December 2021

Annual Project Report

On-farm trials at

Strategic Cereal Farm East

(harvest 2021)

CONTENTS

1. Managed lower fungicide inputs trial

Objective

To test whether a managed approach to lowering inputs can be used at different application timings without compromising yield but improving the cost of production.

Why test a managed lower fungicide input programme?

Disease management in cereals is a challenge. Loss of chemistry and fungicide resistance means that we need new ways to manage cereal diseases.

Our projects help support farmers and agronomists to manage cereal diseases. AHDB's **fungicide performance research** provides information on the effectiveness of new products.
The **Recommended List** can help with selecting the best varieties for your farm.

This trial tests the cost-benefit of high and low-cost input programmes.

How is the managed lower input fungicide trial run?

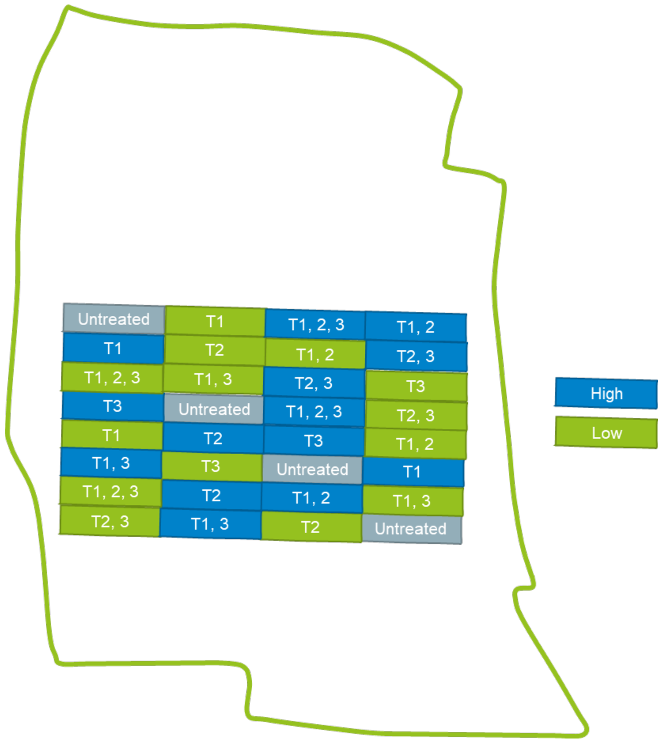
The trial design includes untreated plots and seven timing treatments (T1, T2, and T3 combinations).

There are two replications of each treatment and four untreated plots. Each plot is 100m x 30m. The field team from NIAB complete assessments in four locations within each plot, measuring 3m x 2m.

The replicated plot trial is in Barn Field in Gleam winter wheat. Strategic Cereal Farm East host, Brian Barker, drilled the trial on 17 October 2020 at a rate of 205 kg/ha. The main soil type is sandy loam.

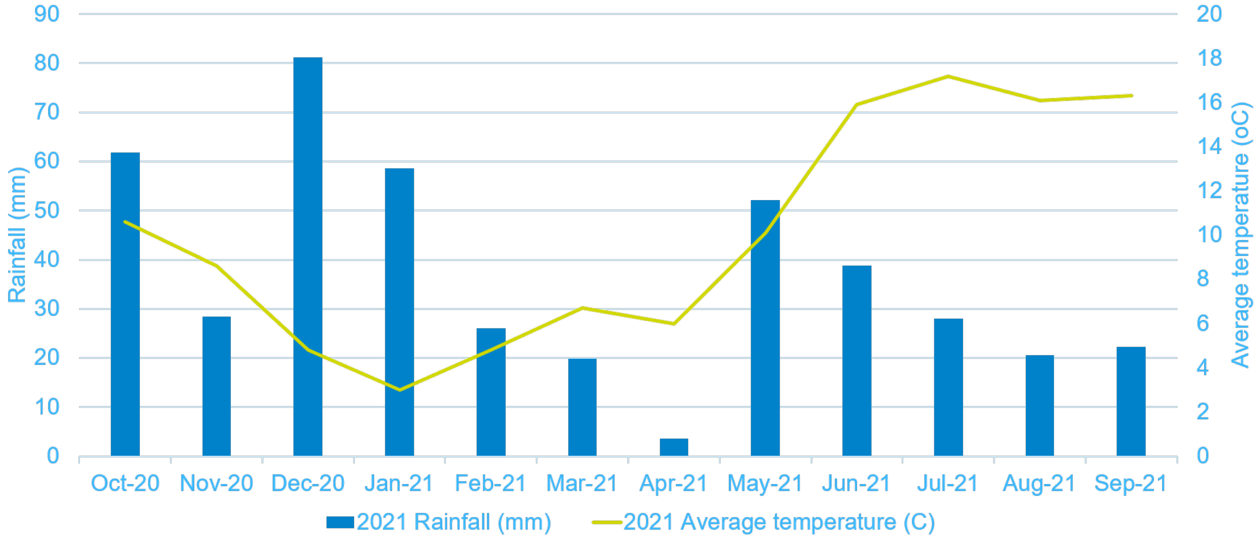
Treatment applications

Timing	Low		High	
	Product	Rate (l/ha or kg/ha)	Product	Rate (l/ha or kg/ha)
Autumn Boost			Epsotop	8
			YaraVita Mancozin	1
			YieldOn	1.5
T1	3C Chlormequat 750	1	3C Chlormequat 750	1
	Firefly 155	1	Bugle	1
	Headland Boron	0.125	Headland Boron	0.25
			Tempo	0.1
			Tubosan	0.5
T2	Epsotop	5	Epsotop	4.167
	Headland Boron	0.25	Headland Boron	0.5
	Verydor XE	0.8	Verydor XE	1.5
			YieldOn	1.5
T3	Firefly 155	1.15	Bridgeway	2
			Firefly 155	1.5



What were the growing conditions like?

Across the growing season, temperatures were lower than the long-term average for the area. In the months of March, April and May, the temperatures were particularly low. These months were generally much drier than the average, with May being the exception. This was preceded by another wet autumn, particularly December and January.



Graph: weather data for harvest 2021 at Strategic Cereal Farm East

Results from the lower input trial

- Managing inputs requires a tailored approach for product choice and rate, but shouldn't involve completely dropping applications in a sequence
- A lower T1 was appropriate, but using stronger chemistry at T3 was necessary
- The most expensive programme supported the highest yielding crop, however this was not the most profitable approach
- Low input levels were generally associated with a better gross margin, however this trial had low levels of disease and may not be reflected across future years

Disease infection

Disease levels were very low (15% septoria tritici infection on Leaf 2 in untreated plots). The dominant disease was septoria tritici, although yellow rust did develop at low levels later in the season. Fusarium was more present in crops this season and in this trial an average of 1.4% was detected in plots that were untreated at T3.

This is due to a combination of the late autumn drilling date and robust variety selection. The local weather conditions before the T1 application (07/05/2021) were ideal for preventing disease infection. Rainfall between February and April was approximately 55% of the long-term average.

Since sowing, temperatures have been around 5°C below the long-term average, and since November 2020 the temperatures haven't gone above 10°C. These conditions are not conducive to the initial infection and spread of septoria tritici and yellow rust. In the days before the T1 application, it was humid with regular rainfall and higher temperatures. This is likely to drive the spread septoria infection already detected in the crops' lower leaves.

June 2021 Assessment:

Yellow rust

An average of 3.7% was recorded across the untreated plots, however the foci were still very distinct and patchy. The average of rust levels, where recorded in the untreated, was 10% on Leaf 1. Yellow rust was much easier to spot in the treatments that did not have a T2 application. But in the plots that did have a T2, the research team didn't record any yellow rust.

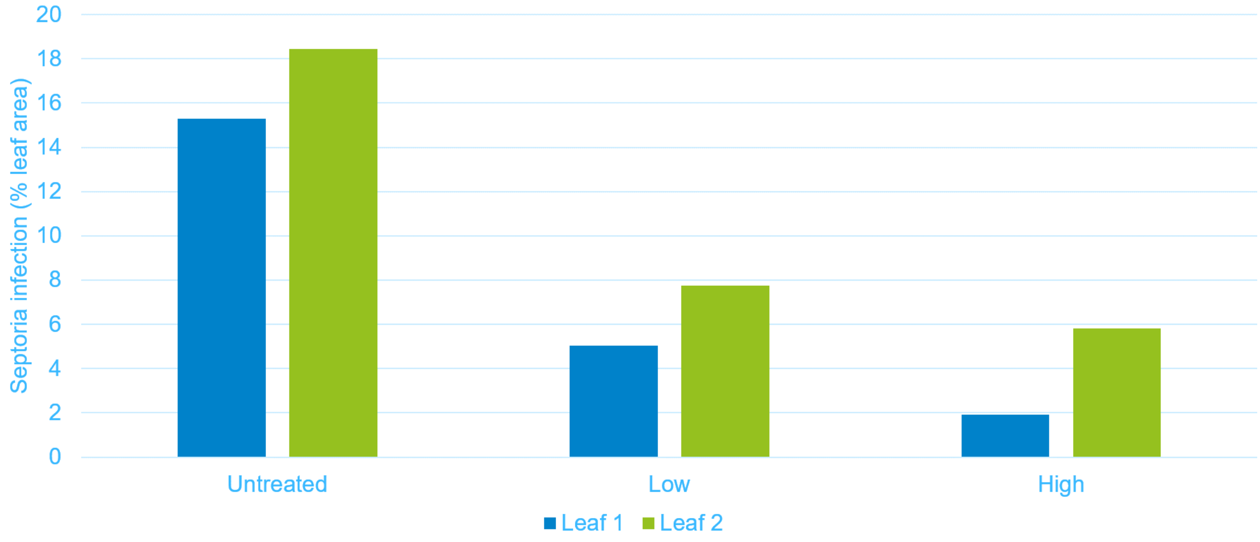
Septoria

Septoria is rather more rampant. Infection moving a whole leaf layer up since the last assessment. The research team only assess active disease and so they assess green leaf area (GLA) (%) at the same time.

The GLA assessments showed some surprising results in the untreated plots. Septoria has moved through the plant so there is less disease on Leaf 4 in the untreated compared to a treated plot. The graph on page 7 shows a summary of the GLA% score from the treatments that are currently the same (pre-T3). While differences are not large, the GLA is lower in the 'Low' input level with inconsistent differences between the fungicide treatments.

What was the impact of fungicide inputs on disease control?

The use of fungicides was able to significantly reduce the disease levels in the crop, regardless of overall input level. There was a small non-significant decrease in the septoria infection associated with the increasing input level on the suppression, and prevention, of disease infection in this trial when compared across all treatment timings.



Graph: The level of septoria infection recorded in one month after T2 application on Leaf 1 and Leaf 2. Pooled across application timing factor.

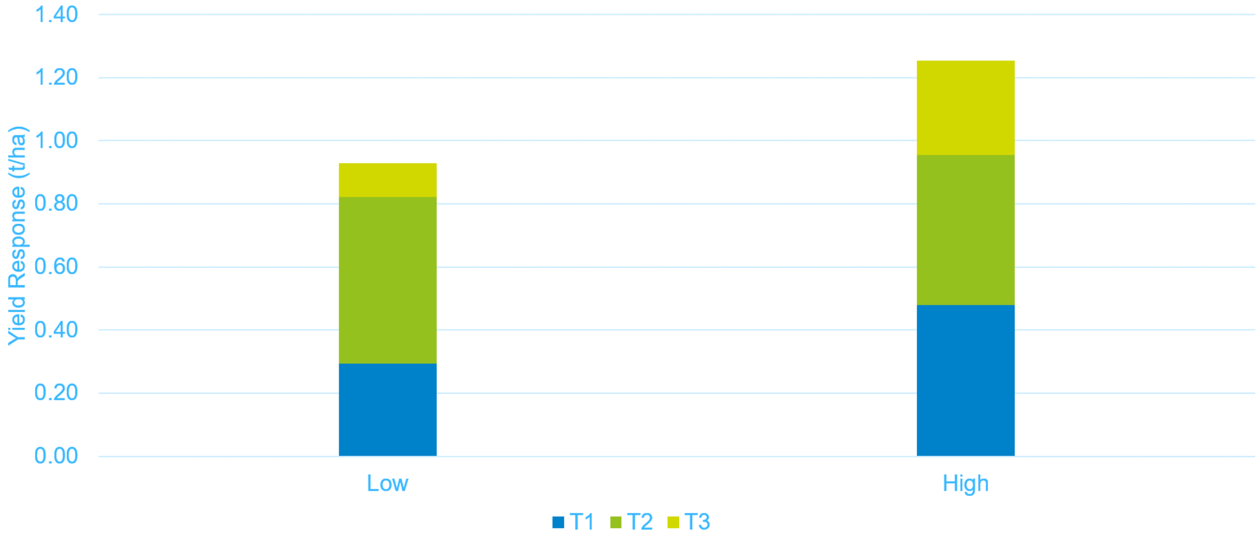
What was the impact of fungicide inputs on yield?

The trial average yield was 9.71 t/ha, slightly above the long-term performance of the field as a first wheat. Fungicide input level was a significant factor when influencing crop yields in this trial. The low input level increased mean yield by 0.48 t/ha, and the high input by 0.75 t/ha. These increases were both significant above the untreated.

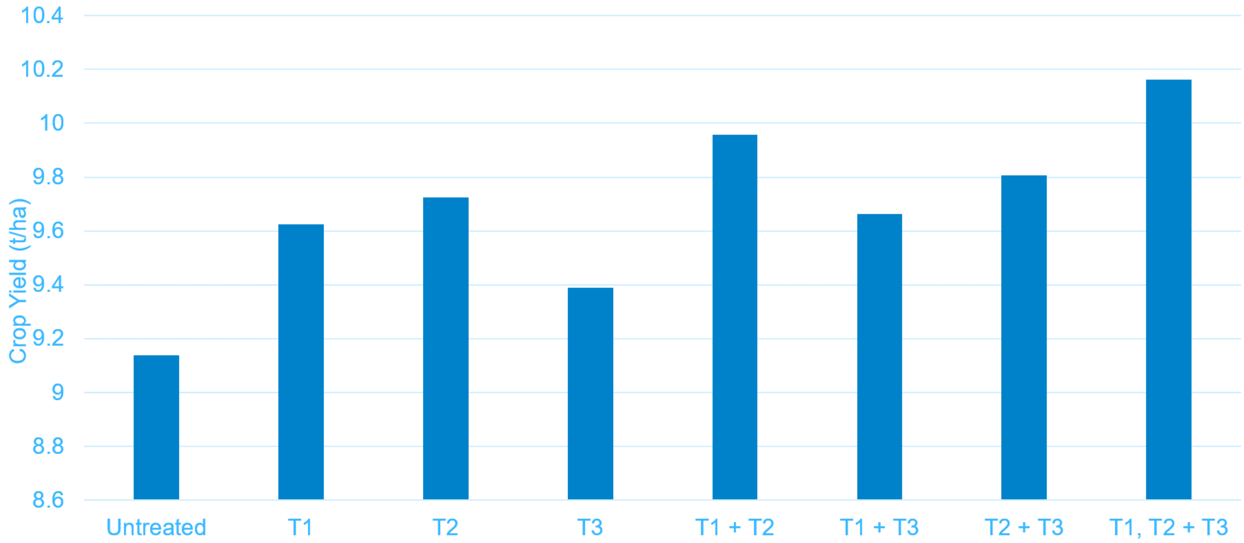
Fungicide response

Comparing across the two levels of inputs, it is clear that the additional spend was most beneficial at T1 and T3, albeit with contrasting reasons. At T1, the additional chemistry has improved the protectant element of the programme with an SDHI (fluxapyroxad) providing more robust protection from incoming disease. This is in comparison to the prothioconazole and fluoxastrobin combination used in the low input. At the T3 application, the higher product rate was more effective at controlling the yellow rust that was present and the fusarium infection that was developing.

At T2, there was no difference in yield response between the approaches, largely as a result of the lower dose of Revystar XE having sufficient activity in a low disease year. However, it was the single most important timing in terms of total yield protected, and when compared across input level was more effective than the T1 & T3 combined. This demonstrates the need for a flexible approach across the year, and that insufficiently protecting crops at key timings can severely harm the yield potential of crops.



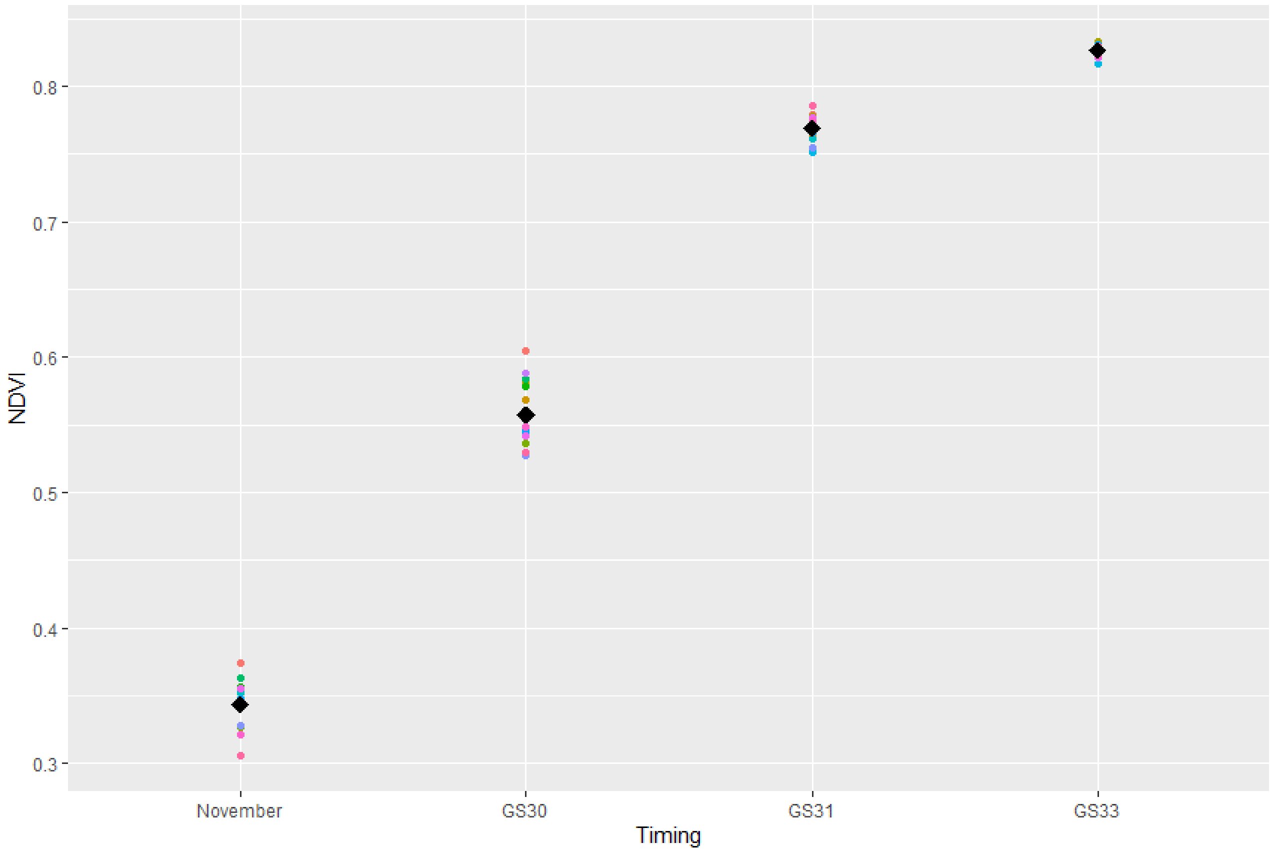
Graph: yield response from each application timing across fungicide inputs



Graph: crop yields when pooled across input levels

The field team at NIAB also monitored the crop normalised vegetation difference index (NDVI) to measure the uniformity of crop establishment and the timing of senescence.

Data analysis showed statistical differences in NDVI between the plots in November and at growth stage 30. This result is not surprising due to field variability that affects crop establishment. During the growing season, these differences reduce. The crop compensates by increased tillering in areas of lower density. After growth stage 31, there are no differences.



Graph: NDVI results across the season. The black diamonds indicate the means from each timing.

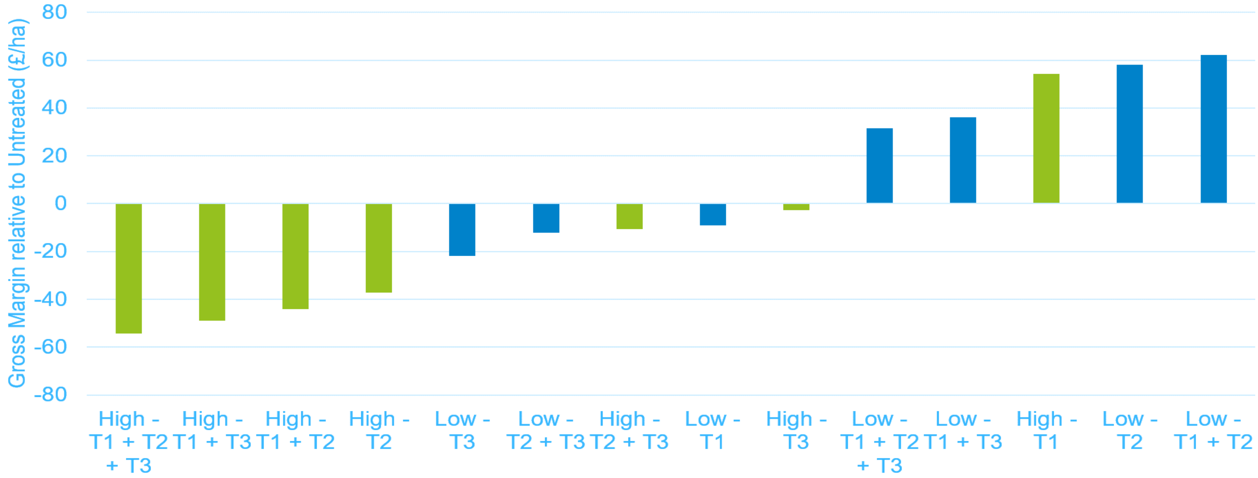
There was no correlation between the final yield and the NDVI assessments at any of the assessed timings. But there was correlation between the late season Green Leaf Area (GLA) scores from Leaf 1 and Leaf 2, and final yield. This reiterates the importance of maintaining clean, green leaves for as late as possible in the season to maximize yields.

Gross margin analysis

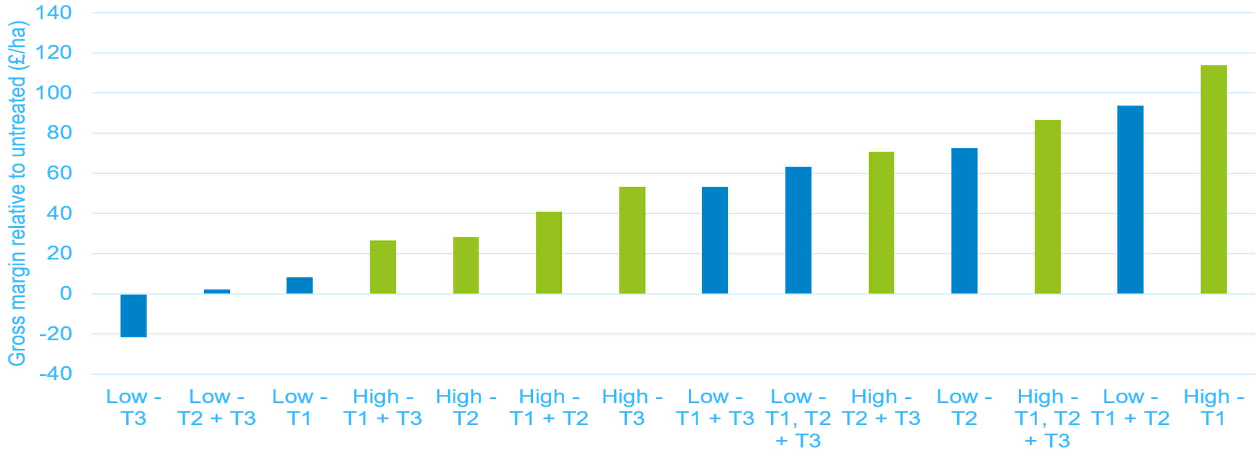
A predicted gross margin has been calculated for each treatment, using the untreated plots as a baseline. The high input plots perform very poorly in comparison, with lower input levels the most impressive.

When removing the additional products added (bio-stimulants, micronutrients etc), particularly to the 'high' input plots, the balance of power shifts. Almost all treatment combinations perform better than the untreated.

This trial did not test for the contribution of these products in isolation. But the results strongly indicate that if benefits exist they are not contributing to profitable crops when used alongside high levels of fungicide.



Graph: The gross margin of each treatment relative to the untreated, ranked lowest to highest



Graph: the gross margin of each treatment minus costs of non-fungicide products, relative to the untreated, ranked lowest to highest

Results from previous fungicide trials at Strategic Farm East

- This trial adds to the work carried out at Strategic Cereal Farm East in 2018/19 and 2019/20
- In both of these years, the project focused on the interactions between varieties and agronomy programmes
- Harvest 2019 and 2020 were low disease pressure seasons. Results showed that growing more resistant varieties with a low input programme produced the best net margin
- There was a minimal yield response to increasing fungicide spend on the resistant varieties
- The low input programmes resulted in the best net margins
- The highest percentage of septoria was seen on the most susceptible variety, Santiago
- More resistant varieties (i.e. Graham and Siskin) tended to hold onto green leaf area for longer

2. Reducing nitrate leaching with cover crops

Objective

To determine the role of cover crops in reducing nitrate leaching losses across a rotation.
Essex & Suffolk Water analysed water collected from land drains in 2017/2018 and showed that cover crops improve water quality. There is evidence that cover crops reduce nitrate leaching, but their benefits across the rotation are still not clear. The establishment of cover crops and the next cash crop is not always straight forward and this impacts nitrogen uptake. There are questions about when this nitrogen is released across the rotation.

Testing impact of cover crops on nitrate

This split field trial uses two fields:

Appletree

- 10.06-hectare field
- Cultivated using a plough
- Sandy loam soil

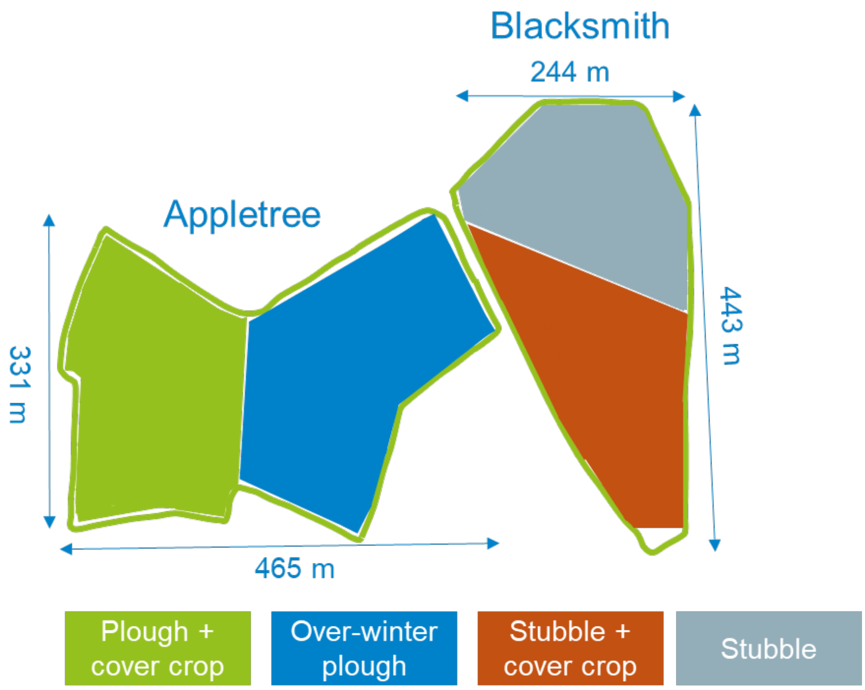
Blacksmiths

- 7.32-hectare field
- Crop established using a one-pass system
- Sandy loam soil

Strategic Cereal East host, Brian Barker, drilled a cover crop mix on 24-28 August 2019 at 40 kg/ha:

- Rye (32%)
- Buckwheat (40%)
- Phacelia (8%)
- Oil Radish (8%)
- Sunflowers (12%)

The cover crop was destroyed on 13 March 2020. Spring barley was undersown with herbage grass on 28 March 2020 and harvested on 10 August 2021.



Cover crop results from harvest 2020 on nitrate levels

A well-established cover crop is effective at improving water quality. Nitrate concentrations in drainage water were below 50 mg/l.

Reductions were found in spring crop yields after cover crops because of slug damage and crop establishment in wet conditions.

Assessing the impact of cover crops

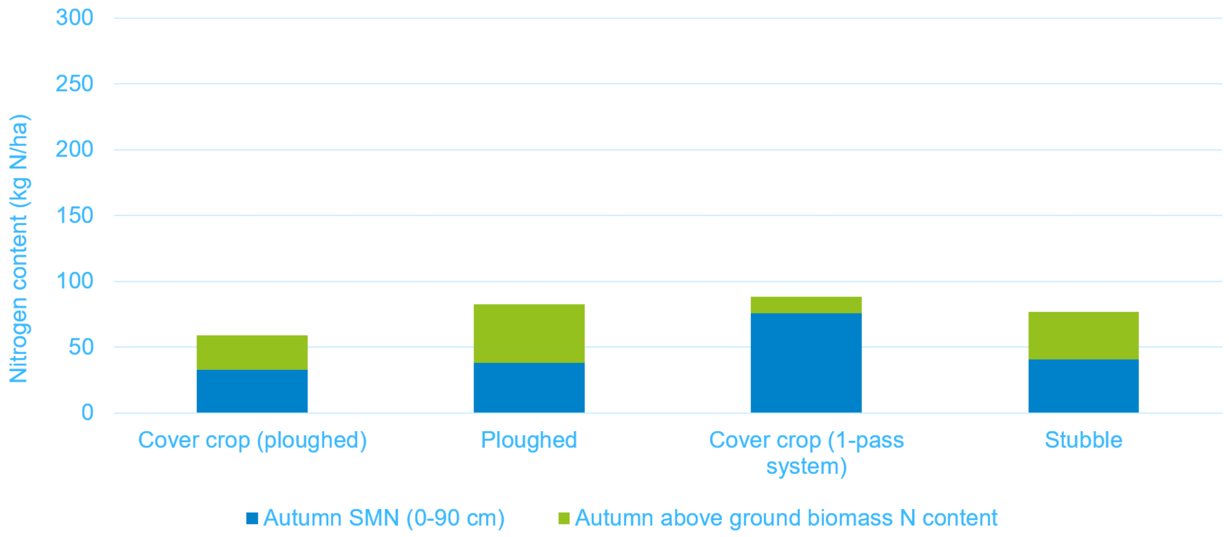
Soil nutrients

Table: topsoil nutrient analysis measured in November 2020. SEM is the Standard error of the mean

Treatment	pH	*pH SEM*	P mg/l	*P SEM*	K mg/l	*K SEM*	Mg mg/l	*Mg SEM*	O.M. %LOI	*O.M. SEM*
Cover crop (ploughed)	7.0	*0.14*	14.4	*1.62*	143	*1.87*	53	*2.11*	3.5	*0.20*
Ploughed	7.1	*0.08*	18.8	*4.28*	154	*17.41*	56	*4.62*	3.6	*0.13*
Cover crop (one-pass system)	7.2	*0.15*	23.0	*1.51*	157	*0.53*	59	*1.23*	3.8	*0.28*
Stubble	7.3	*0.06*	24.3	*0.50*	150	*9.19*	59	*5.77*	3.9	*0.41*

Autumn soil nitrogen supply

The soil nitrogen supply was assessed in November 2020. The results show that the above-ground biomass had captured between 15 and 45 kg N/ha. The soil mineral nitrogen ranged between 33 to 76 kg N/ha.

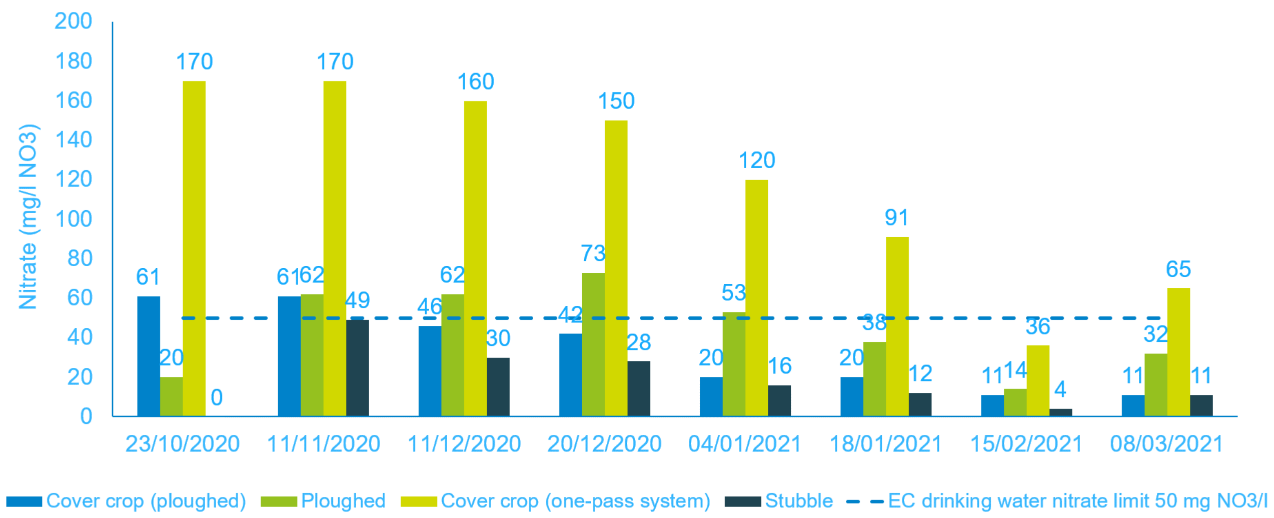


Graph: Soil mineral nitrogen (0-90 cm) and above ground biomass nitrogen uptake measured in autumn 2020

What is the impact on water quality?

The results from the cover crop one-pass system have likely increased the risk of N leaching to water:

- Autumn herbage grass biomass was 0.44 t/ha compared to 1.1 to 1.7 t/ha in the other treatments
- The above-ground biomass N content was lower and SMN was higher
- Higher nitrate (NO3) concentrations in drainage water. The high winter rainfall (276 mm Oct-Mar) is also likely to have exacerbated the risk of SMN leaching into the water. More work is needed to understand these results.



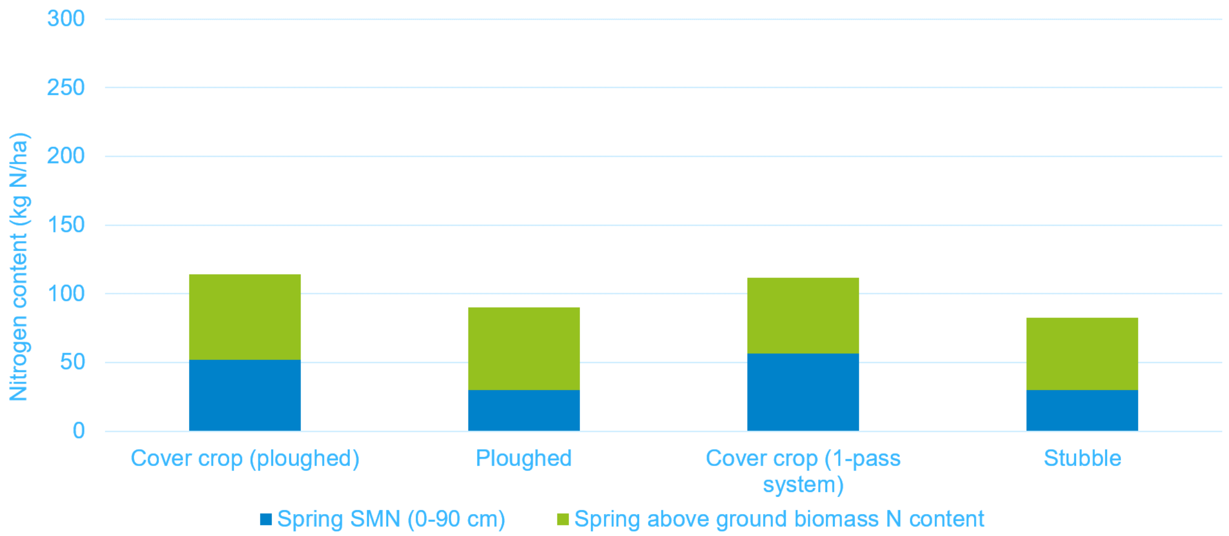
Graph: Drainage water nitrate concentrations from October 2020 to March 2021

Spring soil nitrogen supply

April 2021 assessments showed that the crop had captured between 53 and 62 kg N/ha. The soil mineral nitrogen ranged from 30 to 56 kg N/ha.

The average crop biomass was 1.5 t/ha in all treatments apart from the cover crop one-pass system which resulted in 1.3 t/ha.

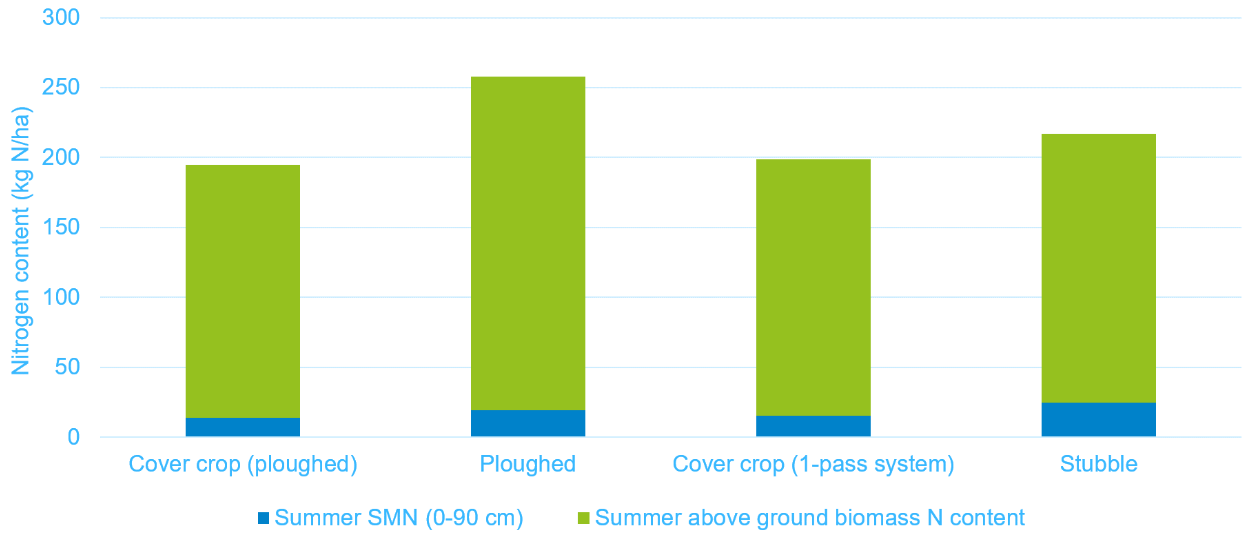
The cover crop treatments resulted in increased SMN by around 20 kg/ha. This resulted in total nitrogen content of 113 kg N/ha compared to 86 kg N/ha where there hadn't been any cover crops.



Graph: Soil mineral nitrogen (0-90 cm) and above ground biomass nitrogen uptake measured in spring 2021

Summer soil nitrogen supply

The soil nitrogen supply (SMN and above ground biomass nitrogen content – assessed in June 2021) indicated that the forage grass had captured most of the nitrogen, both residual soil N and applied inorganic N, 181-239 kg N/ha in addition to the SMN which resulted in 14 to 25 kg N/ha. The highest nitrogen supply was in the ploughed treatment, with all other treatments showing similar levels.



Graph: Soil mineral nitrogen (0-90 cm) and above ground biomass nitrogen uptake measured in summer 2021

Legacy effect of cover crops

The legacy effect of the previous cover crops on soil properties were assessed in spring 2021. There was no effect of the cover crop treatments on topsoil bulk density, visual soil structure (VESS score) or earthworm numbers.

However, differences in penetrometer resistance observed in spring 2021 with the cover crop, 1-pass system resulting in the higher soil strength at 30 cm depth compared to the other treatments (1.91 MPa c.f. 1.25-1.54 MPA, P=<.001 at 30cm).

The soil bulk density also showed a small increase, although not significant.

Treatment	Bulk density (g/cm³) [a]	Earthworm count (No./pit) [b]	VESS Score	Maximum penetration resistance at 30cm (MPa)
Cover crop (ploughed)	1.23 (a)	4 (a)	2.5 (a)	1.49 (a,b)
Ploughed	1.26 (a)	6 (a)	2.2 (a)	1.25 (a)
Cover crop (1-pass system)	1.22 (a)	7 (a)	2.4 (a)	1.91 (c)
Stubble	1.22 (a)	5 (a)	2.8 (a)	1.54 (b)
P [c]	NS	NS	NS	<.001
SED	0.03	1.35	0.26	0.11

[a] *at 5-10 cm depth*

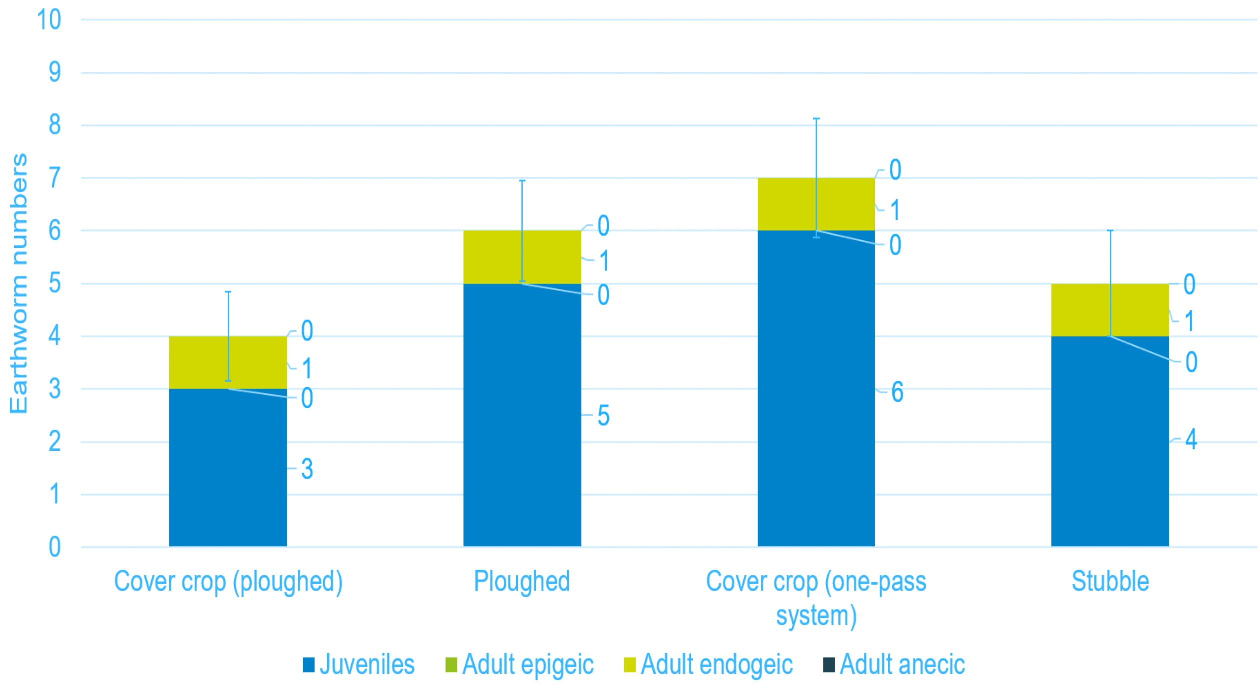
[b] *Adults and juveniles*

[c] *P statistic: NS = not significant*

Impact of cover crops on earthworms

A good number of earthworms (i.e. >8/pit = 'active' population for arable soils) are beneficial for soil function. Lower numbers were recorded in spring 2021, which in part, may be due to the dry weather reducing their activity.

In all treatments, there was an absence of adult anecic (deep-dwelling) and adult epigeic (surface/litter dwellers) worms indicating an un-balanced community structure that may lead to some earthworm-mediated soil functions becoming compromised.



Graph: Number of earthworms recorded by functional group. The error bars represent the standard error of the mean number of total earthworms, calculated across the sampling zones.

3. Flower strips in arable fields for pests and beneficials

Objective: To find out whether flower strips affect the diversity, distribution, and number of beneficials and pests in an arable field.

Why are flower strips beneficial to arable farms?

Integrated pest management is an important part of arable farming. Our previous research reported that **non-crop habitats are important sources of biodiversity**. This trial is looking at whether the results found in research trials are also seen on a commercial farm.

Flower strips attract insects that are beneficial for pollination and pest control. Field margins play an important role in enhancing insect predators and parasitoids. The trial will see if flower strips can help farmers to reduce their use of insecticides.

How is the flower strip trial run?

This field-scale trial uses three fields on the farm:

Big Guinea Row:

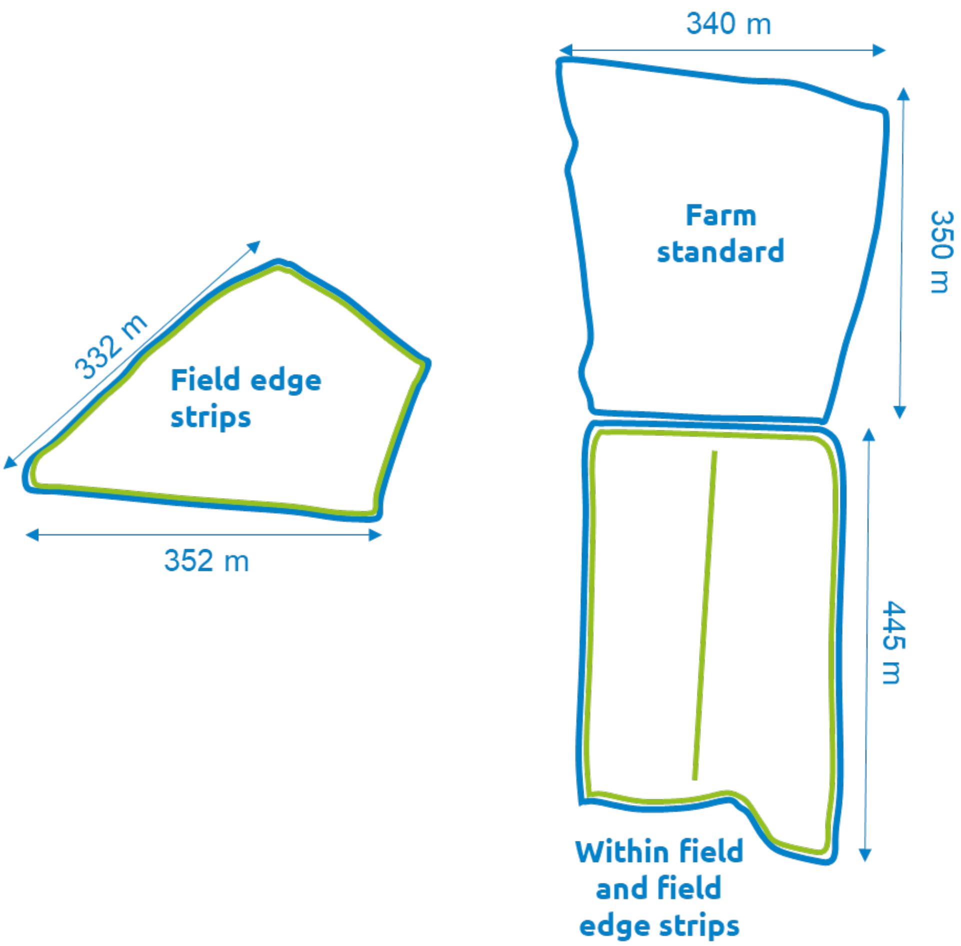
- 78-hectare field in the farm standard
- Sandy clay loam soil and no flower strips

Top 59:

- 39-hectare field with flower strips at the edge of the field.
- Sandy loam soil

Bottom 59:

- 61-hectare field with flower strips within the field and at the field edge.
- Sandy clay loam soil



Slug monitoring and pitfall trapping

In October and November 2020, and again in March 2021, the field team at NIAB set the slug and pitfall traps. The team used a 100 m transect along each field strip, 1m into the field and 100 m into the field. Every 25 along each transect, the team completed their assessments.

Information on integrated slug control

The field team placed each pitfall trap 30 cm away from the slug traps. For the traps, they used a plastic 520 ml food pot submerged into the ground so that the open end was level with the soil surface. Each pot was partly filled with about 200 ml of a saline solution (30 g salt per 100 ml water) and a drop of odourless washing-up liquid.

Solitary bee nests

Between late spring and early autumn, the team monitored mason, leaf-cutter and other solitary bees using bee nests. These nests are made from 25 nesting tubes placed within a 68 mm round plastic guttering downpipe. Each nest is cut to 17 mm in length and attached by its centre to a post in the field margin at a height of 90 cm from the ground. The nests are in the best position for continuous sunlight with the openings facing South to South East. To allow any rain to drain freely, they are angled down slightly. In late August, the research team collected the nests from the field to remove and identify the contents.

Pitfall traps

Ground dwelling invertebrates were monitored using pitfall traps made from a yoghurt pot. The pot was partially filled with saline solution.

Water traps

To monitor aerial natural enemies and invertebrates which live off the ground, the team used 2.5 litre clear tubs suspended a short distance off the ground. They were partially filled with saline solution.

Summer aphids and natural enemies

Summer aphids and their natural enemies were monitored using plant counts. Each monitoring point consisted of twenty randomly selected tillers. On each tiller the number of aphids, mummified aphids or other invertebrates were counted.

Flower and grass strip establishment

The flower and grass margins established well despite the poor weather in winter 2020. The total cost of establishment was £714.91/ha.

Between 15-21 species were recorded in the margins in each of the fields. The most frequently occurring species were common knapweed, wild carrot, oxeye daisy,ribwort plantain, common sorrel and musk mallow. Overall, they had a rich species diversity, providing floral resource before and during the summer assessments. They also provided overwintering habitat for autumn and spring assessments.

Other non-sown species including ploughman's spikenard, birds foot trefoil, cut leaved cranesbill and smooth hawksbeard were found infrequently throughout the margins.

The floral strips were different in their plant species composition. Strips within each field were more similar than across fields. This reflects the soil conditions, species selected, and date of drilling.

The fields where floral margins were present there was no encroachment of any of the sown species into the main crop.

Crop performance

Crop establishment was poorer in Big Guinea Row, likely due to waterlogging in the field. There was some reddening and chlorosis observed on the winter wheat.

The estimated yield and margin loss due to area of the field taken out of production for the in-field strips across the rotation is estimated at £150.60/ha. For wheat only, it is estimated at £140/ha based on current wheat prices in November 2021.

Pests and beneficials

No two fields were alike in their composition of invertebrate pests and beneficials.
Larger studies have shown that the number of beneficials reduces further into the field. But in this study, there was no clear evidence of the impact of distance into the crop on pests or beneficial numbers

Slug monitoring

Slugs were found in all the fields, close to the field margin and in the field centre. There was a slight trend for higher numbers in the field centre.

Big Guinea Row (farm standard) recorded the highest number of slugs. In March, no slugs were found in any of the traps. This is probably due to the very dry weather in the weeks before the traps were placed in the fields.

Ground beetles

Ground beetles were found in all fields. The adult P*terostichus* spp. was the most common species found. *Adult Poecilus* spp. were almost exclusively found in spring assessments and tended to be found further into the field. Adult *Nebria* spp. were only found in summer assessments. Most were found in Top 59 where no floral margins were present.

Rove beetles

Tachyporus spp. were the main adult rove beetles found in all fields all year around. Numbers of adult *Aleochara* spp. started to increase in spring and were found in both fields where margins were present during summer assessments. Adult *Ocypus* spp. were only found in autumn and spring; there was no clear trend with regards to presence of margin or distance from margins.
Spiders

Money and wolf spiders were recorded in all fields at all assessments timings with additional species of spiders, such as long-jawed spiders, recorded in summer assessments. Harvestmen were also found infrequently across fields; these are often confused with spiders and although both are generalist predators, they have different numbers of eyes and body types. In July, there was a clear trend towards a greater diversity of spiders present in Bottom 59.

Hymenoptera-wasps and ants

Wasps were identified throughout the year and were more prevalent at Bottom 59. There was a clear trend for wasps to be present close to the margin edge in winter and spring and an uplift in numbers observed 100m from the margin edge in July. Ants were recorded in high numbers at the first and second assessments in July with numbers declining by the end of July. This was a trend observed across all fields despite large difference between fields.

Diptera-flies and midges

A wide range of fly species and adult and larval forms of midge were identified throughout the year with a general trend for more flies occurring at Big Guinea Row.

Cereal aphids

The number of aphids and parasitised aphids (known as aphid mummies) was very low in 2021 with numbers recorded well below treatment thresholds in all fields monitored. Visual observations suggested that there was a slight trend for more numbers of both aphids and mummies occurring at Top 59 (no flower margins present).

There was a noticeable absence of aphid predators such as lacewing and hoverfly larvae across the farm. This is unsurprising; while these species are highly effective predators; aphids and soft bodied insects are their predominant prey with hoverfly larvae each able to consume up to 1,200 aphids and lacewing larvae up to 1,500. Hoverfly larvae are also largely nocturnal, so rarely seen on plants when visual assessments may traditionally be carried out.

Solitary bees

While no mason or miner bees were observed in nests, the 6 nests placed across the farm all contained high numbers of leaf cutter bees and there were no observable differences between fields. Five to six tubes of each bee nest were full of leaves used to create nest cells, bee cocoons and beeswax.

What can you do on your farm?

There is a huge benefit in being more familiar with the various insects in and around your crop. Don't spend a lot of time identifying individual species. There are some easy ways to investigate and compare different areas. The first step you need to take is to be able to recognise the common insects in and around your farm.

Action	Description	When
Pitfall and water trapping	Use two pitfall or water traps to look at numbers of ground beetles, spider hoverflies or ladybird numbers. Put one in the field margin and one in the adjacent crop. Count what you see in each and consider what might be influencing the differences.	Sep – Nov Apr – Jul
Slug bait traps	Track slug abundance over time, and in different locations. Consider what might be driving any differences you see.	Sep – Nov
Review your landscape	Identify the areas on and around your farm where floral resources are available. Observe the different insects in and around these habitats and compare what you see with areas far away from floral resources.	May - Jul
Create habitat for beneficial species	In most agricultural landscapes there is often a lack of suitable floral resource and habitat for beneficial insects. Aim for a spread of resources across the farm, rather than all at one site. And select plants known to be beneficial – flowers that are good for bees might not be good for natural enemies.	Drill in spring or early autumn for flowering the following year.