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1. UN Sustainable Development Goals (SDGs) push for sustainable food production systems by 2030 that use resilient agricultural methods to improve soil quality.

European Commission

Science for Environment Policy

Earthworms are essential for soil quality, reducing crop pathogens and ensuring yield

Soil biodiversity, soil quality, and soil health are integral to protecting the natural environment. Soils are crucial to food production and human well-being, as highlighted by the UN Sustainable Development Goals (SDGs)[1]. The abundance of soil biota is of great importance for the provision of associated ecosystem services (ES) and fundamental driver of self-regulation in soil. This study explores how the presence, or absence, of earthworms affects aspects of crop health and productivity, focusing on their shielding of winter wheat from the toxic plant fungi *Fusarium*.

Soil-dwelling organisms are key for ecosystem services (ES), natural processes, and human health. Soil health and soil biodiversity are interdependent, with earthworms usually the most abundant soil animal group among soil organisms present in agricultural soils. Earthworms are proven to positively affect plant production, soil structure and pathogen control, and act as an important indicator of soil health. Intensive farming methods and impacts of climate change are currently causing soil-dwelling organisms, such as earthworms, to decline in Europe and are driving an associated decrease in soil fertility.

This study focuses on the role earthworms play in lowering toxic plant fungi, specifically *Fusarium* species — a pathogen of cereals — and the associated value of this disease suppression, in terms of farm revenue. It also examines the use of crop management to increase soil biodiversity, and how standard gross margin (SGM) – the profits from crops — can be increased via the anti-fungal activity of earthworms and decreased use of fungicide. SGM is affected by crop management practices together with plant pathogens, causing severe economic losses in the EU every year. In 2015, 68% of the EU cropland hosted crops susceptible to *Fusarium* infection[2].

Earthworms play many important roles in soil: as ecosystem engineers, helping to improve soil quality and structure; as chemical engineers, decomposing organic residues to ensure soil fertility; as biological regulators, reducing soil-borne pathogens; and their biological activity drives ecological processes, and thus also provides an economic service.

This study focused on valuing the disease suppression of *Fusarium* spp., a major agricultural plant pathogen in temperate regions that can affect especially maize, wheat and other grains. The deep burrowing earthworm species *Lumbricus terrestris* is particularly important in controlling *Fusarium* spp. and their mycotoxins, and, consequently, mitigating its potential fungal contamination of crops.

The researchers analysed a number of studies concerning the positive effects of earthworms on aspects of and soil health and crop production. They first analysed findings relating to two types of earthworm feeding traits — *detritivorous* (eating dead plant and animal matter) and *geophagous* (eating soil) — and their impact on the direct inhibition of fungal plant pathogens on cereals. They examined aspects such as soil type, crop growing conditions and density of worms, and considered the indirect effects of geophagous earthworms by summarising their impact on plant growth in fungally infected wheat.

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2. Eurostat, 2017

European Commission

Science for Environment Policy

Earthworms are essential for soil quality, reducing crop pathogens and ensuring yield *(continued)*

Specifically, the researchers analysed datasets of winter wheat harvests from the lower Saxony region of Germany. They assumed the only benefit caused by the earthworms to be pathogen suppression, ignoring other ES provided by earthworms, and assumed the yield level to be the same across all scenarios (using the average for Germany for the 2015–2017 period). The difference between the cost of growing the wheat and that at which the wheat was sold (the Standard Gross Margin, SGM), calculated per hectare (ha), was used as a measure of the relative contribution of wheat production to overall farm revenue.

The study involved both types of earthworm and considered three scenarios: A) ploughing and two fungicide applications; B) ploughing and only one fungicide treatment; and C) conservation tillage (no ploughing) and one fungicide treatment. Reduced fungicidal application in conventional argicultural practice, as in case B, bears the risk of greater mycotoxin contamination of the crop, which in turn results in a reduced price. This study makes the assumption that this reduced price is the price obtained by crops that are only good enough to use for animal feed: 149.03 euros per tonne (although higher contamination could reduce the price further).

Scenario A was found to produce wheat worth 624 euros per ha. Scenario C produced wheat worth up to 699 euros per ha. In the latter scenario, the SGM is increased by 75 euro per ha (+12%) due to the presence of a healthy and active earthworm population. Scenario B performed less well, achieving 132 euros per ha less than the conservation Scenario C; this is due to the effects of fungus contamination coupled with ploughing, which detrimentally affected the worm population.

The literature data showed detritivorous earthworm species reduced fungal infection by 72% on average (48–99%), whereas geophagous species reduced infection by 43% on average (28–68%). Earthworms also reduced the disease severity of major fungal pathogens (*Fusarium* spp., *Verticilium* spp.) infesting horticultural crops such as asparagus (50%), tomatoes (68%) and aubergine (28–61%).

As well as having a direct impact on plant pathogens the presence of geophagous earthworms have a positive effect on growth of wheat plants infected with the fungal pathogen *Gaeumannomyces graminis* — 20% more plants emerge, plant shoot weight increases by 58% and grain yield increases by 26%.

The disease suppression value demonstrated by the financial benefit in price per hectare, under the researchers' conservation strategy 'scenario C', is accompanied by the additional benefits of improved soil structure and nutrient availability. Aside from a decrease in fungicide use, this would also mean fertilisers could be used less frequently over time — avoiding negative effects on water quality and assisting the EU Water Framework Directive.

The researchers suggest that pathogens and pollutants may be effectively controlled, and soil biota supported in their provision of ES, through sustainable agricultural practices (e.g. residue management, crop rotation, less susceptible cultivars and sustainable fungicide application) — and that farmers could be encouraged to change their soil management practices if presented with an economic assessment of earthworm services. With this in mind, they call for closer co-operation between scientific experts, such as soil researchers and economists, to support farmers in moving towards more sustainable farm-management practices.