



CASE STUDY: GWCT (ARABLE RESEARCH TRIALS)

Measuring what matters: quantifying the environmental cost and opportunity of legumes

At a time when nitrogen use, emissions and input costs are all under increasing scrutiny, understanding what's happening beneath the soil surface is becoming just as important as what's growing above it.

At Game & Wildlife Conservation Trust's Allerton Project, a working demonstration farm designed to bridge science and practice, that's precisely the focus. As part of the NCS project, the team has been exploring one of the more complex and often misunderstood parts of the system – greenhouse gas emissions from cropping, and how legumes might shift that balance.

For Jenny Bussell, head of agri-environmental sciences, the work sits firmly at the intersection of practical farming and detailed measurement, turning field-scale trials into insights that can inform both policy and practice.

"I head up the research side of the Allerton Project," says Jenny. "We've got a commercial farm, where we run trials and then translate those findings into something useful for farmers, policymakers and the wider industry."

From nitrogen use to nitrous oxide

The starting point for GWCT's involvement in NCS was clear. While legumes offer a well-established route to reducing reliance on synthetic nitrogen, the full environmental picture is more nuanced – particularly when it comes to emissions from soil.

"One of the key benefits of legumes is that they fix nitrogen," says Jenny. "That means you don't have to apply as much fertiliser, which is a big saving in terms of the environmental cost of producing nitrogen."

However, beyond fertiliser manufacture, the real focus lies in what happens after nitrogen enters the system, she continues. "When you have freely available nitrogen in the soil, denitrifying bacteria can convert it into nitrous oxide. And nitrous oxide has a global warming potential 296 times greater than CO₂."

Reducing fertiliser inputs therefore has a dual benefit – lowering both embedded emissions and the risk of nitrogen losses from the soil itself. "If you're not applying nitrogen, you reduce that pool of available nitrogen in the soil, and potentially reduce those emissions significantly," adds Jenny.

Trial design

To explore these dynamics in practice, the Allerton Project hosted a series of field-scale trials comparing different cropping approaches, with a particular focus on intercropping.

"We looked at a pea and oat intercrop, alongside peas on their own, oats on their own, and what we would normally grow – which in our case was spring beans," says Jenny.

The trial was designed to answer two key questions. Firstly, whether intercropping could improve the agronomic performance of peas, particularly on heavier soils such as those at Allerton. Secondly, how these systems compared in terms of nitrogen use, greenhouse gas emissions and overall protein production.

Importantly, the work extended beyond a single season. "We then followed that with a wheat crop the next year," says Jenny. "So we could look at how those different treatments affected the following crop – while still measuring nitrous oxide emissions."

Additional measurements were also taken at external trial sites, helping to build a broader dataset and capture variation across different systems and conditions.



A challenging year for measurement

As with many on-farm trials, the results were inevitably shaped by the season, and in this case, conditions were far from ideal for capturing emissions data.

"In all honesty, it wasn't a good year for measuring nitrous oxide," says Jenny. "We had a very dry year, and nitrous oxide is produced under waterlogged, low-oxygen conditions – so we didn't see much at all."

That highlights one of the key challenges in this area of research. Emissions such as nitrous oxide are highly dependent on environmental conditions, meaning short-term studies can struggle to capture the full picture. "You need multiple years to really understand what's going on," she adds. "Because if you get an unusual season, it can mask the differences you're trying to measure."

Headline insight

Despite those limitations, the work reinforces a consistent message emerging across the wider project – that legumes offer a clear opportunity to improve nitrogen efficiency within cropping systems. "There's a real lesson here in valuing legumes for replacing nitrogen," says Jenny. "Not just for environmental reasons, but for farm efficiency."

That efficiency operates on several levels, from reducing fertiliser inputs and lowering the risk of nitrogen losses, through to improving system resilience and reducing exposure to volatile input costs. "Nitrous oxide isn't just bad for the environment – it's lost nitrogen," she adds. "That's nitrogen that could have been used by the crop, but instead it's disappearing into the air."

Next steps

Looking ahead, the priority is clear: improving how emissions are measured and ensuring that data better reflects what is happening in the field over time.

"I'd ideally want continuous monitoring of the greenhouse gases emitted," says Jenny. "Because at the moment, it's very easy to miss when nitrous oxide is actually being produced."

More consistent measurement would allow researchers to capture emissions during key periods – such as fertiliser applications or residue breakdown – and better understand how weather patterns influence nitrogen losses.

Alongside this, there remains a need to better understand how nitrogen from legumes behaves within the system, she adds. "We still need to understand when that nitrogen becomes available, and when it's lost."

Understanding when and why those losses occur is therefore critical, both from an environmental perspective and in terms of improving overall farm performance.

Beyond single trials

While the field trials provide valuable insight, Jenny is clear that one of the most important aspects of the NCS project is its scale and joined-up nature. "My favourite part of the project has actually been what everyone else is doing," she says. "It's the breadth of it."

From feed trials replacing imported soya, to agronomic work on legume performance, through to supply chain and market analysis, the project spans the entire system.

"This isn't just about growing better legumes," notes Jenny. "It's about understanding the whole system – from production through to markets – and where the barriers really sit."

"Without that, you're just solving one small part of the problem. You're not going to change the system."

Making it matter on farm

Ultimately, the challenge is not just scientific, but practical – ensuring that these insights translate into decisions on farm. "I think a lot of farmers do care," says Jenny. "But they don't like being blamed."

Instead, there is a clear opportunity to reframe the conversation around efficiency, resilience and profitability. "Lowering inputs is the main way you become profitable – or at least resilient," she adds. "And resilience is something all farms are now looking for."

NCS Project

Nitrogen efficient plants for Climate Smart arable cropping systems (NCS) is a four-year £5.9m research programme aiming to enable UK farming to bring about a reduction of 3.4MtCO₂e p/a or 54% of the maximum potential for the industry through increased production and use of pulses. Led by PGRO it involves 200 UK farms and 17 partners. The project is funded by the Farming Futures R&D Fund: Climate smart farming, part of Defra's Farming Innovation Programme. Defra is working in partnership with Innovate UK who are delivering the programme.

