SIP

SUSTAINABLE INTENSIFICATION RESEARCH PLATFORM

SCIENCE, POLICY AND PRACTICE NOTE 3

The Role of Cover Crops within Sustainable Soil Management

The Issue

Healthy soils are vital, not only for the long term performance of farming systems but also their wider implications for soil erosion, water pollution and flooding risks. Cover crops can contribute to enhanced soil sustainability, as well as providing other benefits for farming and land management. They have been found to improve the soil structure and enhance soil biology, depending on cover crop type and circumstance. However, cover crops can sometimes create challenges for farmers, such as conflicts within crop rotations. There is a need for more information, particularly from long-term and field-scale studies. Beneficial effects on the soil, crop performance or the environment may only become apparent after several years or over a large area. Much of the research outlined in this Science, Policy and Practice Note is based on on-going long-term research to address these issues.

Cover crops are crops grown when the soil would otherwise remain bare, usually in the autumn and winter prior to establishing a spring-sown crop. However, they can also follow an early harvested crop, prior to establishing an autumn-sown crop. They are primarily used to improve soil structure and biological activity, making the soil more resilient, for example to adverse weather conditions. Examples include mustard, radish, grasses, buckwheat, Phacelia, vetches and clovers or usually mixtures of these. They can be ploughed in as a green manure afterwards, although more commonly they are sprayed with glyphosate herbicide in order to kill weeds within the field at the same time, before the spring crops are drilled. Some may be used or grazed as forage for livestock.

SIP's Response

As one component of the Sustainable Intensification research Platform (SIP), farming practices with the potential to improve crop or livestock productivity and at the same time deliver environmental benefits were evaluated on a number of Study Farms.

Building on previous research initiatives and linked to on-going projects, SIP work at Morley (NIAB TAG) in Norfolk on a sandy loam soil and at Loddington (Game and Wildlife Conservation Trust (GWCT) in Leicestershire on challenging clay soils, has been examining the effects of cover crops and their interactions with tillage system on soils, environment and on crop yield.

Morley Cover Crop Studies

Studies on cover crops were undertaken at a range of scales at Morley and in the nearby Wensum study area.

1. The New Farming Systems project based at Morley includes a large replicated plot experiment that was established in 2007. It is examining cover crop and tillage system effects on the output and sustainability of conventional arable farming systems. The SIP study has involved a comparison of three tillage approaches:

- plough;
- shallow non-inversion (around 10 cm);
- deep non-inversion (around 20 cm);

all with or without cover crops, within a rotation, based on winter wheat alternating with spring-sown combinable crops. The brassica cover crop, radish (*Raphinus sativus*), was sown as autumn cover before spring crops. Combinable crops grown over the period 2008 to 2017 included spring oilseed rape, spring beans, spring barley, winter oilseed rape, spring oats and winter wheat.

2. Split commercial field studies lasting between one and three years were undertaken on five fields, to investigate the benefits of over-winter crops on the following crop performance, soil nitrogen retention, and soil earthworm population. Cover crops used were: legumes, such as clover and vetch; grasses and cereals, such as black oats; brassicas, such as radishes; and other commercial mixes. They were planted in field strips prior to a sugar beet crop, and compared to areas with no cover crops.

3. The Wensum Demonstration Test Catchment project aims to help farmers to reduce diffuse water pollution from agriculture using land management measures. As part of this project, nine whole fields at Salle Farm had been split between three blocks, to compare conventional ploughing without cover crops to minimal tillage and direct drilled approaches that both included cover crops. This enabled the SIP study to examine system effects on crop performance and soil properties at a larger scale.

Loddington (GWCT) Cover Crop Studies

The research at Loddington tested the potential benefits of cover crops on challenging clay soils. The particular focus was on improving soil structure and organic matter, retaining nutrients, limiting erosion and black-grass control. Over three years a series of cover crop experiments were performed, assessing the impact of different cover crop mixtures on a field scale. For example, a rigorously designed and replicated experiment examined three different mixtures prior to a direct-drilled spring oat crop. These were:

- oats and Phacelia (C+P);
- oats, Phacelia and radishes (oil and tillage) (C+P+R);
- oats, Phacelia, radishes and legumes (vetch and clovers) (C+P+R+L).

A bare, over-winter stubble was used as a control plot in each of the three fields in which the experiment was replicated. Data were gathered on soil physical, chemical and biological properties (including earthworm activity). The economics of the various cover crops were evaluated.

What SIP Learnt

Key Findings from the Morley Cover Crop Studies

- Positive crop yield responses were observed where a brassica cover crop (radish) was included in the rotation, but not with all tillage systems or in all years.
- The most consistent yield benefits were observed from cover crops within the shallow non-inversion tillage system (for example see Figure 1 showing response of winter wheat yield to cover crop use and cultivation system).
- In the shallow non-inversion tillage system, the only appreciable negative yield effect was on winter oilseed rape grown after repeated use of a brassica cover crop in the rotation.
- The cost of regularly including a cover crop in a winter wheat/spring break rotation may not be fully recouped by an increase in crop output, even when used in a shallow non-inversion system. However, depending on the cover crop cost, shallow non-inversion with a cover crop can produce a higher margin than a plough/no cover crop system.

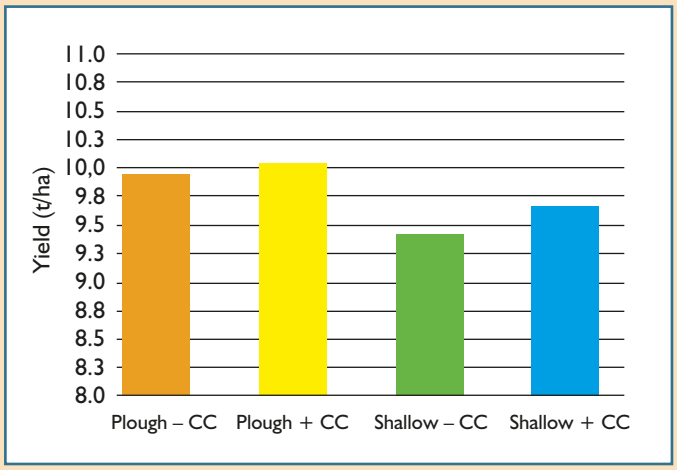

Figure 1. Response of winter wheat yield (mean values over four years) with and without cover crop use (CC) and comparing ploughing with shallow non-inversion cultivation

A number of soil related benefits from cover crop inclusion were observed in the Morley studies, including:

- **increased earthworm numbers** in the soil, prior to sowing spring crops, where a cover crop had been grown in the autumn;
- uptake of available nitrogen by cover crops during the autumn, resulting in a **reduction in the amount leached to depth** in the soil by the spring.

Key Findings from the Loddington (GWCT) Cover Crop Studies

- **Improvements in soil structure** were recorded through the winter where a cover crop had been used, compared to an over-winter stubble area.
- All cover crops **suppressed grass weeds** to a certain extent, both within the cover crop and in the following crop.
- **Higher yields** in the following cereal crop were obtained – the average increase in oats yield associated with the cover crop use was 0.5 tonnes/ha (35%), worth around £60/ha.
- Some cover crops **improved the activity of earthworms and millipedes, with potential benefits for organic matter incorporation** (see Figure 2 showing the abundance of earthworms in soils planted with different cover crops compared to no cover crops).

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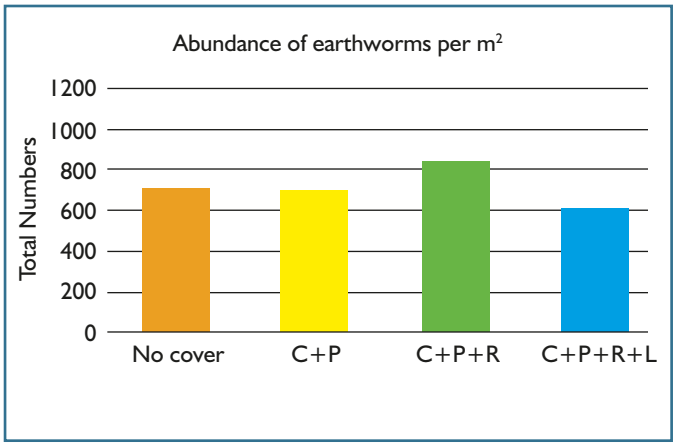

Figure 2. Abundance of earthworms in soils planted with different cover crops, compared to no cover crops

Opportunities for Policy and Practice

The implications of this research for policy and practice are as follows.

Benefits of Cover Crops

The cover crop research has indicated a number of potential benefits including improved soil structure, soil biology (with an increase in earthworm activity) and organic matter, weed suppression and possible increased crop yields. Wider implications of improved soil properties are reduced nitrate leaching, and enhanced water flow through soil thereby helping to reduce flooding and soil erosion.

Barriers to Cover Crop Use

There are also barriers to the use of cover crops, including: their establishment; predictability; rotational complications and cost. Farmers need to be clear about the purpose of the cover crop and need to choose cover crop species and appropriate management systems that fit in with their own situation.

Training and Further Research

With financial benefits not certain, identifying ways to improve the reliability and reduce the cost of establishing cover crops (and the crops that follow them) is essential. More research is needed to aid the evaluation of cover crop effects under different situations, including soil types and weather conditions. Training for farmers on good management practices and provision of information on cover crop benefits would be beneficial.

Authors

Nathan Morris (Farming Systems and Soils Specialist, NIAB TAG, Morley, Norfolk)

Felicity Crotty (Soil Scientist, GWCT, Loddington, Leicestershire)

Caroline Kettlewell (Technical Author, Harper Adams University, Shropshire)

Further Resources

Stobart, R., Morris, N., Hinton, N., Fielding, H. and Stoate, C. (2016) *Evaluation of sustainable soil management and cover crop practices*. 14th ESA Congress, Scotland

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The Sustainable Intensification Research Platform (SIP) is a multi-partner research programme comprising academia, farmers, industry experts, environmental organisations, and policymakers.

Funded by Defra and the Welsh Government, the platform explores the opportunities and risks of Sustainable Intensification (SI) from a range of perspectives and landscape scales across England and Wales.

The Platform, run from 2014-17, has investigated ways to increase farm productivity, reduce environmental impacts, and increase the benefits that agricultural land provides to society.

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More Information

Visit: **www.siplatform.org.uk**

Contact: Nathan Morris (NIAB) nathan.morris@niab.com

Felicity Crotty (GWCT) fcrotty@gwct.org.uk

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