0.8%) caused **noticeable deterioration in specific growth traits.**
- At higher biodegradable MPs concentrations, lettuce showed **reduced shoot length,** had fewer

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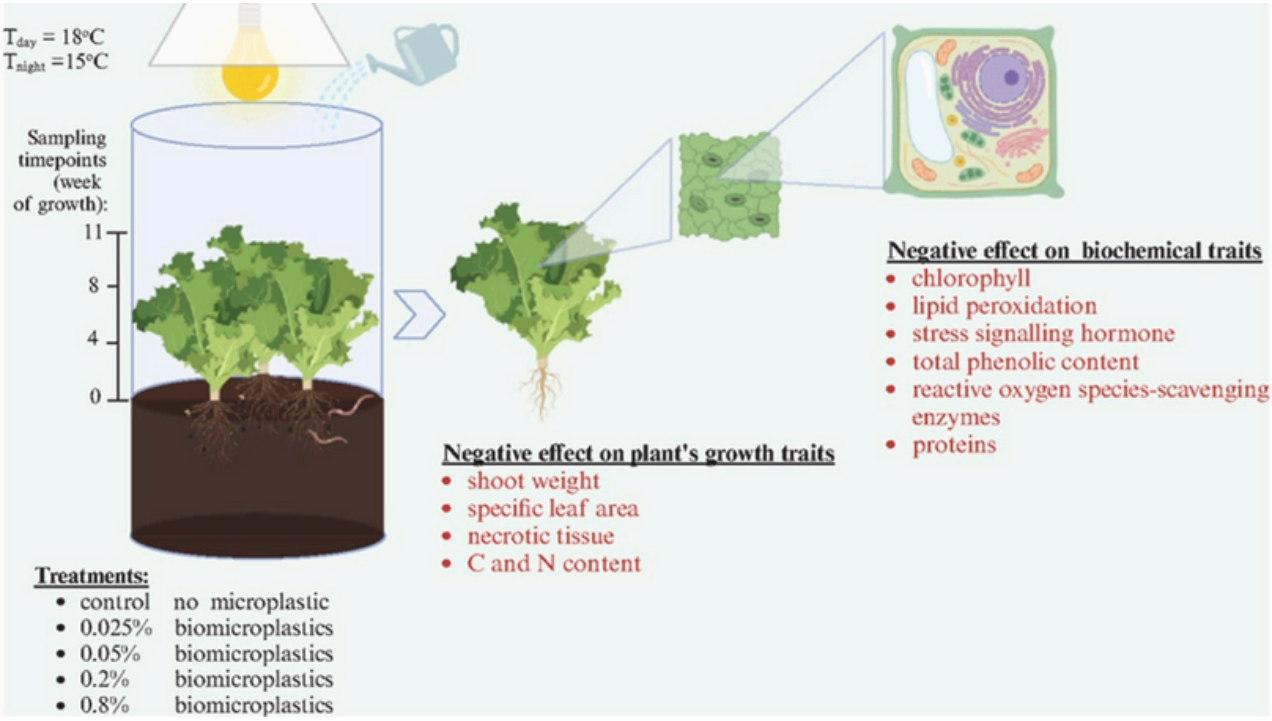
leaves, and had decreased nitrogen levels in leaves.

At the same time, biodegradable MP residues also affected the lettuce biochemical responses:

- Lettuce exposed to biodegradable MPs experienced **oxidative stress**, evidenced by increased lipid peroxidation which is a marker of potential cell damage.
- To cope with this stress, plants ramped up the production of antioxidants and stress-related compounds, such as salicylic acid, to combat damage, meaning that their defense mechanisms had been activated.
- **Chlorophyll** content **decreased**, potentially impairing photosynthesis under long-term or high-concentration exposure.

Third, concerning the plants' resilience mechanisms, researchers observed the following aspects:

- Lower biodegradable MP concentrations triggered moderate stress, which plants managed effectively by activating defense pathways.
- **At higher levels, however, the plant's ability to maintain oxidative balance faltered, leading to reduced resilience.**



Conclusion

In sum, this study shows that MPs derived from biodegradable plastics can alter plant growth and health, raising concerns about their use in agriculture. Therefore, further research is needed, both under field conditions and with diverse crops to better understand long-term implications of these materials on agricultural soils.

Reference: Adamczyk S., et al. Biodegradable microplastics induce profound changes in lettuce (Lactuca sativa) defense mechanisms and to some extent deteriorate growth traits, Environmental Pollution, Volume 363, Part 2, 2024, 125307, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2024.125307.

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