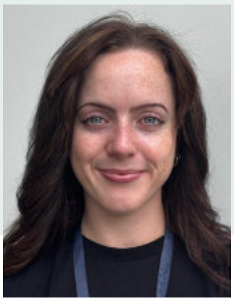
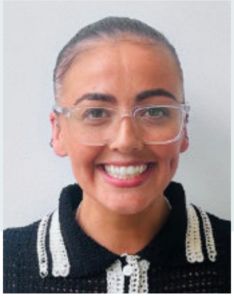
# Improving soil health in the UK

## Why a microbial approach is indispensable in attaining sustainable soils


**Daisy Neale**
Policy and Diversity Manager at Applied Microbiology International

**Lucky Cullen**
Head of Policy Community and Scientific Advancement at Applied Microbiology International

**Aditya Singh Ranout**
Member of Applied Microbiology International; CSIR-IHBT Palampur, India

Soil health underpins many of the UN Sustainable Development Goals since healthy soils not only help to provide food security; they also increase resilience to climate change, reduce the risk of pathogen and AMR transmission through the environment, boost biodiversity, increase carbon storage and nutrient retention and more[1]. With the global population ever increasing and demands on our soils simultaneously growing, soil health must be given the attention it deserves due to the complex processes and factors it underpins, as ultimately healthy soils are essential for a thriving planet and future.

If the UK Government wishes to stay aligned with, and at the forefront of, global developments and ambitions in relation to soil health, imminent action is needed. This action needs to be based on the recognition of the pivotal role played by microbiology in achieving soil health as current practices – which do not consider microbiology appropriately – are unsustainable.

Applied Microbiology International and the wider microbiology community thereby recommends taking action by:

- Considering the opportunity of taking a nation-wide microbiome approach to soil
- Deploying microbial solutions to improve the UK's soil health, whilst exploring and building the basis for a national microbiome approach

### The current state of UK soils

Agricultural land covers 70% of the UK, but only 36% was croppable in 2023[2]. Cereals, which heavily deplete soil nutrients, made up 71% of the crop area[2]. Additionally most UK farming practices are mechanised, involving large quantities of agrochemicals (fertilizers and pesticides); practices which are unsustainable as evidenced by diminishing returns that are predicted to worsen with climate change.[3]

### The role of soil microbes

Soil consists of minerals, plant, animal and microbial residues (organic matter), living organisms (including micro-organisms, or 'microbes') water, and gas. Soil microbes, including bacteria and fungi, have essential roles including removing contaminants, carbon sequestration, plant protection, crop productivity, soil structure and air/water regulation. This complex community of microbes and their interactions are called the soil microbiome; a cornerstone for taking a holistic One Health approach across all ecosystems[4].

Despite the soil microbiome's significance, much remains unknown about it[5 6]. On top of this, current soil health initiatives do not factor in the soil microbiome and its complexities, which risks affecting it negatively, or missing opportunities to optimise its benefits. To circumvent this, AMI proposes taking a holistic microbiome approach to UK soils.

### A microbiome approach to soil – a long-term solution

A microbiome approach to soil leverages the diverse microbial communities within soil ecosystems to improve soil health, agricultural productivity, and environmental sustainability while acknowledging soil's role in waste removal, climate change mitigation, nutrient cycling, and disease suppression[7].Leveraging the soil microbiome will contribute to achieving net zero, food security, and global health and wellbeing.

To implement this approach in the UK, a comprehensive strategy encompassing research, education, policy support and practical implementation is essential. Actions needed to implement this approach include:

#### Study & monitoring

- Conduct further research and studies across the UK to define the UK soil microbiome and have protected funding to do so.
- Establish a regular monitoring framework to ensure the long-term viability of a microbiome approach.

#### Education & outreach

- Better inform farmers, land managers, legislators and the public on soil health.
- Introduce training and incentives to encourage adoption of behaviours that are beneficial to the soil microbiome, while addressing concerns and scepticism.

#### Policy support

- Establish and modify regulations that provide incentives and assistance for farming methods that promote a healthy soil microbiome.
- Major agricultural policies and projects should be reviewed and amended,

where possible, to ensure they incorporate concerns around practices that negatively impact the soil microbiome and to enable a transition towards more sustainable practices.

Technology & innovation

- Allocate resources towards the advancement of soil health promoting alternatives to current agricultural practices by protecting funding.
- Investment to explore the scalability and efficiency of a microbiome approach.

Collaboration & networking

- Promote cooperation across disciplines (scientists, farmers, industry stakeholders, policymakers) to facilitate knowledge sharing.
- Encourage a holistic, collaborative approach to UK soils to avoid future redundancy.

## Intermediary solutions to improve soil health

The microbiome approach to sustainable soils remains in its infancy, but immediate action can improve UK soil health in the meantime. With the agricultural biologicals market projected to grow from $14.6 billion in 2023 to $27.9 billion by 2028, the UK has an opportunity to capitalise on this sector.[8]

## Alternatives to artificial fertilizers

Biostimulants are substances and/or microorganisms that stimulate plant processes, reducing fertilizer dependence and improving growth and stress resistance. If adopted across the European Union, biostimulants could reduce nitrogen use by 517,000 tonnes while improving fertilizer efficiency 5–25%, reducing pesticide use 10–15%, and increasing crop yields 5–10%[9].

## Biofertilizers

Microbes can be used as alternatives to artificial fertilizers which are known to adversely impact soil by hardening it and reducing soil fertility, while also contributing to greenhouse gas emissions linked to their use and transportation[10, 11]. Biofertilizers alone cannot meet food security needs, however, they can supplement and reduce artificial fertilizer use. Efforts to improve biofertilizer reproducibility, shelf-life, and cost-effectiveness are needed, alongside careful regulation to balance innovation with environmental safety[12].

## Microbial inoculants

Beneficial microbes can enhance nutrient uptake and help restore soils degraded by artificial fertilizers. Plant-growth-promoting rhizobacteria (PGPR) and arbuscular mycorrhizal fungi (AMF) are key classes of beneficial microbial inoculants. AMFs facilitate nutrient exchange and enhance resilience to stressors, while PGPRs have plant growth-promotion and bioremediation characteristics. Despite their potential, their market shares remain limited due to lack of research and regulatory challenges[13, 14]. Better communication between researchers and the regulatory sphere is needed to refine this technology and improve adoption[15].

## Biochar

Biochar is formed by heating organic matter. When applied to soil it enhances soil structure, increases nutrient availability, reduces contaminants, and improves water retention. It boosts microbial activity, which supports the soil microbiome. Biochar can be made from local organic waste, reducing waste. However, challenges include varying effectiveness based on feedstock, potential greenhouse gas emissions, and the need for long-term studies on its sustainability[16, 17].

## Biological control agents

Artificial pesticides harm soil microbiomes and the environment[18, 19]. Biopesticides, such as bacteria, fungi, and viruses, provide a sustainable alternative[20, 21]. The UK is the fifth largest consumer of biopesticides globally and delays in the UK's National Action Plan for Sustainable Pesticide Use provides an opportunity to incorporate more sustainable solutions including biological control agents[22, 23]. Barriers to adoption currently include their narrow spectrum of pest activity and lengthy and expensive regulatory processes.

## Modifying current techniques

Although traditional farming techniques have been shown to negatively impact soil health, some conservation agricultural practices have been shown to improve soil health. These techniques

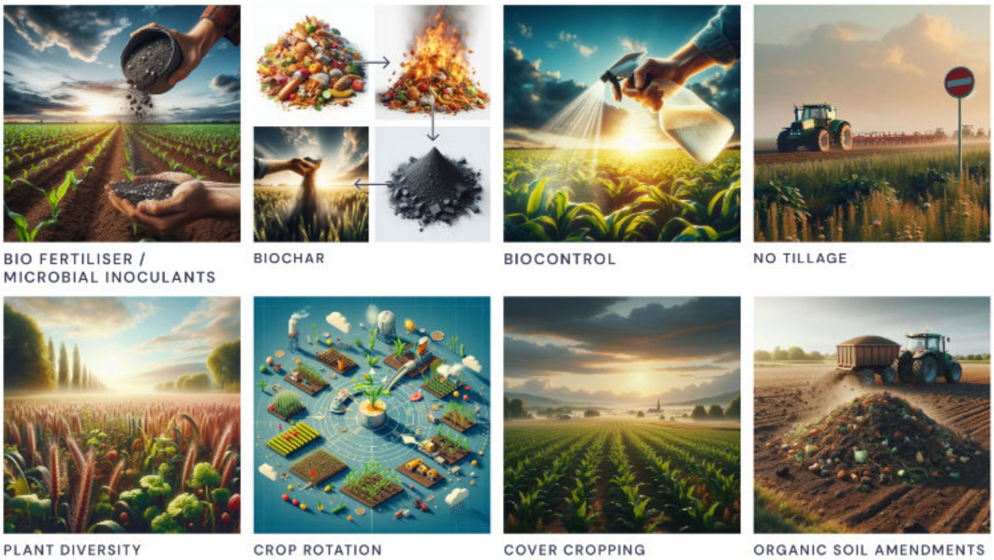



**Figure 1: Interim microbial solutions, which can be deployed now to help address the current soil health crisis and increase the health of UK soils in agricultural settings**

require appropriate incentives but do not require complex innovation and can be deployed now or with minimal intervention. Conservation agriculture improves soil health and productivity, though transitional periods may see short-term losses. Implementing sustainable practices supports long-term soil fertility, water retention, and pest management. These practices include:

– Reduced tillage
– Cover cropping
– Crop rotation
– Plant diversity
– Organic amendments

A shift towards microbiome-based solutions, alongside regulatory reform and research investment, can help the UK transition to a more sustainable agricultural system.

## Conclusion

There is a delicate balance between restoring the health of the UK's soils whilst maintaining sufficient food security. However, historic and current approaches have been, and are, heavily weighted towards the latter. While a short-term drop in yields may be concerning, evidence suggests it is necessary for long-term sustainability. AMI urges the UK government to prioritise soil health to combat climate change, protect ecosystems, and ensure future food security. Supporting microbial solutions outlined in this report is a vital first step. These immediate actions can address the soil crisis while positioning the UK as a leader in microbiome-based agriculture. AMI remains committed to promoting this innovative approach for a sustainable agricultural future.

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