THÜNEN

Project *brief*

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Ecology and economy of ecosystem services provided by the diversity of soil organisms in agricultural systems

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- **Soil organisms provide multiple ecosystem services that are essential for healthy and fertile soils and thus for a sustainable agricultural production.**
- **Farming practices, in particular tillage intensity and crop rotation, impact soil life in arable soils.**
- **Fungivorous soil animals act as bioregulators of phytopathogenic fungi (here: *Fusarium*) and the toxic metabolic products they produce (mycotoxins).**

Background and aims

The observed loss of biodiversity in agricultural landscapes also affects agricultural soils. There are still numerous open questions regarding the relationship between occurrence and diversity of soil organisms, the ecosystem services they provide and their importance for the profitability of agricultural production. In the European BiodivERsA-project SoilMan, soil organisms and the ecosystem services provided by them in cropping systems were comparatively analysed in five European regions (France: Brittany; Spain: Andalusia; Romania: Transylvania; Sweden: Uppland; Germany: Lower Saxony). The focus was on maize and cereal production.

Within the framework of the project we

- investigated the influence of soil biodiversity on agricultural productivity and sustainability and
- quantified the bioregulatory potential of soil animals as antagonists of economically relevant phytopathogenic fungi under ploughless tillage (Fig. 1)

Approach

To capture farmers' attitudes towards the importance of soil biodiversity, focus group discussions were conducted in the five case study regions, complemented by a survey on local management practices. This enabled a socio-economic valuation by practitioners of the services provided by soil organisms. Insights gained from this and from the interdisciplinary exchange in the "Bridging group", bringing together project partners from ecological and economic disciplines were used for the development of long-term scenarios for modelling. We used the general equilibrium model MAGNET. Exemplarily, the effect of increased yield stability through improved soil biodiversity on production and market prices was analysed for wheat.

Figure 1: Soils that are tilled without ploughing usually show a higher biodiversity than ploughed soils

Source: Thünen-Institut/Brunotte, Runge

In field (Fig. 2) and laboratory experiments, the bioregulatory potential of functionally different soil animals (earthworms, enchytraeids and collembolans) to suppress Fusaria and reduce their mycotoxins in the maize mulch layer of arable systems with ploughless tillage was analysed and quantified. The animals' performance was recorded, compared and assessed under various external impact factors (time, temperature, soil texture and chaff size) using modern analytical methods (qPCR, HPLC-MS).

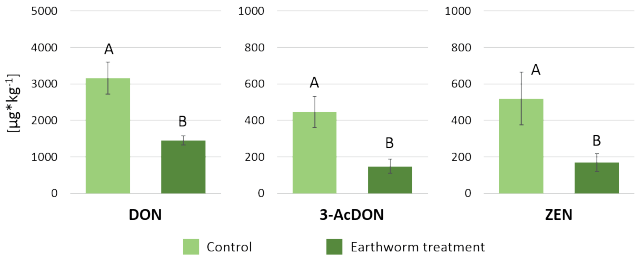
Figure 2: **Mesocosm with *Fusarium*-infected straw and soil animals in a field experiment**

Source: Meyer-Wolfarth

Key findings

Regarding the mycotoxins, a significant acceleration of the degradation of different toxins (Deoxynivalenol (DON), 3-Acetyldeoxynivalenol (3-AcDON), Zearalenone (ZEN) and Fumonisin B1) by soil faunal species was found.The reduction rates depend on the respective toxin, the time period, the prevailing temperatures, the soil texture and the key species involved. Overall, the earthworm species *Lumbricus terrestris* showed the greatest bioregulatory potential (Fig. 3).

Figure 3: **Concentration of the *Fusarium* mycotoxins DON, 3-AcDON and ZEN in the maize straw of the mesocosm field trial after 6 weeks. Arithmetic means and standard errors of the control and the earthworm treatment (*Lumbricus terrestris*) are shown. Different letters indicate significant differences**

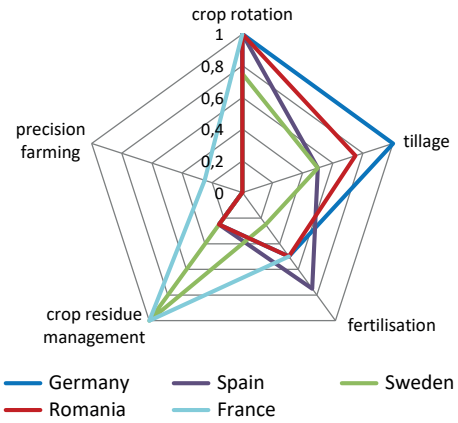


Source: van Capelle (unpublished)

Agricultural management that takes into account the needs and habitat requirements of fungivorous soil animals, and in particular the species *L. terrestris*, can thus lead to a synergy. The interplay between anthropogenic top-down effects (agricultural management) and natural bottom-up-effects (bioregulation by soil fauna) contributes to sustainable agricultural production on healthy and fertile soils in the long term.

In the focus group discussions carried out for the socio-economic analysis, the participating farmers agreed that diverse crop rotations foster soil life. Regarding the other farming practices, there were clear differences in the assessment between the case study regions (Figure 4). Precision farming in the sense of soil life-preserving cultivation has so far only been of minor importance in practice.

Figure 4: **Assessment of farming practices by farmers in the case study regions regarding their effects on soil life (1: greatest importance; 0: least importance)**



Source: Runge (unpublished)

By demonstrating the positive impact not only of the physical but also of the economic yields of farms, SoilMan was able to build a bridge between the analysis of the physical impact of ecosystem services and their economic effects. The model results confirm the importance of considering biological processes for future sustainable agriculture in Europe.

In October 2019, the Thünen Institute hosted the international conference „Soil Biota Driven Ecosystem Services in European Agriculture“. The event addressed the ecosystem services provided by soil organisms and resulting synergies for a sustainable and productive agriculture as well as policy instruments for soil (biodiversity) protection. Further information on the project and the conference can be found at https://soilman.eu.

Further Information

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Publications

Plaas E, **Meyer-Wolfarth F, Banse M**, Bengtsson J, Bergmann H, Faber J, Potthoff M, **Runge T, Schrader S,** Taylor A, (2019) Towards valuation of biodiversity in agricultural soils: a case for earthworms. Ecological Economics 159, 291-300. DOI:10.1016/j.ecolecon.2019.02.003

Schrader S, van Capelle C, Meyer-Wolfarth F (2020) Regenwürmer als Partner bei der Bodennutzung. Biologie in unserer Zeit 3(50):192-198. DOI:0.1002/biuz.202010706

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