FINANCIAL TIMES
SUNDAY 19 MARCH 2023
FT.COM

Tegan Nock collects plant specimens in a field of Canola. The microbiome of different plants is being examined for microbial fungi that could improve soil health © FT Montage/Pip Farquharson / Monique Lovick

The Big Read Agriculture

Microbes on the farm: a solution for climate change?

Evolving technology is enhancing soil's ability to store carbon and mitigate the environmental effects of industrialised farming

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There are few problems larger than the climate crisis. But one potential solution is so small it cannot be seen with the naked eye: microbes.

Tegan Nock, a 32-year-old former rancher who grew up on a farm deep in the Australian outback, is betting microbial technology in soil and crops can mitigate the effects that decades of industrialised farming have had on the planet's ecosystems.

Nock, who co-founded farming start-up Loam Bio in 2019, has developed a microbial fungus that when applied to soil might not only improve its health but greatly enhance its ability to store carbon.

If successful, the benefits would be twofold: it would help farmers on the sharp end of the climate crisis facing increasingly unpredictable weather patterns from droughts, floods and extreme temperatures. It would also mitigate the environmental impact of a food system that contributes up to a third of the world's greenhouse gas emissions. Agriculture has been blamed for environmental damage, such as soil erosion, ocean "dead zones" and biodiversity loss.

Like most growers in Australia who turned to more nature-led approaches in the 1980s and 90s, Nock and her family have been working to increase crop production using well-established conservation or regenerative agricultural methods including no-tillage, crop rotation and growing crops out of season to strengthen the soil.

Finding a way to boost the levels of carbon stored in the soil of her family's 3,000-hectare farm in New South Wales, south-east Australia, was the logical next step.

"When this work came along, it was something that once it bites, it's so hard to step away from," says Nock, now Loam's chief product officer. "I wanted to . . . make sure [the information and technology] was available to all farmers."

Loam's fungal treatment helps the soil store more than double the amount of carbon compared with that of conventional regenerative agriculture, while healthier soils retain more water and other nutrients, thereby increasing production. The start-up then helps farmers sell on their carbon credits to companies looking to offset their emissions. "It's a win-win," she says.

The company has so far raised a little over $100mn with investors including the Australian government's Clean Energy Finance Corporation and Hong Kong billionaire Li Ka-shing's Horizon Ventures. After launching its product in Australia, it is now conducting trials in the US.

Environmentally-friendly "biological" fertilisers and pesticides have been used since the start of crop cultivation. But it was synthetic fertilisers and pesticides that fuelled modern agriculture, powering intensive, large-scale production of food, helping reduce global hunger and support rising populations. However, the negative impacts of such products on the environment, human health and biodiversity have become more acute over the past few decades.

Beneficial microorganisms on farms offer an alternative. But, as with the links between gut microbial fungi and human health, only recently has there been a deeper understanding of the potential of microbes in soil thanks to cheaper technology, from data processing to AI.

Frederic Beudot, global biologicals lead at Corteva, the US agricultural group, says microbial products are on the cusp of a "golden age". There is "a greater awareness of beneficial organisms overall" which ties into "soil health [and] the micro flora in the soil", he adds. "We are understanding better the huge role [microbes] play in the health of the crop."

Motivated by a need to hit climate targets, countries including those within the EU, which have been slow to adopt regenerative practices, are now accelerating a shift into more sustainable farming. New agricultural policies and tighter regulation on synthetic inputs are expected to drive demand for more natural means of increasing production as well as protecting crops from pests and disease. In that context, say supporters, microbial technology represents a huge opportunity.

Billions of dollars' worth of existing products are likely to be banned in Europe, says Corteva's Beudot, adding: "That is driving innovation."

But many growers remain unconvinced by the case for microbials; their effects vary widely depending on climate and soil types, they can be expensive to implement, and properly transforming soil quality can take many years. The revolution Nock dreams of may not be immediate.

Economic and environmental benefits

Advocates argue that there are two good reasons to embrace microbial technology.

The first is that turning fossil fuels into traditional nitrogen fertiliser, one of the three key elements needed for plant growth, not only produces greenhouse gases including methane and CO_2, but also results in biodiversity loss through the mining of its other two ingredients: phosphates and potash.

According to research, about two-thirds of nitrogen-based

The price of conventional fertiliser remains relatively high

Fertiliser price index (Jan 2006 = 100)

Source: CRU
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and half of phosphate fertilisers applied to crops drain away, in many cases washed into waterways and oceans, suffocating aquatic life and creating dead zones, where oxygen is so low that organisms cannot survive.

But the main incentive of microbial fertilisers for growers is an economic one. Fertiliser costs soared when Russia's invasion of Ukraine pushed up the price of natural gas, a key feedstock for nitrogen fertiliser, to a record high. Though prices have fallen, the time lag effect means farmers are still paying more for conventional nutrients.

The microbial version is not only more affordable, it's also longer-lasting. When nitrogen-producing microbes adhere to plant roots, there is minimal runoff, meaning farmers need to apply less conventional fertiliser. Once applied, the microbes continue to work with the plant and, unlike conventional nutrients, do not need additional applications as the crop season progresses.

In Berkeley, California, a start-up called Pivot Bio, which produces a microbial fertiliser, is enjoying strong demand. After a pilot it ran in 2018, US corn acreage where the product was used tripled last year from 2021 to over 3mn acres, about 4 per cent of total corn acreage.

Lisa Peterson, a farmer in northern Iowa, started using Pivot's product in 2019 and was so impressed she became one of its sales representatives: "I know when I'm paying for that pound of nitrogen, I'm getting that pound of nitrogen into my crop. I'm not losing it in the soil profile. It's not leaching. It's not running off." At current prices, she adds, the product is also 40 per cent more cheaper than conventional fertiliser.

Stewardship of the land is as important as having an economically viable asset, adds Peterson, the third generation to work her farm. "I hope that it becomes the fourth generation at some point," she says. "But we have to take care of our land to be able to do that."

Pivot co-founder and chief executive Karsten Temme is bullish about the company's prospects. "We've had extremely robust growth ever since we launched our first product five years ago," he says.

In order to keep up with demand, the start-up doubled output capacity by expanding a facility in St Louis, Missouri, this year and added a distribution centre in Omaha, Nebraska. With increased manufacturing capacity, Pivot hopes to cover about 10 per cent of total US corn acres with its microbial nutrient this year and has started to explore expansion into international markets including Brazil, Kenya and Canada.

Growers are also experimenting with microbial fungicides. In Arkansas, Will Tipton, who farms about 2,000 acres, has been using a product made by Boston-based start-up Indigo Agriculture. The microbes establish a wall between the plant's roots and any pathogens. "It's a different approach to seed treatment," says Tipton. "It's about adding beneficial microbes to take the place of the negative microbes."

Indigo's suite of microbial products include nutrients, and those which aim to protect crops against drought and heat, which could prove useful at a time when extreme weather events are becoming more common.

Microbial products "really contribute to [the farmers'] whole soil journey," says Ron Hovsepian, Indigo's chief executive. "They all know they have to take better care of the soil, so that means they've got to be more selective as to what inputs they're going to use."

Tipton is also a participant in Indigo's soil carbon programme, which last December paid out $30 per carbon credit totalling $3.7mn to almost 450 US farmers for implementing regenerative farming practices that help the soil capture more carbon. This was a sharp increase on 2021, when it offered $15 per credit to 267 farmers amounting to just under $1mn. Like Loam, Indigo sells the credits to corporate buyers.

"We've parked all the ploughs and really haven't looked back. You get paid for doing less and it's real money for doing the right thing," says Tipton, who received more than $10,000 from Indigo in the latest payout.

Indigo's soil carbon programme and microbial products are separately run, but Hovsepian says both fall under the umbrella of regenerative agriculture. The use of microbials to enhance the soil's ability to store carbon is the natural progression from regenerative agriculture, which aims to restore natural ecosystems that have been depleted by traditional farming methods — and, ultimately, to produce food in a more sustainable way.

For every 1 per cent increase in the soil's carbon, an acre of land can hold an extra 25,000 gallons of water, helping productivity and plant health, notes Hovsepian, adding: "Connecting those pieces, that's where we really focused."

Regenerative agriculture has been slow to spread in Europe and Asia, but in other parts of the world take up is high. In Australia and New Zealand, the majority of growers have adopted sustainable farming practices, covering three quarters of the cultivated land.

Grant Sims, a sixth-generation farmer running a 8,500-acre family farm in central Victoria, Australia, has been on a pilot scheme for Loam's microbial product since 2021. His father and uncle adopted no-tillage of the farmland in the early 1980s, and since 2008, Sims started to reduce the farm's usage of synthetic fertilisers and pesticides, using biologically made liquid fertiliser to strengthen the plants instead.

He calls efforts to capture more carbon in the soil a "no brainer", saying that the revenue from selling carbon credits was important, but the production and environmental benefits would be "massive".

"Especially in Australia, we're kind of a land of extremes where one minute we're in drought and the next minute we're in flood because we've lost a lot of carbon out of the soil that's reduced the soil's ability to buffer those extremes," he says.

A reluctant revolution

Although the momentum behind the use of microbials on the farm continues to build, moving away from conventional farming methods remains a risky choice for many growers. If harvests fail, a year of lost crops means a year with no revenues or resources to recover the costs.

Scepticism about microbial products remains strong among mainstream growers especially as, unlike synthetic fertilisers, their effectiveness tends to vary depending on factors such as soil type, climate and weather conditions.

"There have been a lot of promises made around biologicals and the fact that they can replace obviously incredibly active and effective synthetic chemicals," says Alastair Cooper of agricultural venture capital Cibus. "The reality is when you're farming, you're in different climates, you're in different soil types, [with] different pHs. You'll have different temperatures, weather conditions, growing different crops."

For governments, promoting a transition to any kind of regenerative agriculture comes with food security risks if something goes wrong. A recent radical shift of farming methods in Sri Lanka and the economic crisis that ensued, for example, highlighted the dangers of sudden moves.

The European Commission is pushing ahead with greater regulation of the agricultural sector in order to lower its environmental impact and wants to promote the use of microbial products in a "soil health" law to be proposed in June.

Clara Aguilera, a socialist lawmaker on the European parliament's agriculture committee, says it would "allow the EU to have better control on [fertiliser] costs — to the benefit of farmers".

But tensions with farmers, due to the bloc's stringent regulation of the sector, are increasing and a previous attempt to regulate the treatment of soils was rejected by EU member states in 2007, in part due to the cost of implementing it.

Celia Nyssens, senior policy officer for agriculture and food systems at the European Environmental Bureau, says a key concern among some policymakers was whether such schemes would be subsidised "well enough so that farmers pick them up. We often see that unambitious [measures] pay more than ambitious ones."

Copa Cogeca, which represents EU farmers, says it is fully supportive of the protection and management of nature. "However, the current proposals coming from the commission do not provide coherent and concrete financial backing to support the transition and to maintain this transition," it adds.

Nyssens worries that some farmers mistakenly might view microbials as a short-term fix. "If you do [apply them] while simply maintaining business as usual for the rest and continuing to till heavily and continue intensive land management then it's not really going to solve the problem."

Transforming soil quality can take years, depending on factors including existing quality, methods and products used. Reduced tillage, for example, leads to increased weeds and more herbicide use, which may carry the same environmental and health risks as pesticides, say organic farmers and regenerative farming sceptics.

For farmers in developing countries, the challenge is even greater. In sub-Saharan Africa, for example, poor market access and affordability often preclude the use of herbicides, while manual weeding increases the demand for human labour, according to Katrien Descheemaeker, a professor at Wageningen University in the Netherlands.

The lack of distribution power among smallholder growers limit opportunities for crops grown in rotations or cover crops, while mulching advocated in regenerative agriculture is hard to apply where crop residues are used as animal feed, she says.

Beudot, at Corteva, acknowledges that one of the biggest hurdles over the last 30 years has been the variable effect of microbial and biological products. "Ultimately to drive adoption, we need to be able to explain to the farmer and help them make the right decision to pick the right product, at the right time," he says.

He does not see the transition to regenerative agriculture as an all-or-nothing situation, but something that could be used interchangeably.

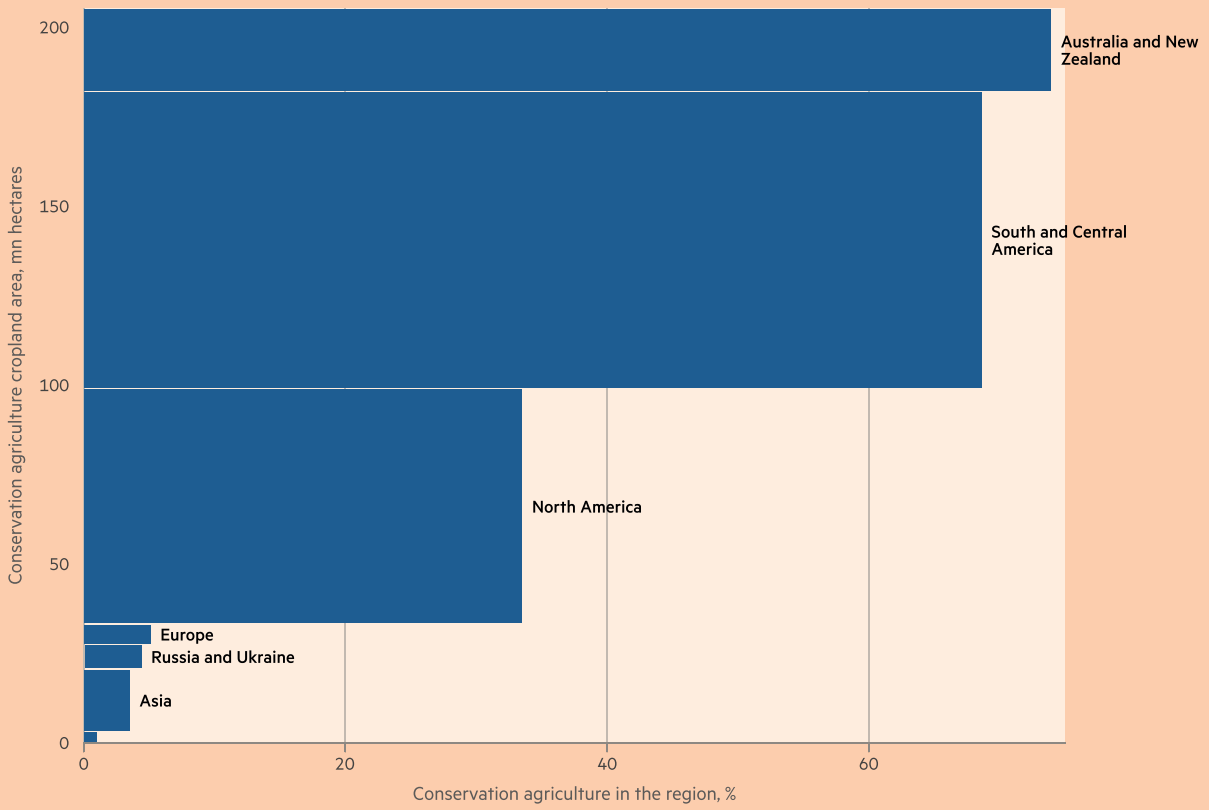
"You're going to need all sorts of synthetic tools to address higher stresses, diseases, insects that are getting out of control. And we see those practices as being very complementary," Beudot adds. "In a perfect year, a farmer may be able to cutback significantly on the use of synthetic products. And then the following year it's going to be raining every other day and diseases are going to get absolutely out of control and they're going to need to rely more heavily on a fungicide."

Back in Australia, Nock sees growing use of microbial products on the farm as progress towards a deeper understanding of soil and plant biology supporting a greater shift towards sustainable agriculture.

She likens the microbial movement to the postwar green revolution which started in the 1960s, where technological advances in seed development and chemical fertilisers led to major advancements in farming.

"It feels like it's a bit of a wave," adds Nock. "I like to call it the 'unseen revolution' . . . we're [moving towards] really understanding the whole system."

Europe and Asia lag behind in conservation agriculture



Source: Kassam et al, "Successful Experiences and Lessons from Conservation Agriculture Worldwide", Agronomy 2022, 12(4)

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