Final Project Summary

Project title	Maximising the benefits from cover crops through species selection and crop management (Maxi Cover Crop)		
Project number	21140009	Final Project Report	PR620
Start date	01/08/2016	End date	31/01/2020
AHDB Cereals & Oilseeds funding	£230,000	Total cost	£315,300

What was the challenge/demand for the work?

Cover crops are grown primarily to 'protect or improve' soils between periods of regular crop production. They can be effective at improving soil functions by increasing soil nutrient and water retention, improving soil structure/quality, reducing the risk of soil erosion, surface run-off and diffuse pollution by providing soil cover and by managing weeds or soil-borne pests. Factors to be considered when using cover crops include rotational conflicts, which may affect the yields of following cash crops, increased weed pressure and increased costs. For the benefits of cover crops to be fully realised, understanding what different cover crop species can achieve and how to manage them on different soil types and rotations is crucial. A recent survey of UK farmers indicated that the three most common reasons for not growing cover crops were: (i) they did not fit with the current rotation, (ii) expense and (iii) difficulty of measuring their benefit. Understanding the effects of different cover crops on soil properties, yield and other ecosystem services is essential to realise the potential benefits and encourage greater uptake of cover cropping in arable and horticulture systems.

How did the project address this?

The Maxi Cover Crop project has characterised the performance of a range of cover crop species, both individually and in mixes of increasing complexity, under field conditions. The study has measured the impact of cover crops on soil properties (structure, nitrogen supply and biological activity), provided new data on cover crop rooting and evaluated the performance of the subsequent two crops in the rotation. Work was undertaken at three replicated large plot experimental sites (Stetchworth in Cambridgeshire, Kneesall in Nottinghamshire and Wilberfoss in East Yorkshire), evaluating the performance of seven cover crop species (including cereals, brassicas, legumes and 'others' – phacelia and buckwheat) and three mixes of these species, with an untreated control (weedy stubble). A key feature of this project was the use of eight tramline trials on commercial farms (in Kent, Yorkshire and two farms in Cambridgeshire) using field-scale comparisons to complement the work at the experimental sites. Results from these sites extended the database to cover a wider range of soil types. Four tramline trials evaluated two of the cover crop mixes used in the experimental sites, and four evaluated various methods of establishing the cover crop mixes (with varying levels of soil disturbance). Measurements included: cover crop rooting, yield and nitrogen uptake, soil mineral nitrogen levels, soil structure and earthworm numbers, cash crop rooting and yield. A cost benefit analysis was performed for all of the experimental and tramline trial sites used in the project.

What outputs has the project delivered?

The Maxi Cover Crop project has shown that:

- Early establishment (August rather than September) is important to maximise the benefits of cover crops, particularly to ensure good crop cover and nutrient recovery. Typically, the different cover crops yielded between 1 and 3 t/ha aboveground biomass and took up between 30 and 50 kg N/ha, although up to 90 kg/ha N was recovered following early establishment at one of the sites.
- Highest N recovery was achieved by using either species that were able to fix N from the atmosphere (i.e. clover and vetch) or establish good above or below ground biomass, early in the season (e.g. radish, phacelia and rye).
- Rye produced the largest root length early in the season. Phacelia also rooted well although the roots were slower to develop. By the time the cover crops were destroyed (February), phacelia had produced the greatest amount of roots, particularly in the topsoil, and it also had the narrowest roots, suggesting it explored more of the soil for a given root biomass compared to the other cover crop treatments. There was no relationship observed between the amount of cover crop rooting and rooting of the following spring cash crop.
- Soil structural improvement from a single year of cover cropping was difficult to detect. However, at two of the tramline trial sites with medium textured soils, penetration resistance, bulk density and visual structural scores were lower (i.e. ‘better’) where cover crops had been grown indicating improved soil structure and workability. Earthworm numbers were also increased where a five species mix (comprising phacelia, oats, oil radish, clover and buckwheat) had been grown.
- Cover cropping on heavy textured soils can result in increased topsoil moisture content, probably as a result of the vegetative cover preventing evaporation from the soil surface. Late destruction and incorporation of a high cover crop biomass (< 1 week prior to drilling) resulted in poor seedbed conditions for the establishment of the following cash crop, which led to lower crop yields.
- Cereal cover crops (as a single species) should not be grown ahead of a spring cereal cash crop. At the experimental sites, spring barley establishment, rooting to depth and grain yields were all reduced following oat and rye cover crops. The reason for this is uncertain, but N immobilisation, and pest and pathogen carry-over (‘green bridge’) have been cited as possible causes.
- A buckwheat cover crop may enhance P availability to the subsequent cash crop. At the experimental sites, there was a trend for higher phosphorus concentrations in spring barley grain

following a buckwheat cover crop compared to the control (volunteer/weeds). It is uncertain what the mechanism is for this, as rooting by the buckwheat and total above ground biomass production was low compared to the other species evaluated.

- A single year of cover cropping does not improve gross margins. Nearly all the cumulative (2 year) margins calculated across the sites (20 comparisons) showed a reduction in margin from growing a cover crop compared to no cover crop (ranging from + £64/ha following oil radish on a clay loam to - £476/ha following a two species mix on a clay soil). The lower margins were caused by an absence of sufficient yield increases to compensate for the additional seed and establishment costs. The benefits from changes in soil physical properties or nutrient dynamics are unlikely to appear within the 2 years of the project so the longer-term use of cover crops over a full rotation (including more than one year of cover cropping) is required to fully assess the impact on margins. Moreover, non-tangible benefits such as improved water quality, erosion control and enhanced biodiversity should be considered as a wider public good.

The project has featured at a wide variety of knowledge exchange events: open days, farmer meetings, scientific conferences and in popular press articles. A template has also been produced for growers to perform a cost/benefit analysis for using cover crops in their own rotations.

Who will benefit from this project and why?

The results from the Maxi Cover Crop project will feed directly into new cross-sector guidance on cover cropping being developed by AHDB, providing new information on how different cover crops perform in UK soils and how to manage them. This will be of direct benefit to growers and agronomists, with the aim of encouraging more effective use of cover cropping across the arable and horticultural sectors.

The wider societal and public benefits from using cover crops include improved nutrient retention, reduced nitrate leaching and reduced erosion and surface run-off. Improvements in soil structure will also improve water regulation (reduced compaction and lower flood risk) and air quality (reduced greenhouse gas and ammonia emissions). The results are therefore of value to policy makers providing evidence and guidance to support the move from basic payments to payments for public goods and services. For the general public the benefit comes from improved air and water quality, reduced risk of flooding and increased biodiversity.

If the challenge has not been specifically met, state why and how this could be overcome

Maxi Cover Crop has advanced our knowledge of the physiology and performance of a range of cover crop species, particularly in relation to the way they root, take up nitrogen and affect the performance of the subsequent cash crops. It has also provided useful insights into the practicality of using cover crops across a range of soil and climatic conditions and provided data on the cost and benefits of

including cover crops in rotations. However, there are still a number of important knowledge gaps that the project was unable to address and that prevent more widespread use of cover crops, particularly: • How to destroy cover crops to maximise the benefit and move away from a reliance on glyphosate • Understanding when nitrogen taken up by the cover crop is released, and the impact of this on nitrogen fertiliser recommendations and over-winter nitrate leaching • Understanding the longer-term effects of repeated cycles of cover cropping on soils, crop yields and farm economies

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Industry partners	Amazone Ltd, Cousins of Emneth Ltd, Hutchinsons, RAGT Seeds Ltd
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