Covering the carbon cost

Cover crops are often promoted for their benefits to soil health, water quality and erosion control, but what role can they play in reducing the carbon footprint of arable systems? *CPM* explores the latest ADAS research.

By Charlotte Cunningham

Cover crops have become an increasingly familiar feature of UK arable rotations, valued for protecting soils, improving structure and retaining nutrients over winter. But as carbon accounting becomes an increasing priority for growers and supply chains, attention is also turning to their role in reducing greenhouse gas emissions.

According to ADAS crop physiology consultant, Ben Hague, understanding where emissions originate within crop production is key. "Nitrous oxide and carbon dioxide are the main drivers of greenhouse gas emissions associated with crop production," he explains. "Nitrous oxide has a warming impact around 265 times greater than carbon dioxide, so reducing nitrogen losses is a major opportunity for reducing the carbon footprint of arable crops."

Data from ADAS' YEN Zero network highlights the challenge, with Ben noting that carbon footprints range from around 750kg CO_2e/ha for pulse crops to more than 2500kg CO_2e/ha for high nitrogen-demanding crops such as winter wheat and winter oilseed rape – with nitrogen fertiliser accounting for much of those emissions. "As such, reducing the nitrogen input within crops is the big lever to reduce the overall carbon footprint."

Cover crops can contribute by capturing nitrogen that might otherwise be lost through leaching, and according to ADAS' head of crop physiology Pete Berry, this is where their greatest carbon benefit lies. "The majority of the benefit is going to come from reducing fertiliser use, and that's the main route for reducing carbon emissions," he explains.

ADAS research has shown a well-established cereal cover crop can typically take up around 45kgN/ha, while brassica and legume mixtures may capture as much as 90kgN/ha. However, success depends heavily on establishment timing. "We're really looking at establishing before early September to take up these levels of nitrogen," says Pete. "Anything later than mid-September significantly reduces nitrogen uptake and the potential benefits."

Great carbon benefits

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Making every hectare count

As growers look to reduce inputs without sacrificing output, three years of farmer-led trials have highlighted the potential of cereal-legume intercropping

While cover crops help retain nutrients already within the system, intercropping offers another route to improving nitrogen use efficiency by growing cereals and pulses together. Results from the Europe-wide LEGUMINOSE project suggest the approach can reduce reliance on fertiliser while improving productivity, grain protein and system resilience.

As first reported in August 2023 issue of *CPM*, the project involved partners from nine countries, with UK work delivered through a Soil Association Innovative Farmers Field Lab. Over three years, 26 farmer plots were established, with 17 producing usable results after weather disrupted some sites. Despite contrasting seasons, the Soil Association's Jerry Alford says that one finding has remained consistent. "In every year an intercrop produced more crop per hectare than had we had the monocrops," he states

Across the three years of trials, intercrops produced an average of 20% more output from the same area of land, with yield advantages ranging from 3% in the driest season to 27% in more favourable conditions.

For Jerry, consistency is one of the main strengths of the system. "The dry countries seem to have a much higher response to intercropping than wetter countries," he explains. "If we're moving to a time where dry springs become normal, it may be that intercrops provide more resilience."

That resilience is something Norfolk estate manager Matt England has seen first-hand on Fring Estate's organic land. "The first spring bean and oat intercrop immediately stood out. They were the best crop on the farm," he says. "They just looked healthier and better than everything else the whole way through."

More output from intercropping

Across the three years of LEGUMINOSE trials, intercrops produced an average of 20% more output from the same area of land, with yield advantages ranging from 3% in the driest season to 27% in more favourable conditions, explains the Soil Association's Jerry Alford.

Since then, he's trialled combinations including peas and oats, beans and oats, winter beans and oats, peas and barley, and more recently wheat, beans and linseed as part of the Field Lab.

One of the best performers was a pea and barley intercrop, delivering a gross margin of around £2000/ha. "We had a lot of peas in it which sold for £590/t; the barley sold for £280/t at 4.5t/ha, so it was a really successful crop."

Jerry believes the success comes from the complementary nature of the two crops. "In a bad year for pulses, the cereals tend to hold up, and in a better year for pulses they can really perform. You have that resilience coming from the mixture."

University of Reading's Professor Tom Sizmur, who leads the university's involvement in the project, agrees. "The intercrop hedges your bets," he explains. "In some years the cereal might do well and in other years the pulses might perform."

Alongside yield improvements, the trials also highlighted gains in nitrogen use efficiency. Across the wider European project, grain protein levels averaged around 1% higher than equivalent monocrops, while UK work also showed improvements in cereal grain protein.

Tom says this reflects the interaction between cereals and legumes below ground. "The legume is fixing nitrogen from the atmosphere in the root nodules and some of that nitrogen can be transferred to the cereal," he explains.

At the same time, the cereal competes strongly for soil nitrogen, encouraging the pulse crop to fix more atmospheric nitrogen and improving overall nitrogen use efficiency. However, these benefits decline as fertiliser rates increase.

"Some of the benefits that you get from the intercrops start to diminish as the fertiliser rate increases," says Tom.

Jerry believes this demonstrates where the system is likely to fit best. "It certainly looks like it performs in organic and low-input systems better," he says.

The environmental benefits extend beyond nitrogen use, and University of Reading research has demonstrated reductions in nitrate leaching and nitrous oxide emissions compared with monocrops. Ongoing work is also investigating whether intercrops could increase soil carbon storage through the interaction of cereal and legume residues.

The trials went on to highlight potential pest management benefits, and although no insecticides or fungicides were used by UK trialists, only one grower reported disease levels high enough to consider treatment.

Monitoring also found greater numbers of beneficial insects within intercrops, points out Jerry. "By having that mixture, we're bringing the beneficials in a lot faster."

Tom adds that pea and oat intercrops contained significantly higher levels of parasitised aphids than monocrops, suggesting natural enemies may help suppress pest populations. He notes that the cereal component can also provide valuable physical support for the pulse crop. "When you look at the peas in the intercrop, the pea plant is a lot straighter because it uses the oat as a scaffold," he explains. "The oat plant helps hold up the peas, and so you can harvest more of it with the combine."

However, for growers considering the approach, the greatest challenge may come after harvest. "The key is knowing what you're going to do with it at the end," says Matt.

While growing the crop is relatively straightforward, separating species can be expensive and time consuming, particularly for premium human consumption markets. Nevertheless, Matt believes the system is worth exploring. "Just try it on a small scale," he advises. "Even a hectare block in a field.

"We've seen that crops respond better when grown together. Each species has requirements for nutrients, sunlight and moisture at different times. The more diversity you can get within a single point in the rotation, the better."

▶ The effect on nitrate leaching can also be dramatic, explains Pete. In one ADAS trial on a light, freely draining soil, nitrate losses from uncropped stubbles reached 90kgN/ha over winter. Where cover crops achieved 80-90% ground cover, losses fell to less than 10kgN/ha.

Another study found cover crops retained 70-80kgN/ha within crop biomass by spring, protecting nutrients until they could potentially be used by the following crop. "The cover crop has protected that nitrogen against nitrate leaching," comments Pete.

Current UK guidance suggests a successful cover crop can justify reducing subsequent fertiliser applications by around 30kgN/ha. However, Pete stresses that this depends on mineralisation, with nitrogen release influenced by several environmental and management factors. "One of the most important things growers can do to maximise the chance of that nitrogen becoming available is to destroy the cover crop quite early," he explains. "By quite early, we'll be destroying it in January or February."

Termination method also matters, with ADAS' research suggesting herbicide destruction can improve nitrogen availability compared with some mechanical approaches. "We actually found that using glyphosate to destroy the crop is more effective at enabling the release of the nitrogen from the cover crop for the crop following it," notes Pete.

Of course, cover crops aren't without their own emissions costs. ADAS estimates greenhouse gas emissions associated with establishment and destruction range from around 20kg CO_2e/ha to more than 160kg CO_2e/ha, depending largely on species choice and management. "If you were simply broadcasting mustard seed and then using glyphosate herbicide to destroy it, then you'd be at the lower end of the range," says Pete. "If you were using larger-seeded species such as peas or beans and mechanically destroying the crop by disking or chopping it, then you're looking at more than 160kg CO_2e/ha."

Even so, he argues these emissions remain relatively small when compared with the 700-2500kg CO_2e/ha carbon footprints typically associated with cash crops – particularly where cover crops allow nitrogen fertiliser savings.

However, cover crops don't automatically improve following crop performance, and ADAS trials have recorded both yield increases and reductions, with management proving the deciding factor. "Where we've seen a yield reduction following a cover crop, it's been largely due to late destruction, often using mechanical methods in wet conditions," says Pete.

Capturing nitrogen

When it comes to capturing nitrogen ADAS research has shown a well-established cereal cover crop can typically take up around 45kgN/ha, while brassica and legume mixtures may capture as much as 90kgN/ha.

Heavy soils can be particularly challenging, as large amounts of residue combined with wet weather can delay drilling, encourage slugs and compromise crop establishment, he warns. "It's especially important in these cases to have a decent long window between destruction of the cover crop and establishment of the following crop."

Mixed farms can also gain additional value by grazing cover crops, although this also requires careful management. ADAS has observed increased nitrate leaching where crops are grazed too tightly or too early, as nitrogen captured within the crop is rapidly returned to the soil through dung and urine. "If the grazing occurs quite early on in the winter, then we've actually seen quite a lot of nitrate leaching," comments Pete.

To minimise losses, ADAS recommends grazing as late as practical while retaining at least 20% ground cover. "Our advice is that if you're grazing and you want to minimise those nitrate leaching losses, then you should graze as late as possible in winter and also try to leave a bit of crop cover," he adds.

While reducing carbon emissions is becoming an increasingly important objective for growers, Pete believes it should be viewed as one of several benefits associated with cover crops rather than the sole driver for adoption.

Reduced nitrate losses, improved soil protection, enhanced biodiversity and opportunities for winter grazing all contribute value, while many of the wider soil benefits become more apparent over time. "Cover crops must be viewed as part of the whole farming system," he says. "When they're managed well, the benefits go far beyond carbon alone." ●