Genetically modified microbes in EU agriculture

an ecological assessment of COM (2025) 1031

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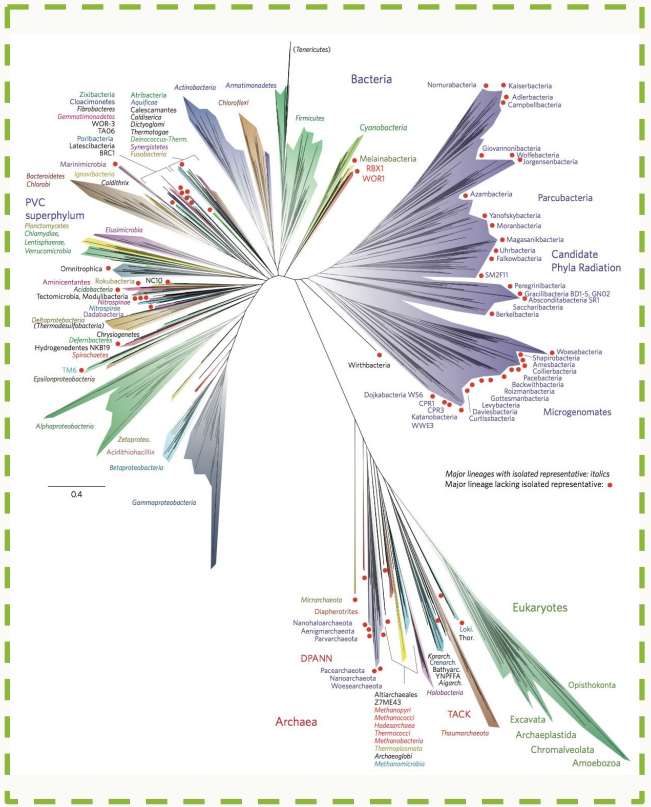
Microbes: ancient, essential and barely known



42% of bacteria have likely never been detected. Field studies of microbes only became possible about 20 years ago, with DNA sequencing.

Essential

Soil microbes recycle nutrients, build soil structure, support plant growth and suppress plant disease. They are also biodiversity worth protecting.

Wikimedia Commons · Wu et al., 2025 · Averill et al., 2022 · Fan et al., 2026

Microbial products are ecological rather than engineered

> A **fertiliser or pesticide** acts in roughly the same way wherever it is applied, and generally, more product means more effect. **Live microbial products** respond to the ecosystem.

In order to begin to work, microbial products must:

1 Arrive in the soil → **2** Find a niche where it can thrive → **3** Establish in the presence of residents → **4** Perform its function

Each step can fail, and each depends on climate, soil and the resident community. Outcomes vary across sites and years.

Jurburg et al., 2022 · Giller et al., 2025

The promised functions are already present

Soils usually already contain the genes plants need. Poor function reflects conditions that keep those genes from working.

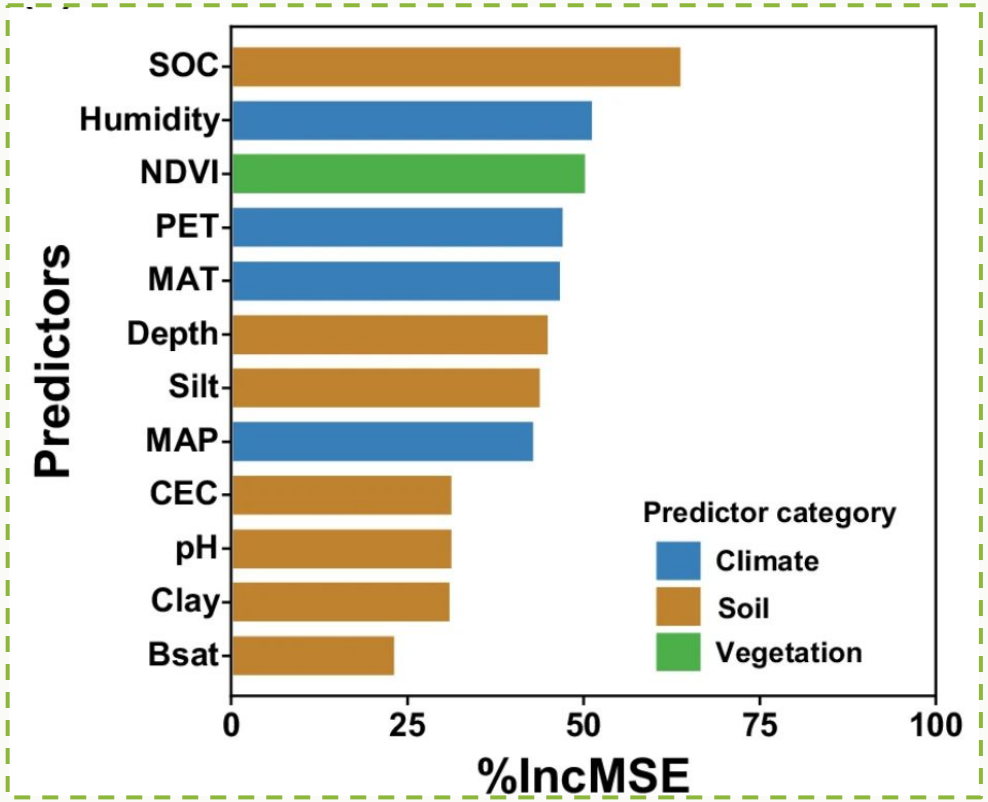
Nitrification

Nitrifying bacteria, which convert ammonium to nitrate, are present in the great majority of soils. They rarely work at their maximum rate, because ammonium supply, pH, oxygen, moisture and temperature are never all ideal in the field.

In soil, genes are rarely the bottleneck

Nitrogen fixation, phosphate release and disease suppression are already carried out by native soil communities. What determines the overall functioning is a mixture of environmental conditions

Microbial inoculants have a record of variable and inconsistent results (e.g., in cereals)

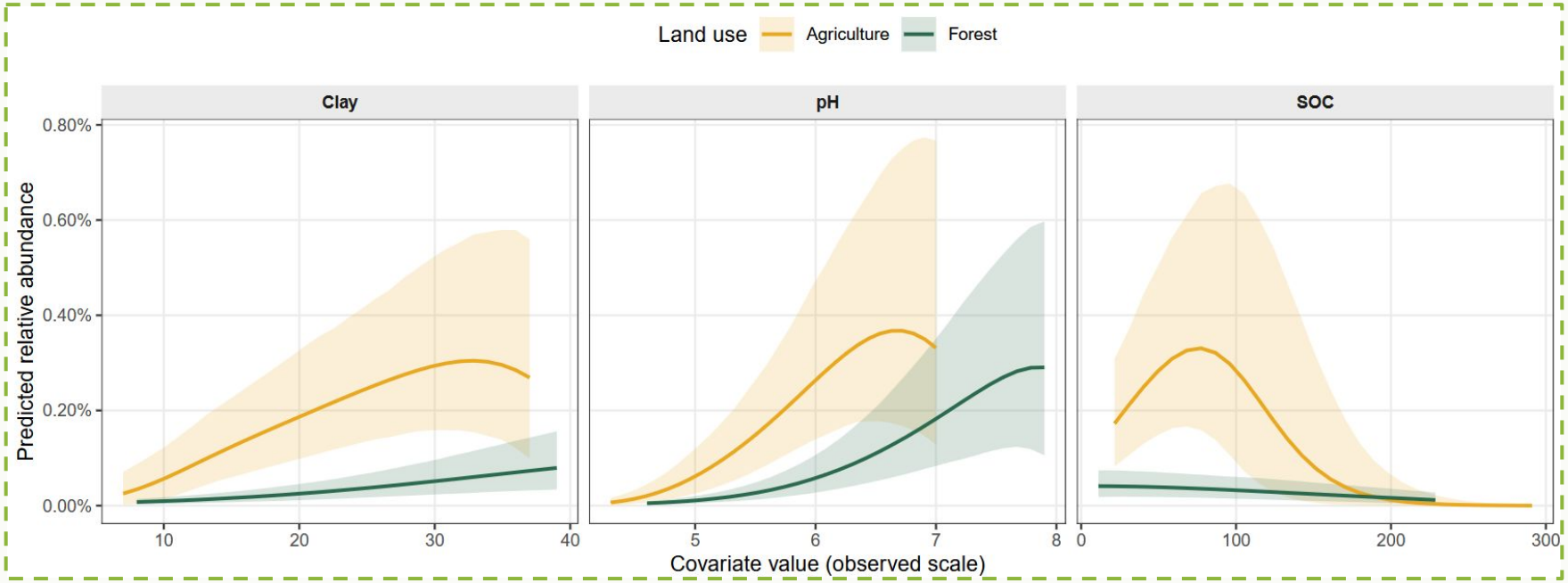


Relative importance of environmental factors on NUE

Gao et al., 2026, Nature Communications

Results are context-dependent and transfer poorly

- **Soil conditions.** Moisture, pH and land-use history filter bacteria and fungi differently, even within one landscape.
- **Management.** The same taxa assemble differently depending on farming practice and soil depth.
- **Climate change.** Shifting temperature and rainfall move the niches microbes depend on.



Environmental optima of *Neorhizobium* vary by land use

Festa et al., *in prep*

The resident community plays a role… and is in turn affected

Resident microbes and their predators influence whether an inoculant establishes and how far it spreads.

Evidence

A labelled microbial consortium added to two soils with different pollution histories was consumed early by eukaryotic predators. Establishment differed between the soils.

Reliability

Performance varies with climate, soil and resident biota. Approval should require evidence across realistic conditions, and labels stating where a product works.

Safety

Risk depends on the receiving environment, not only on the organism released.

Nieto et al., 2024, Microbiome

Resident microbes routinely change in response to invasions

Evidence

The ability of *E. coli* to colonize soil microcosms depended on the diversity of the resident microbiota. Once colonized, the resident microbiota changed to consume resources not consumed by E. coli, and remained altered even once E. coli was no longer detectable.

Safety

No application can be considered risk-free when it comes to protecting soil biodiversity

Mallon et al., 2018, The ISME Journal ·

Microbes in the context of COM (2025) 1031

Classical risk assessment frameworks previously used to regulate plants do not fit microbes.

Risk assessment asks
Which organism is this, and which genes were changed?

→

implicit assumption:
We can predict where the microbe and its modifications are and do over the long term.

→ We don’t know how most microbes behave

→ Behavior depends on the environment and its inhabitants

→ Once in the environment, we cannot always detect where the modification is

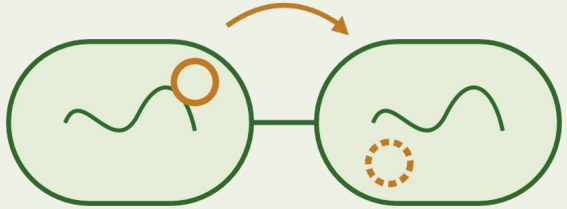
Jurburg et al., 2022

Unintended consequence: spread that cannot be tracked

Wide dispersal

Microbes travel by wind, water, insects, birds, livestock, and even on protists, fungi and other bacteria. Spread is wide, poorly understood, and depends on how and where a product is released.

Gene transfer



Microbes pass genes to unrelated neighbours. Genes on plasmids move most easily, so an engineered trait can become a property of the whole community.

Detection limits

Current methods cannot show where a modification has ended up, or whether a modified gene remains in the target organism or has moved into non-target organisms. Sampling destroys the sample.

Unlike GM plants, GM microbes cannot be seen, contained or recalled.

Who owns, and is liable for, modified genes in non-target species?

Hawxhurst et al., 2023 · Kohlmeier et al., 2005 · Muok & Briegel, 2021 · Zhu, Hong & Wang, 2024

One final note

> We know very little about the ecology of GMMs because research into them in natural systems has been extremely restricted. Much fundamental research is still needed

Microbial products should be regulated as ecology, with ecologists and microbiologists consulted before the rules change.

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