FARMEXCELLENCE

AHDB

Strategic Cereal Farm East
Harvest 2020 Report

Strategic Cereal Farms are a key part of AHDB's Farm Excellence network. They provide a platform to showcase research in practice via a structured combination of short and long term field and farm scale trials.

Each Strategic Cereal Farm runs for six years to allow independent demonstration of research to be conducted across a full rotation.

The farms test and demonstrate new ways of working in a commercial setting. Approaches are subject to full cost-benefit analyses using Farmbench which helps other farmers to assess the possibility of changing approaches on their own farms.

There are three Strategic Cereal Farms as part of the AHDB network:

- Brian Barker, Strategic Cereal Farm East
- Rob Fox, Strategic Cereal Farm West
- David Aglen and Johnnie Balfour, Strategic Cereal Farm Scotland

Visit our website for more information on AHDB Farm Excellence network: ahdb.org.uk/farm-excellence

Contents

Strategic Cereal Farm East

Host Farmer: Brian Barker

Location: E. J. Barker & Sons, Lodge Farm, Westhorpe, Stowmarket, Suffolk IP14 4SZ

Duration: November 2017 – September 2023

Introduction

E. J. Barker & Sons is, a family farm partnership and contracting business in Suffolk which dates back to 1957. The 513 ha arable farm business uses a traditional 12-year rotation, incorporating winter wheat for feed, herbage grass seed and break crops of spring barley, beans, oilseed rape and linseed. The farm is on a medium to heavy soil type and uses a cultivation strategy appropriate to that field and year, from ploughing to direct drilling.

Mission statement

An independent, open and honest platform for UK farmers to see and learn from the integration of research in a practical way within a commercial farming system.

Vision

The vision of the Strategic Cereal Farm East is to understand the farmed environment and develop a long-term strategy to increase productivity and produce a high quality product without having a negative effect on the farmed environment. The project will bridge the gap between research and practical farming and provide a programme of demonstrations, subject to full net-margin cost benefit analysis, which are relevant to the current situation facing UK farming. The project will allow farmers to make informed decisions and increase farmer-to-farmer engagement.

The core values of the Strategic Cereal Farm East are independent, honest, practical, productive, cost effective and relevant.

Weather summary

The monthly average temperature (°C) and total rainfall (mm) between 1 August 2018 and 31 August 2020 is shown in Figure 1.

Between 1 August 2019 and 31 July 2020, the Strategic Cereal Farm East weather station recorded a total of 474 mm of rainfall. The maximum temperature recorded was 35.2°C on 7 August 2020. The minimum temperature recorded was -1.9°C on 30 November 2019.

Watch a harvest 2020 season overview with Brian Barker

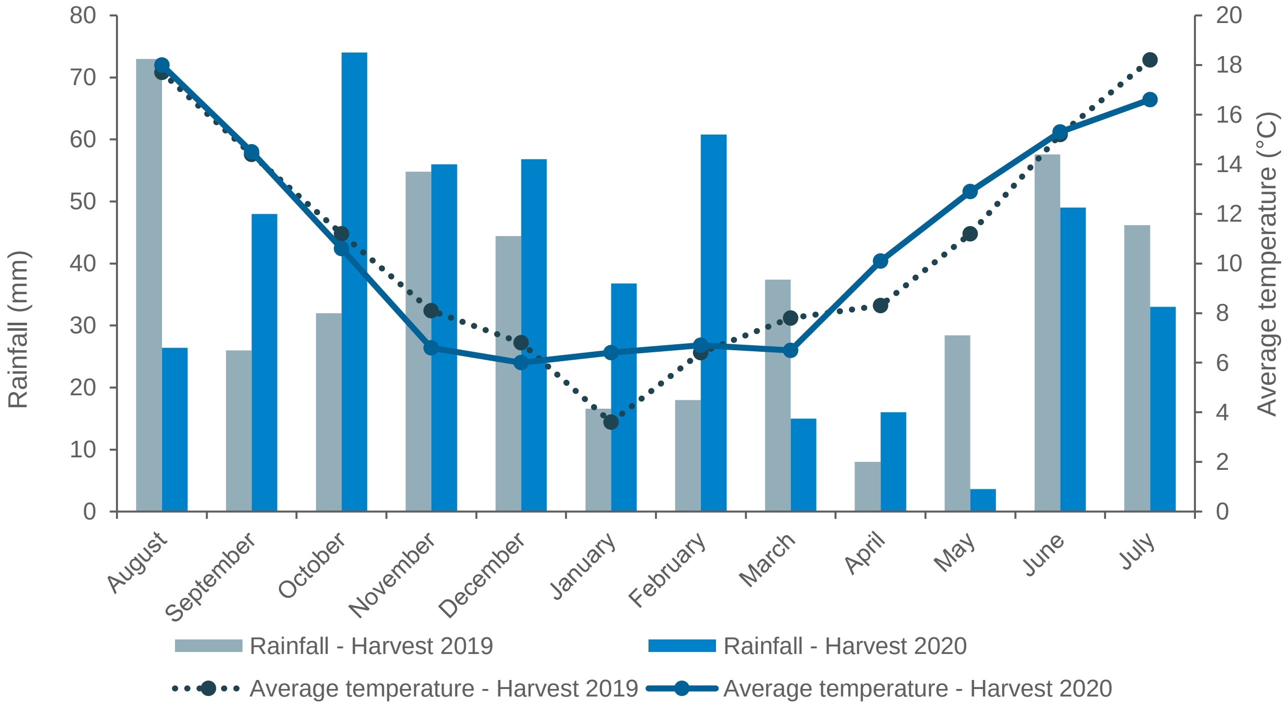


Figure 1. Weather data from weather station at Strategic Cereal Farm East (1 August 2018 – 31 August 2020)

Timeline

2017-2018 - Baselining year

The aim of the first year of the Strategic Cereal Farm project, known as the baselining year, was to determine the starting point of a number of indicators within the farmed environment before any changes are investigated and evaluated. The baselining activities completed at the Strategic Cereal Farm East September 2017 – September 2018 are listed below:

- Weather station
- Soil nutrient analysis
- Soil biology
- Earthworms
- Electrical conductivity scanning
- Water sampling
- Physical soil structure
- Crop biomass monitoring
- Black-grass mapping
- LEAF Sustainability Review

2018-2019

- **Managed lower inputs**: To determine the effect of high, medium, low and untreated fungicide strategies on disease control in varieties with different disease ratings
- **Cover crops**: To determine the role of cover crops in reducing nitrate leaching
- **Early crop biomass**: To explore ways in which canopy size in late-drilled crops of winter wheat can be enhanced to improve final yield

2019-2020

- See below for all trial details

Watch an introduction to the harvest 2021 trials and demonstration with Brian Barker

2020-2021

- **Managed lower inputs:** Large plots of a single variety of winter wheat will be tested under high and low input agronomy strategies compared with untreated plots. 7 timing treatments will be used to determine the effect of fungicide application timings on disease control, yield response and cost of production.
- **Cover crops:** This is a continuation of the trial established in a cover crop in autumn 2019 which was then followed by a spring crop for harvest 2020. The team will assess the fields through to harvest 2021 including soil structure, health and nutrient assessments and crop nitrogen biomass. We will continue to work with Essex and Suffolk Water to assess the nutrient and pesticide levels in the land drain water samples.
- **Pests and natural enemies:** We will continue to monitor the pest and beneficial insect populations across the Strategic Cereal Farm, including on perennial flower strips options and look at BYDV presence in the crops.
- **Marginal land:** The aim of this work is to conduct analysis of multiple farm datasets to classify areas of land on the Strategic Cereal Farm East that provide agricultural value, and to identify those areas of land that have little agriculture value and potential for profit from an arable rotation and could be used in the future as an opportunity for implementing environmental schemes. The data sets will include: farm rotation, yield, soil and satellite imagery maps, farm costings, drainage maps and many more.

Full details about the baselining and trials at the Strategic Cereal Farm East are available online: ahdb.org.uk/farm-excellence/strategic_cereal_farm_east

Partners

We are very grateful to Brian Barker and all the team at EJ Barker and Sons for carrying out the operations, assessments and analysis as part of the Strategic Cereal Farm East.

We are pleased to have worked with ADAS to carry out the assessments and analysis on the demonstrations at the Strategic Cereal Farm East for harvest 2020.

Many thanks go to Essex & Suffolk Water for the analysis of the drainage water samples from the cover crop demonstration and wider baselining work at the Strategic Cereal Farm East.

Demonstrations

1. Managed lower inputs

Trial leader: Phil Walker

Start date: October 2019

End date: August 2020

Headline

Based on the results from harvest 2020, in this low disease pressure season growing more resistant varieties with a low input regime gave the best net margin. Even on susceptible varieties there was only a small improvement in net margin between the low and high input regimes.

What was the challenge/demand for the work?

The aim of this trial was to determine the effect of reduced fungicide applications and other inputs on varieties with different disease ratings, for disease control under high, medium, low and untreated fungicide strategies.

In order to maintain activity of fungicides and control disease, there needs to be a step-change in the way cereal fungicides are used. AHDB already plays a key role in fungicide anti-resistance through monitoring and research of key diseases to develop the most effective anti-resistance strategies, including more resistant varieties. The AHDB Recommended Lists have raised minimum standards for variety disease resistance which potentially enables the reduced use of, and thus reduces pressure on, fungicides.

In 2018-2019 the Strategic Cereal Farm East investigated the impact of fungicide inputs on five winter wheat varieties: Siskin, Shabras, Graham, Santiago and Silverstone. Based on the results from harvest 2019, growing more resistant varieties with low fungicide inputs gave the best net margin. However, this was a single year with moderate disease pressure. Varieties that are more resistant do nevertheless reduce risk to the business, as even in a high disease pressure year they will be less impacted by disease.

In harvest year 2020, the demonstration was repeated in the same field, which has gone into second wheat with the varieties Siskin, Shabras, Graham, Santiago, Crispin. Farmers are under increasing pressure to produce the best gross margins by managing all inputs other than fungicides, therefore each fungicide programme will also vary in inputs for plant growth regulators and bio-stimulants. This is to stimulate the decisions that farmers have to make into managing the crop over the whole season to produce the best net margin for disease control, crop growth and resulting yield.

How did the project address this?

Site details

- Field name: Kells
- Size: 18 ha
- Soil type: sandy loam
- Crop: winter wheat
- Drill date: 31 October 2019

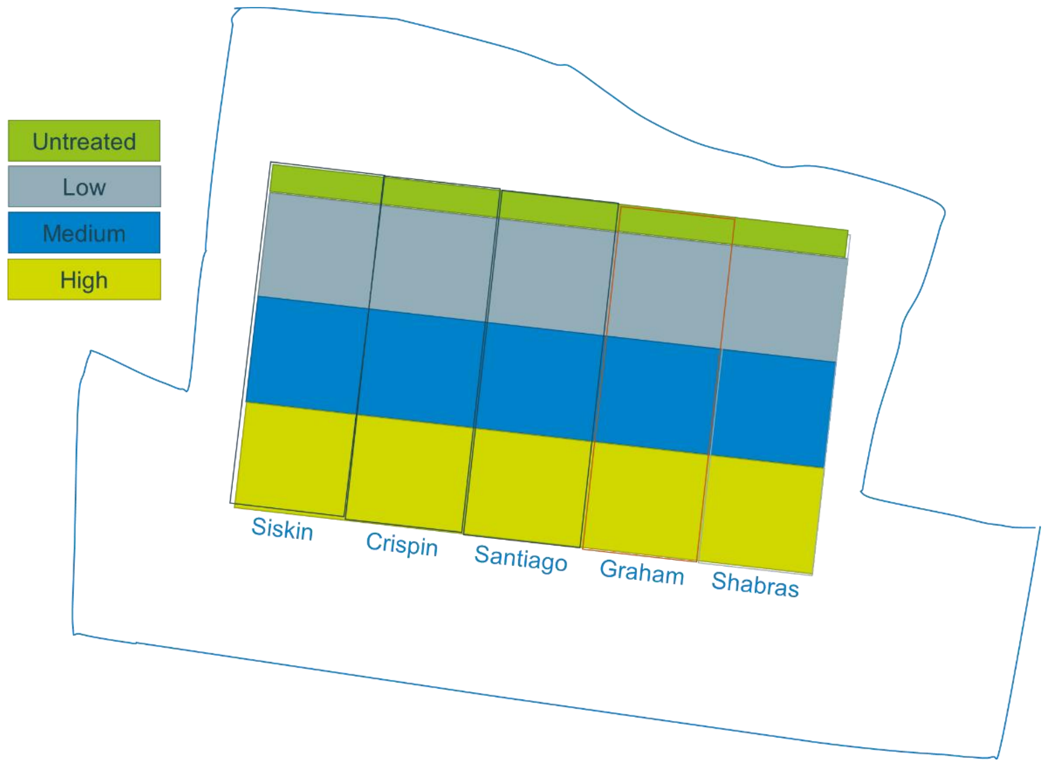


Figure 2. Field layout for Managed Lower Inputs demonstration at Strategic Cereal Farm East

Treatments were five winter wheat varieties with differing disease susceptibility (Table 1). The treatments were in second wheat and were positioned in the same location as the 2019 trial to help assess the cumulative effect of lower inputs.

Table 1. Winter wheat varieties and Recommended Lists (RL) disease ratings for septoria, yellow rust and brown rust

Variety	Septoria RL rating	Yellow rust RL rating	Brown rust RL rating
Siskin	6.7	9	5
Graham	6.9	8	6
Shabras	6.2	7	5
Crispin	5.8	9	5
Santiago	4.3	7	5

Each of the varieties received four fungicide and other inputs programmes of varying intensity (high, medium, low and control). Treatments were repeated twice and set up to fit in with the tramlines (i.e. not randomised). The fungicide programme was decided upon as the season progressed, reflecting current weather and disease assessments, the treatments applied are listed in Table 2.

Table 2. Details of treatment inputs (up to T1) for low, medium and high inputs (note: the untreated area did not receive any inputs of fungicide, plant growth regulator and trace elements)

Product	Type	Application Rate (l/ha)	Cost
Low inputs			
T0 - 11/04/20			
Tempo	PGR	0.05	£5.70
Gramitrel (Yara)	Trace Element	1	
T1 - 02/05/20			
Toledo (tebuconazole)	Fungicide	0.5	£14.18
3C Chlormequat 750	PGR	1	
Tempo	PGR	0.05	
Headland Magnesium Super 80	Trace Element	2	
T2 – 22/05/20			
Firefly 155 (prothioconazole + fluoxastrobin)	Fungicide	1.192	£28.39
Headland Magnesium Super 80	Trace Element	1.5	
Total spend			**£48.27**
Medium Inputs			
19/03/20			
Headland Multiple Pro	Trace Element	1	£11.32
Maxi Phi Fast Root (Agrimax)	Trace Element	0.80	
T0 – 08/04/20			
Toledo (tebuconazole)	Fungicide	0.30	£11.58
3C Chlormequat 750	PGR	1	
Tempo	PGR	0.05	
Gramitrel (Yara)	Trace Element	1 (11/04/2020)	
T1 – 02/05/20			
Toledo (tebuconazole)	Fungicide	0.5	£25.08
Amistar Opti (azoxystrobin + chlorothalonil)	Fungicide	1	
3C Chlormequat 750	PGR	1	
Headland Magnesium Super 80	Trace Element	2	
T2 – 22/05/20			
Elatus Era	Fungicide	0.75	£40.11
Headland Magnesium Super 80	Trace Element	2	
T3 – 15/06/20			
Toledo (tebuconazole)	Fungicide	0.3	£4.38
Total spend			**£92.47**

High Inputs			
19/03/20			
Headland Multiple Pro	Trace Element	1.6	£33.00
Maxi Phi Fast Root (Agrimax)	Trace Element	2	
T0 - 08/04/20			
Bravo 500 (chlorothalonil)	Fungicide	1	£17.58
Toledo (tebuconazole)	Fungicide	0.3	
3C Chlormequat 750	PGR	1	
Tempo	PGR	0.05	
Gramitrel (Yara)	Trace Element	1	
T1 - 02/05/20			
Wolverine (fluxapyroxad + metconazole)	Fungicide	1	£43.48
Bravo 500 (chlorothalonil)	Fungicide	1	
3C Chlormequat 750	PGR	1	
Tempo	PGR	0.1	
Headland Magnesium Super 80	Trace Element	2	
T2 – 22/05/20			
Elatus Era	Fungicide	1	£50.86
Headland Magnesium Super 80	Trace Element	1.5	
T3 – 09/06/20			
Proline (prothioconazole)	Fungicide	0.3	£17.29
Epso Combitop	Trace Element	2.5	
Maxi Phi Fast Root	Trace Element	0.25	
Total spend			**£162.21**

N.B. Prices drawn from industry averages for the season.

Assessments

- Disease assessments at key growth stages
- Routine topsoil analysis
- Crop yield
- Pests and natural enemies monitoring

What results has the project delivered?

The disease pressure was generally low throughout the season, with the highest percentage of septoria seen on the most susceptible variety, Santiago (Figure 3a). On average across all varieties the different input regimes from low to high showed a similar level of septoria control (Figure 3b). The more resistant varieties (i.e. Graham and Siskin) tended to hold onto green leaf area for longer but there were minimal differences between the inputs regimes (Figure 4a and b). The percentage of yellow rust seen on the leaves was low but the susceptible variety Santiago did show a moderate incidence on the ears (Figure 5a); although all the input regimes did show close to complete yellow rust control on all varieties. The high input regime did show the highest reduction in ear fusurium (Figure 5b) but the level of disease reported was considered too low to have any major impacts on yield. Yields were generally quite low being a second wheat situation, but there was a minimal response to increasing fungicide spend on the resistant varieties (medium input mean yield of 6.0 t/ha) with the low inputs (mean yield of 6.2 t/ha) showing the best net margins (Table 3a). Even on the susceptible varieties, Santiago and Crispin, where the highest yields (mean of 6.9 t/ha) were seen on the high input regimes, the net margins were similar to low inputs (Table 3a).

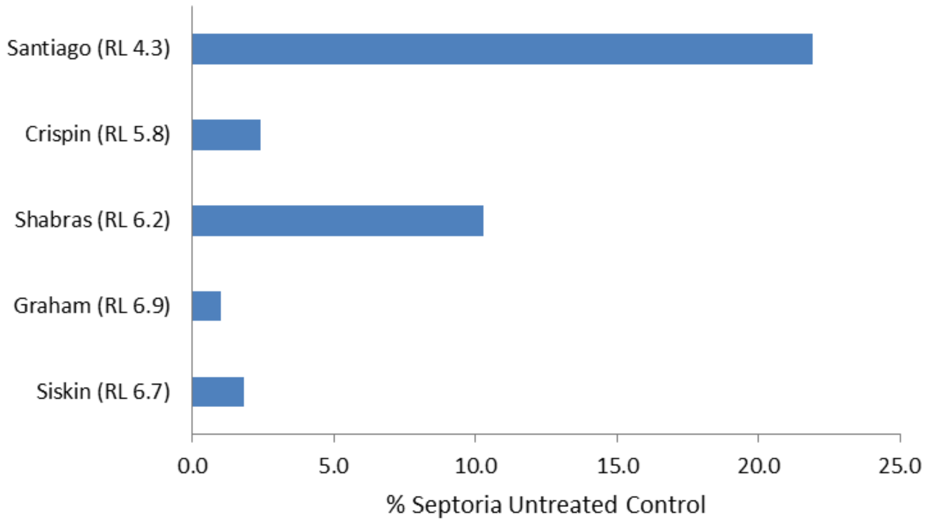


Figure 3a. Percentage septoria on leaf 2 on untreated control across varieties at GS75.

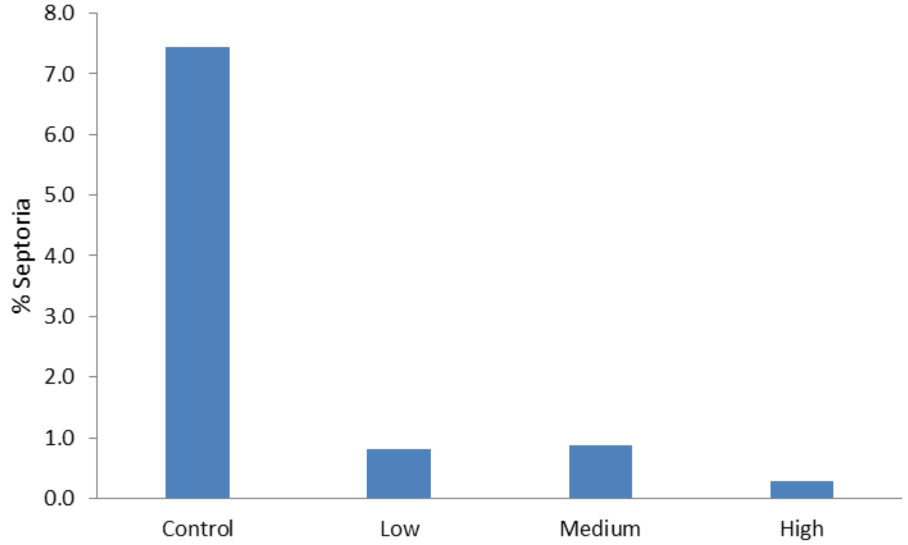


Figure 3b. Percentage septoria on leaf 2 across input regimes average all varieties at GS75.

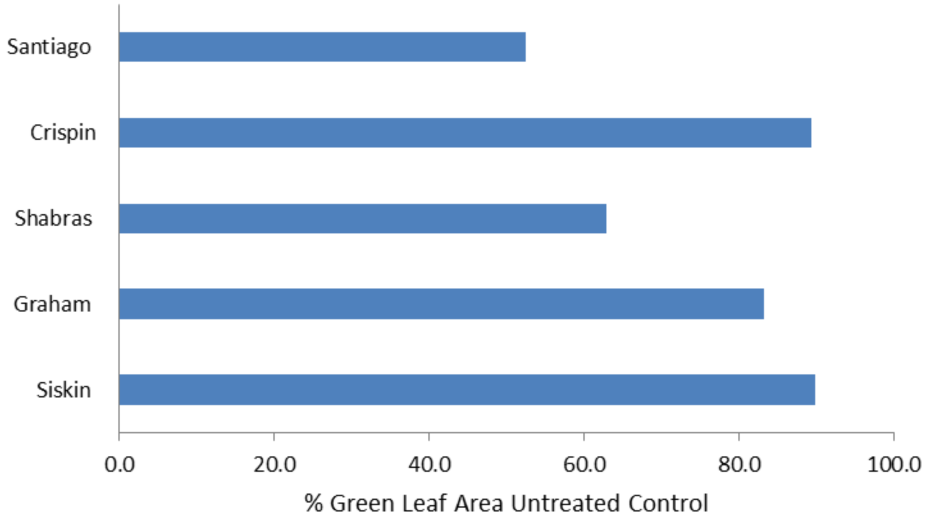


Figure 4a. Percentage green leaf area on leaf 2 on untreated control across varieties at GS75.

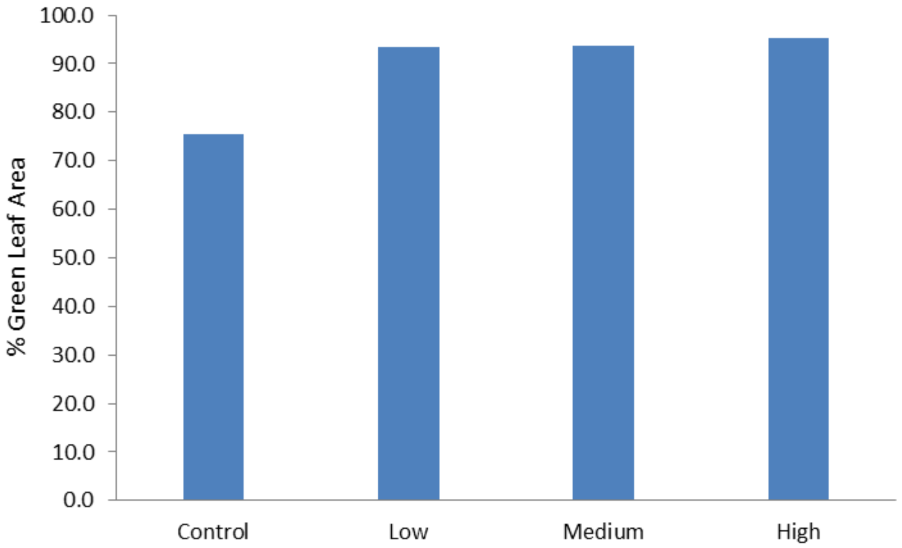


Figure 4b. Percentage green leaf area on leaf 2 across input regimes average all varieties at GS75.

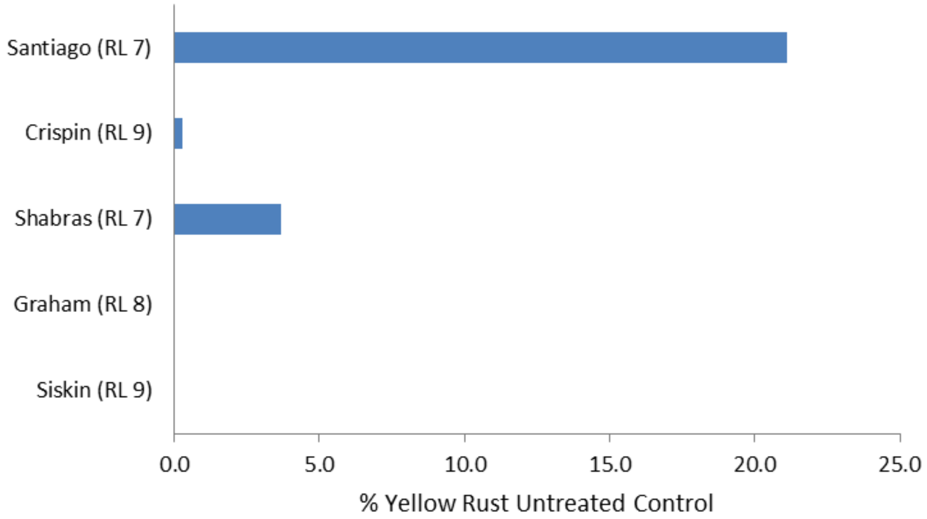


Figure 5a. Percentage yellow rust on ear on untreated control across varieties at GS75.

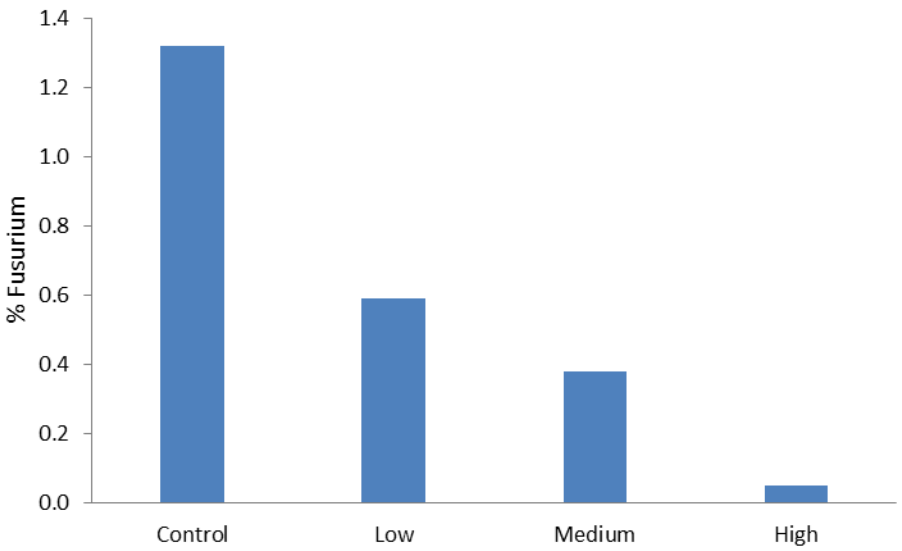


Figure 5b. Percentage fusurium on ear across input regimes average all varieties at GS75.

Table 3a. Yield and net margins for low, medium and high inputs the varieties Crispin, Graham, Santiago, Shabras and Siskin.

Cost of production (per ha)	Crispin Untreated (Wheat)	Crispin Low (Wheat)	Crispin Medium (Wheat)	Crispin High (Wheat)	Graham Untreated (Wheat)	Graham Low (Wheat)	Graham Medium (Wheat)	Graham High (Wheat)	Santiago Untreated (Wheat)	Santiago Low (Wheat)	Santiago Medium (Wheat)	Santiago High (Wheat)
Yield (t/ha)	5.46	6.07	5.57	6.93	5.17	6.34	6.35	6.50	3.96	5.87	5.26	6.86
Price (£/t)	175	175	175	175	175	175	175	175	175	175	175	175
Variable costs (Per hectare)												
Total seed costs (£/ha)	61	61	61	61	61	61	61	61	61	61	61	61
Total fertilisers, trace elements and biostimulants (£/ha)	197	207	217	244	197	207	217	244	197	207	217	244
Fungicides (£/ha)	0	32	65	108	0	32	65	108	0	32	65	108
Total crop protection (£/ha)	70	107	140	185	70	107	140	185	70	107	140	185
Total variable costs (£/ha)	340	386	430	503	340	386	430	503	340	386	430	503
Gross margin (£/ha)	615	676	544	710	565	723	681	635	353	641	490	698
Overheads (Per hectare)												
Total labour, machinery and equipment (£/ha)	270	297	315	315	270	297	315	315	270	297	315	315
Total property and energy costs (£/ha)*	46	46	46	46	46	46	46	46	46	46	46	46
Total administration costs (£/ha)*	33	33	33	33	33	33	33	33	33	33	33	33
Cost of production and margins (Per hectare)												
Cost of production excluding rent and finance (£/ha)	689	763	825	897	689	763	825	897	689	763	825	897
Net margin excluding rent and finance (£/ha)	266	300	150	316	216	347	287	241	4	265	96	304
Cost of production (per tonne)												
Cost of production excluding rent and finance (£/t)	126	126	148	129	133	120	130	138	174	130	157	131

** These costs are the East Anglia regional averages from Farmbench for feed wheat for harvest 2019*

NB. All figures exclude subsidy payments, rent and finance

Cost of production (per hectare)	Shabras Untreatred (Wheat)	Shabras Low (Wheat)	Shabras Medium (Wheat)	Shabras High (Wheat)	Siskin Untreated (Wheat)	Siskin Low (Wheat)	Siskin Medium (Wheat)	Siskin High (Wheat)
Yield (t/ha)	4.74	6.25	6.13	4.24	4.50	5.90	5.57	4.84
Price (£/t)	175	175	175	175	175	175	175	175
Variable costs (Per hectare)								
Total seed costs (£/ha)	61	61	61	61	61	61	61	61
Total fertilisers, trace elements and biostimulants (£/ha)	197	207	217	244	197	207	217	244
Fungicides (£/ha)	0	32	65	108	0	32	65	108
Total crop protection (£/ha)	70	107	140	185	70	107	140	185
Total variable costs (£/ha)	340	386	430	503	340	386	430	503
Gross margin (£/ha)	489	707	642	239	447	646	545	344
Overheads (Per hectare)								
Total labour, machinery and equipment (£/ha)	270	297	315	315	270	297	315	315
Total property and energy costs (£/ha)*	46	46	46	46	46	46	46	46
Total administration costs (£/ha)*	33	33	33	33	33	33	33	33
Cost of production and margins (Per hectare)								
Cost of production excluding rent and finance (£/ha)	689	763	825	897	689	763	824	897
Net margin excluding rent and finance (£/ha)	140	331	248	-155	98	270	151	-50
Cost of production (per tonne)								
Cost of production excluding rent and finance (£/t)	145	122	135	212	153	129	148	185

** These costs are the East Anglia regional averages from Farmbench for feed wheat for harvest 2019*

NB. All figures exclude subsidy payments, rent and finance

Action points for farmers and agronomists

In a low disease pressure season, there could be little benefit in disease control and improving yield by increasing inputs. This suggests that fungicide usage can be varied due to the seasonal variation in disease development. In these situations crops need to be inspected regularly to decide on the disease risk so fungicide inputs can be adjusted accordingly. By responding to disease pressure based on varietal resistance, opportunities can be taken to reduce inputs and save cost, which improve net margins and the environmental impact of pesticide usage.

Links to further information/ references

- Strategic Cereal Farm East Results from harvest 2019 for this managed lower inputs trial
- AHDB Recommended Lists
- AHDB Fungicide performance in cereals and oilseed rape
- AHDB Biostimulant Product Review - Final Report
- Combining agronomy, variety and chemistry to maintain control of septoria tritici in wheat (Project number: 2140003105)

2. Early crop biomass

Trial leader: Damian Hatley

Start date: October 2019

End date: September 2020

Watch an overview and summer results video from Brian Barker and Damian Hatley

Headline

The trial showed that there may be yield benefits from broadcasting kieserite and possibly TSP at planting where soil nutrient indices are low.

What was the challenge/demand for the work?

The aim of this trial was to demonstrate how the use of starter fertilisers and the technique used to apply them, may contribute to increasing early season biomass in winter wheat.

In 2018-2019 Strategic Cereal Farm East investigated whether biomass can be accelerated with starter fertilisers or biostimulants. This is in response to the agronomic challenge of achieving high yielding fields whilst utilising integrated management techniques such as delayed drilling to reduce black-grass and barley yellow dwarf virus (BYDV) pressure.

The results from harvest year 2019 showed that using a starter fertiliser may improve initial crop establishment in late-sown crops, with placement alongside the seed tending to give the best results. There was no significant difference in crop yields between broadcast and placed fertiliser, however, there was an indication that placed kieserite yielded slightly more compared to broadcast.

In harvest year 2020, the demonstration was repeated to assess how the use of starter fertilisers, and the technique used to apply them, may contribute to increasing early season biomass in late-drilled winter wheat.

How did the project address this?

The two fields used in this demonstration are shown in Table 4. Table 5 shows the details of the treatments applied. The layout of the demonstration is shown in Figure 6.

Table 4. Early crop biomass field sites and establishment methods

Field name	Wyverstone Road	Crown Field
Size	12.7ha	10ha
Soil type	Sandy loam	Loamy sand
Method	Plough and broadcast fertiliser	Strip-till with placed fertiliser
Drilling / starter Fertiliser date	19 October 2019 (fertiliser applied 30 October 2019)	30 October 2019

Table 5. Early crop biomass treatments

Treatment	Nutrient content	Product application rate (kg/ha)	Cost (Product + Operation Cost)
Untreated	n/a	n/a	n/a
Kieserite Broadcast	0N:0P:0K:25Mg:50S	125	£40.25/ha
Kieserite Placed	0N:0P:0K:25Mg:50S	125	£37.25/ha
Triple superphosphate Broadcast	0N:46P:0K:0S	125	£46.00/ha
Triple superphoshate Placed	0N:46P:0K:0S	125	£37.00/ha
Polysulphate Broadcast	0N:0P:14K:6Mg:48S:17Ca	125	£28.00/ha
Polysulphate Placed	0N:0P:14K:6Mg:48S:17Ca	125	£19.00/ha

N.B. Prices drawn from industry averages – purchased September 2019.

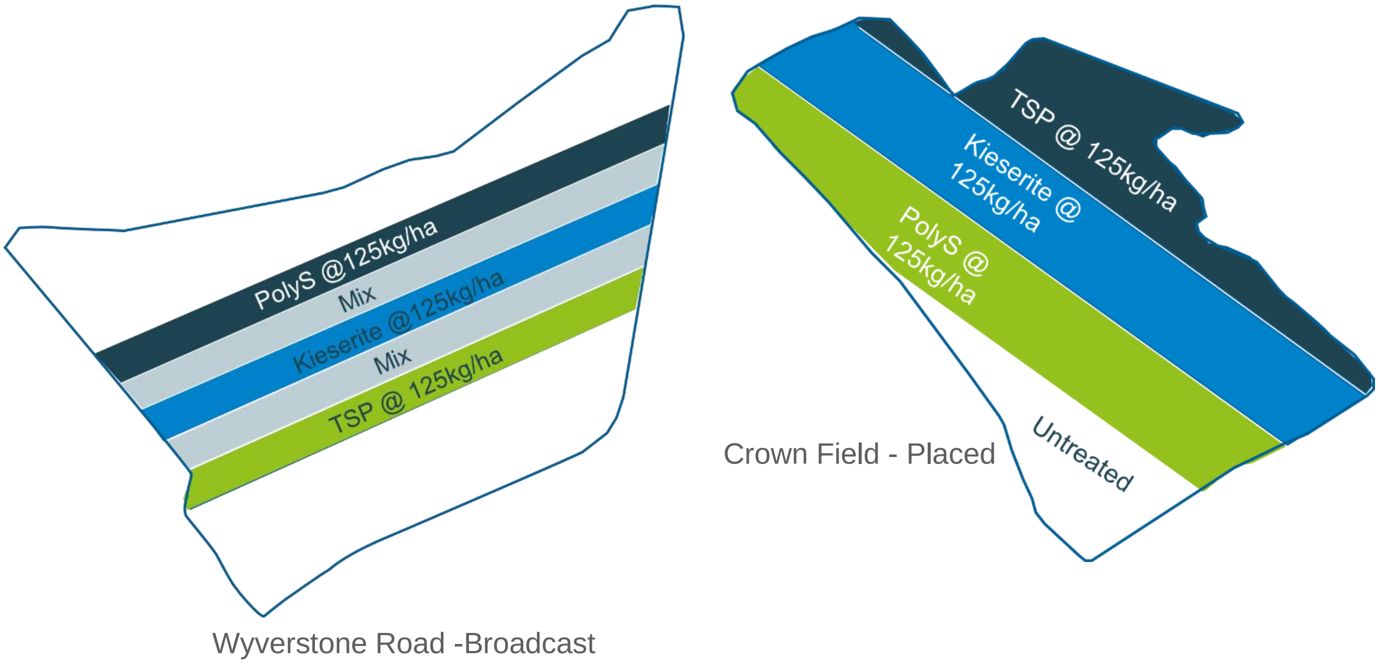


Figure 6. Early crop biomass demonstration layout

Assessments

- Biomass - plant counts, NDVI, tissue analysis and crop yield
- Soil - routine topsoil analysis

What results has the project delivered?

Established plant populations (Figure 7) in both fields were fairly low and crop development was slow over winter.

Within each field there was no effect of starter fertiliser on plant counts and no differences between fertiliser types. Wyverstone Road had slightly lower plant populations compared to Crown Field, however differences in establishment practices (i.e. plough or strip till, respectively) and soil nutrient availability (see Table 6) are likely to be a factor.

Table 6. Topsoil (0-15 cm) analysis

		Wyverstone Road	Crown Field
pH water		8.1	8.2
Available Phosphorus (Index)	mg/l	13.2 (1)	28.0 (3)
Available Potassium (Index)	mg/l	106 (1)	235 (2+)
Available Magnesium (Index)	mg/l	39.2 (1)	43.6 (1)
Organic matter	%	3.5	4.0

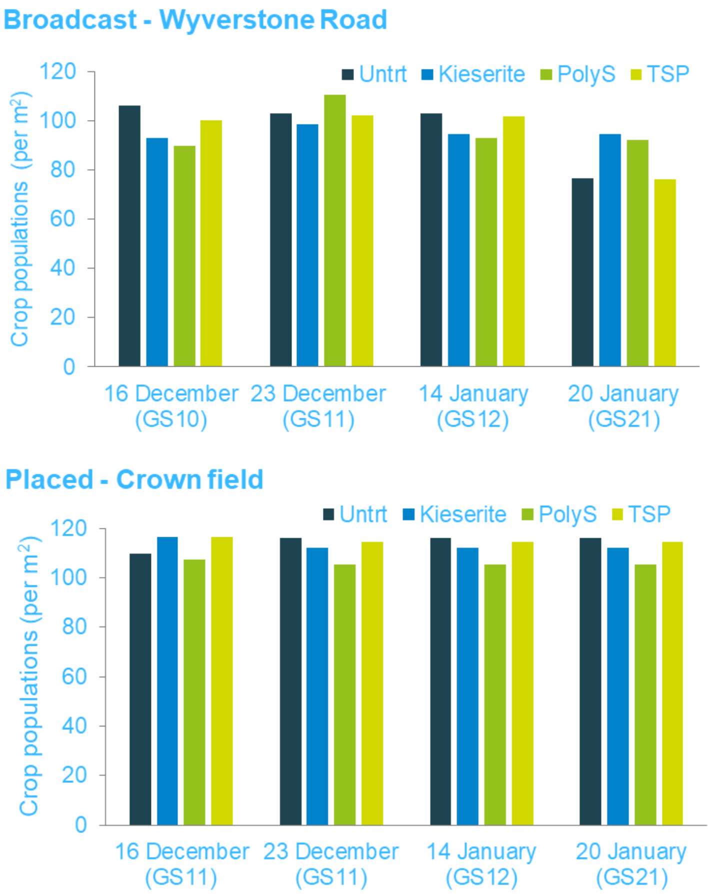


Figure 7. Crop populations (per m^2) measured on plots within Wyverstone Road (broadcast fertiliser) and Crown Field (placed fertiliser)

Yield data

Overall, Wyverstone Road yielded 9.2 t/ha under standard farm practice whilst Crown Field yields were slightly greater at 9.4 t/ha (from modelled combine mapping data).

On Wyverstone Road, broadcast kieserite and TSP appeared to increase yield by up to 0.4t\ha, whilst polysulphate showed no yield benefit compared to standard farm practice (Figure 8).

In Crown Field complications at drilling time led to an uneven distribution of treatments across the field. Reliable analysis of yield data from Crown Field was not possible as the 'Farm standard' treatment area was very small.

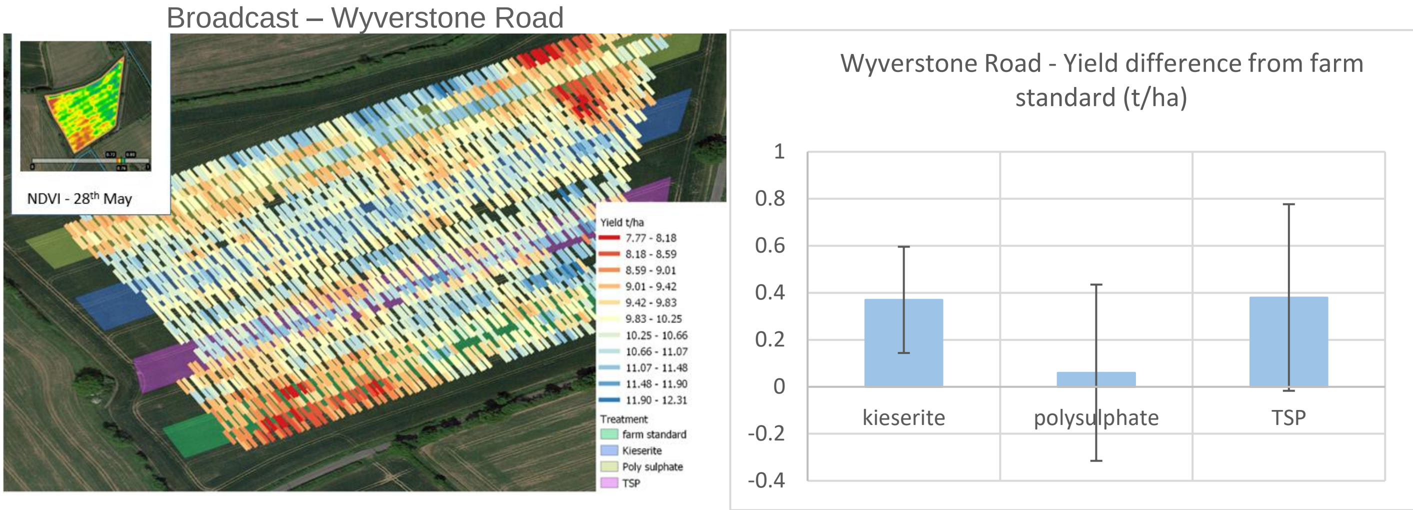


Figure 8. Crop yield (t/ha) from combine mapping data (top) and modelled treatment yield effects relative to the farm standard treatment areas (bottom) for Wyverstone Road.

Action points for farmers and agronomists

The trial showed that there may be yield benefits from broadcasting kieserite and possibly TSP at planting where soil nutrient indices are low.

Links to further information/ references

- Strategic Cereal Farm East Results from harvest 2019 for this early crop biomass demonstration
- Nkebiwe, P. M., et al. (2016). "Fertilizer placement to improve crop nutrient acquisition and yield: A review and meta-analysis." Field Crops Research 196: 389-401

3. Cover crops

Trial leader: Kate Smith & Anne Bhogal

Start date: August 2019

End date: August 2021

Watch the results video from Brian Barker and Kate Smith

Headline

The results demonstrate that a well-established cover crop is effective at improving water quality by bringing nitrate concentrations in drainage water below 50 mg/l. However, reductions in spring crop yields following cover crops were observed as a result of poor spring crop establishment due to a combination of slug damage and ploughing or drilling in wet soil conditions.

What was the challenge/demand for the work?

The aim of this trial was to determine the role of cover crops in reducing nitrate leaching losses.

During the first year of the Strategic Cereal Farm East project, a comprehensive baselining assessment was completed, including the analysis of water removed by the field drains under different crops, establishment systems and soil types. Overall, the loss of nutrients from fields with cover crops was lower compared to those which had been left bare (ploughed) over winter.

As part of the second year at Strategic Cereal Farm East (2018-2019) a cover crop trial was established to assess if nitrogen (N) taken up by cover crops will be used by the subsequent cash crops or released and leached later on. The results demonstrated that a well-established cover crop is effective at taking up nitrogen and improving water quality by reducing nitrate concentrations in drainage water, however the impacts on the following spring crop (linseed) yields were variable. This demonstration is being continued into a second year in order to assess the impact of cover cropping on this years' winter wheat crop.

As part of Strategic Cereal Farm East 2020, a new cover crop demonstration (Table 7) has been set up, to help assess the effects and impact on cost (Table 8) of cover cropping in a different season.

How did the project address this?

Table 7. Field details for cover crops demonstration

	Field 1 – Appletree	**Field 2 – Blacksmiths**
Area:	10.1 ha	7.3 ha
2019 harvest crop:	Winter wheat	
Treatments: Drilled: 28/08/2019 (Apple tree) and 24/08/2019 (Blacksmith) Destroyed: 13/3/20 (using Glyphosate)	Treatment 1:	Treatment 3:
	Plough – soil left bare over-winter	Over-winter Stubble
	Treatment 2:	Treatment 4:
	Rye (32%), Buckwheat (40%), Phacelia (8%), Oil Radish (8%,) Sunflowers (12%), drilled at 20kg/ha	Rye (32%), Buckwheat (40%), Phacelia (8%), Oil Radish (8%), Sunflowers (12%), drilled at 20kg/ha

	Established into ploughed soil	Established in one pass system into stubble
2020 harvest crop:	Spring barley (drilled 28 March 2020), under-sown with herbage grass	

Assessments

- Biomass - cover crop establishment, dry matter yield and N uptake, spring crop establishment, yield and N uptake
- Soil assessments - standard topsoil analysis, soil nitrogen supply, penetrometer resistance, gravimetric soil moisture, soil bulk density, Visual Evaluation of Soil Structure (VESS) and earthworms
- Nutrient content of drainage water
- Pests and natural enemies monitoring

What results has the project delivered?

Cover crop establishment

- Following drilling, cover crop establishment was better (i.e. greater biomass and more even cover) on the strip-tillage one-pass system compared to ploughing (Figure 9)

Figure 9. Cover crop establishment (Photos taken 2 December 2019).

Soil Nitrogen Supply

- By February 2020, cover crops had produced similar amounts of biomass at 1.4 t/ha (ploughed) and 1.6 t/ha (one-pass system) taking up around 45 kg N/ha (Figure 10).

- The spring soil nitrogen supply (SMN and above ground biomass nitrogen content) indicates that mineralisation had occurred over-winter, with an additional 25–30 kg N/ha recovered in the crop and soil in spring 2020 compared to that present in the autumn; in the absence of a cover crop, this N would have been lost as nitrate leaching.

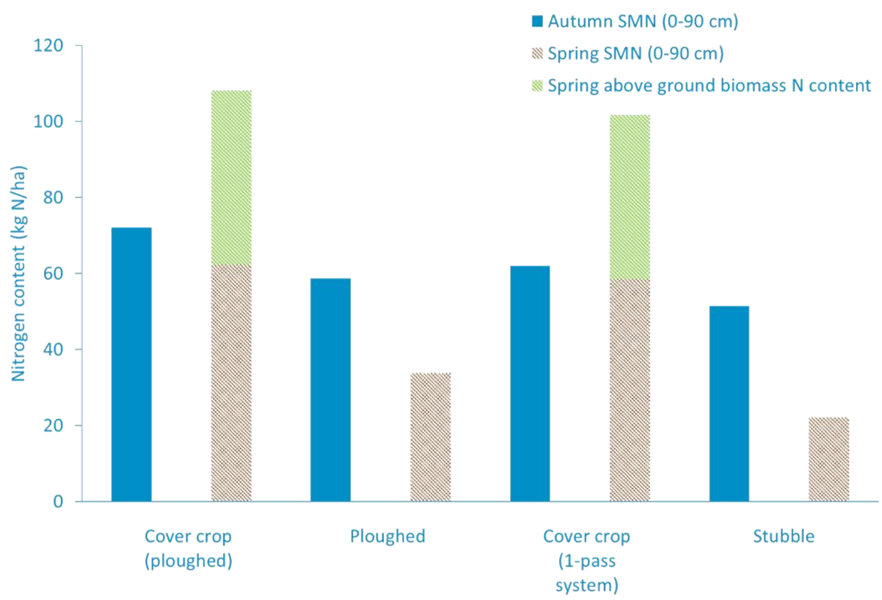


Figure 10. Soil mineral nitrogen (0-90 cm) measured in autumn 2019 and spring 2020 and above ground biomass nitrogen uptake

Over-winter drainage water nitrate concentrations

- The higher nitrate (NO_3) concentrations in drainage water (Figure 11) from the ploughed and over-winter stubble treatment compared to the cover crop treatments indicate that more NO_3 was leached over-winter from these treatments.

- This is supported by, the lower soil mineral nitrogen contents measured in February 2020 (Figure 10) on the ploughed and stubble compared to the cover cropped treatments.

- On the cover crop one-pass system, NO_3 concentration in drainage water was consistently below the EC drinking water nitrate limit of 50 mg/l (Figure 11).

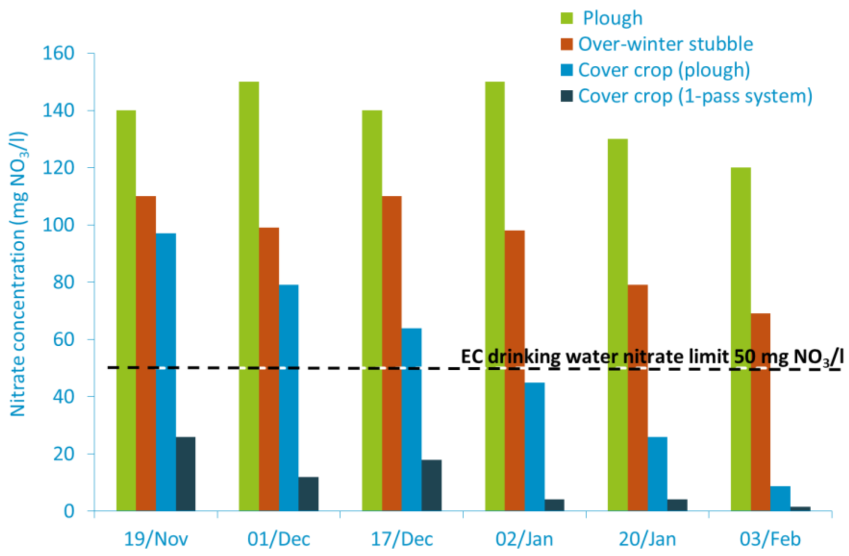


Figure 11. Drainage water nitrate concentrations from November to February

Soil structural assessments

Soil structural assessments were carried out on 14 February 2020. The Visual Evaluation of Soil Structure (VESS) scores indicated that the soil on Appletree was classed as being ‘firm’ with some angular non-porous aggregates (i.e. clods) present; whereas on Blacksmiths soil structure was better (i.e. friable/intact) containing more porous aggregates and no clods. Bulk density within the cover crop-plough was marginally higher at 1.57 g/cm^3 compared to no cover crop-plough suggesting the soil was more compact which could have impeded root growth.

Table 8. Soil structural assessments at Appletree and Blacksmiths

Field	Treatment	VESS[a] limiting layer score	VESS depth of limiting layer (cm)	Soil moisture (0-30 cm) (%)	Penetrometer resistance at 30cm depth (MPa)[b]	Bulk density 5-10cm depth (g /cm^3)[c]
Appletree	Cover crop (ploughed)	3	11 to 30	10	0.9	1.57
	Ploughed	3	11 to 24	12	0.8	1.47
Blacksmiths	Cover crop (1-pass system)	2	6 to 24	9	0.8	1.44
	Stubble	2	6 to 23	10	1.0	1.48

[a]VESS scores, penetrometer and bulk density measurements have been colour coded according to the Soil Health Scorecard that is being developed as part of the AHDB/BBRO Soil Biology and Health Partnership (ahdb.org.uk/greatsoils). Here ‘traffic light’ coding is used to identify properties where further follow-up investigation is required to help guide management decisions.

VESS limiting layer score is the maximum score recorded to 30cm depth. Scores of 1 or 2 indicate good soil structure (friable/intact); a score of 3 indicates moderate structure (firm) and scores of 4 or 5 poor soil structure (compact or very compact);

[b]Maximum penetrometer resistance to 40cm depth; root growth becomes restricted at resistances > 1.25 MPa and severely restricted at resistances > 2MPa

[c]Root growth can be restricted at high bulk densities, with threshold values depending on the soil organic matter content (SOM). At a SOM content of 2.5-2.8%, the threshold value is 1.35 g/cm^3 (little or no soil compaction), with values in the range 1.35-1.5 g/cm^3 indicating moderate levels of soil compaction.

Earthworm assessments

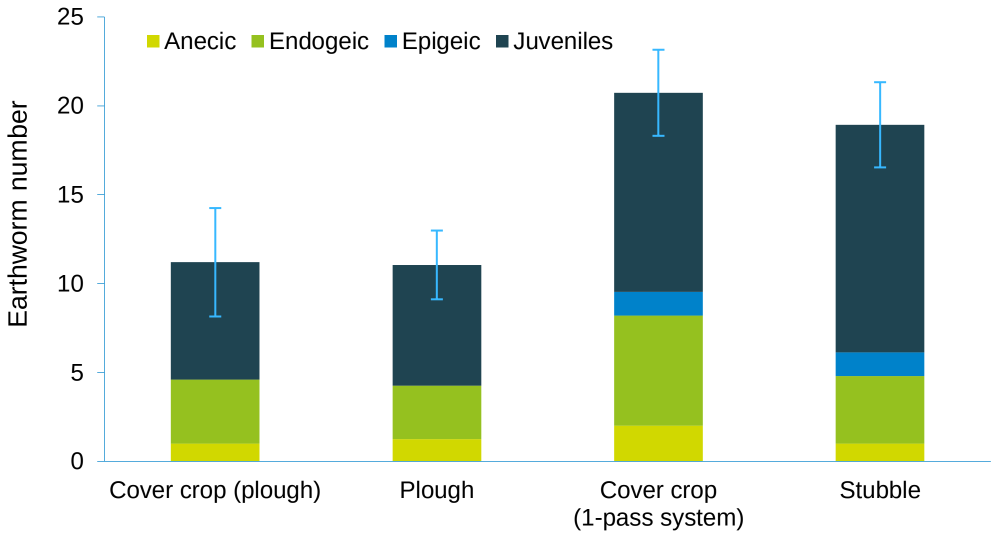


Figure 12. Number of earthworms by functional group. Error bars represent the standard error of the mean number of total worms, calculated across the 3 sampling zones.

A good number of earthworms were recorded across both fields (i.e. more than 8 per pit), mainly comprising juvenile and adult endogeic (topsoil) earthworms (Figure 12). Overall number of earthworms were greater on Blacksmiths, which was cultivated using a strip-tillage one-pass system (mean = 20) compared to Appletree which was ploughed (mean = 11), with no difference between areas with or without cover crops. Epigeic, (i.e. surface/ litter dwelling) earthworms were recorded on Blacksmiths but not Appletree fields; this corresponded to there being more surface trash following one-pass cultivation, compared to ploughed. The overall greater number of earthworms and presence of epigeic earthworms on Blacksmiths compared to Appletree, indicates that ploughing maybe having a detrimental impact on both overall earthworm numbers and community structure by reducing the availability of surface trash and disturbing burrows.

Crop yields

Appletree

- Mean yield measured within the cover crop area was *c*.2 t/ha *lower* (95% confidence interval = ± 0.24 t/ha) than the ploughed treatment at 8.1 t/ha (Figure 13).
- Drilling the cover crop after autumn ploughing, caused some surface soil compaction and Brian Barker (host) noted that it was harder to drill the spring crop; the slots did not close and pigeons

ate the seed. The bulk density assessments indicated a slightly higher level of compaction within the cover crop compared to no cover crop treatment.

- Throughout the season, on the cover crop treatment the spring crop was consistently ‘behind’ compared to no cover crop treatment.

Blacksmiths

- Mean yield measured within the cover crop area at 6.6 t/ha was *c*.1.7t/ha lower (95% confidence interval = ± 0.37 t/ha) than on the stubble treatment at 8.3 t/ha (Figure 13).
- Brian Barker (host) noted that wetter soil conditions at spring crop drilling on the cover crop treatment led to poor crop establishment, in comparison on the stubble treatment the soil had dried-up to give a ‘crumb’ texture and the crop establishment was better. Throughout the season, on the cover crop treatment the spring crop was consistently ‘behind’ compared to the overwinter stubble treatment.
- Furthermore, slug damage within the cover crop treatment, caused significant crop establishment losses; and the barley/grass crop did not recover.

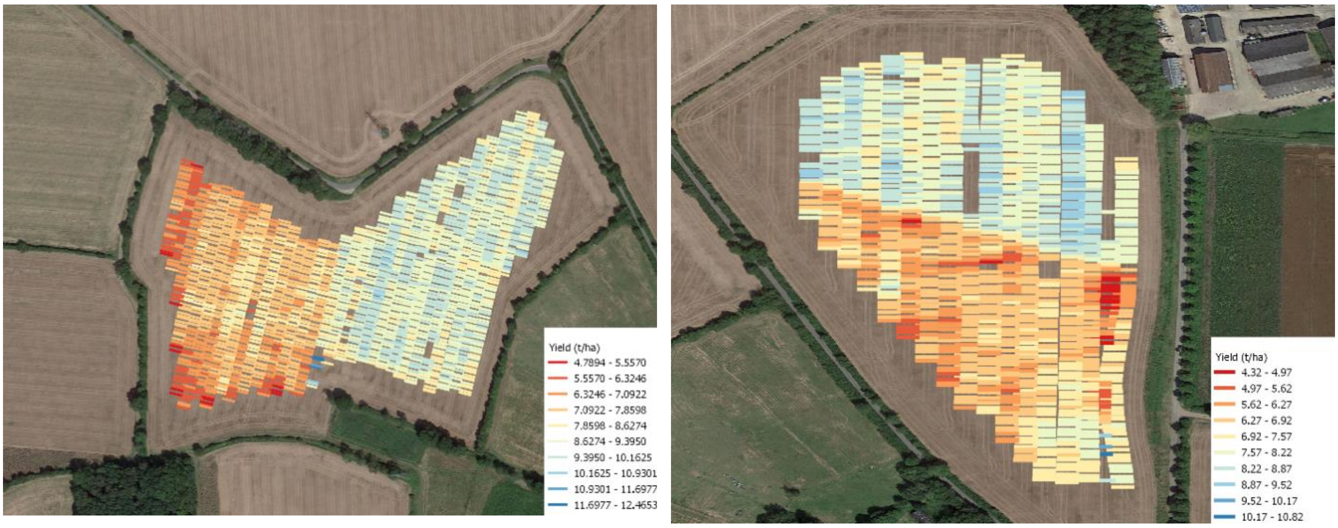


Figure 13. Modelled yield (t/ha) Appletree (left), Blacksmiths (right)

Costings

Table 9. Yield, net margin and cost of production for cover crop demonstration treatments

Cost of production (per hectare)	Appletree - Plough (Barley)	Appletree - Plough + CC (Barley)	Blacksmiths - OWS (Barley)	Blacksmiths - OWS + CC (Barley)
Yield (t/ha)	8.10	6.10	8.30	6.60
Price (£/t)	150.00	150.00	150.00	150.00
Variable costs (Per hectare)				
Total seed costs (£/ha)	116.76	158.76	121.54	163.54
Total fertilisers, trace elements and biostimulants (£/ha)	114.44	114.44	114.44	114.44
Total crop protection (£/ha)	100.50	100.50	92.76	92.76
Total variable costs (£/ha)	343.70	385.70	340.74	382.74
Gross margin (£/ha)	871.30	529.30	904.26	607.26
Overheads (Per hectare)				
Total labour, machinery and equipment (£/ha)	327.07	377.07	271.00	321.00
Total property and energy costs (£/ha)	46.01	46.01	46.01	46.01
Total administration costs (£/ha)	33.11	33.11	33.11	33.11
Cost of production and margins (Per hectare)				
Cost of production excluding rent and finance (£/ha)	749.90	841.90	690.87	782.87
Net margin excluding rent and finance (£/ha)	465.10	73.10	554.13	207.13
Cost of production (per tonne)				
Cost of production excluding rent and finance (£/t)	92.58	138.02	83.24	118.62

Future work

On-going work will follow the potential impact of the cover crop on winter crop yields and soil properties.

Action points for farmers and agronomists

The results demonstrate that a well-established cover crop is effective at taking up nitrogen and improving water quality by reducing nitrate concentrations in drainage water. During the wet autumn 2019, establishing cover crops following ploughing resulted in soil compaction which subsequently affected the establishment of the spring crop. On the strip tillage one-pass system, slug damage was particularly evident and higher trash following the cover cropping, meant soils did not dry out ahead of spring crop drilling. As a consequence, of poor spring crop establishment due to pest damage and ploughing or drilling in wet soil conditions, a *c.*2t/ha reduction in spring crop yield was observed following cover cropping, with an associated reduction in net margin.

During wet autumn conditions, where possible avoid establishing cover crops following ploughing. In the spring if wet soil conditions are likely, allow soils to dry out by leaving a large enough 'window' between cover crop destruction and spring crop drilling.

Links to further information/references

- Strategic Cereal Farm East Results from harvest 2019 for cover crops and water quality demonstration
- AHDB Maxi cover crop project: Final Report
- AHDB (2015). Opportunities for cover crops in conventional arable rotations. Information Sheet 41
- Crop Production Magazine (2019). A clearer course for cover crops

4. Pests, natural enemies and flower strips

Trial leader: Mark Ramsden & Sarah Cook

Start date: May 2020

End date: Ongoing

Watch the background video with Brian Barker, Rob Fox and Kate Smith

Headline

All fields exhibited different species abundance of pests and natural enemies, and no field could be considered 'average'. Management options to increase beneficial populations need to be applied to fit each field, where possible, accounting for surrounding habitats, underlying conditions and existing management practices.

What was the challenge/demand for the work?

Within arable crop production, strips of pollen and nectar flowers can be used to increase numbers of pollen- and nectar-feeding insects. In 2004, AHDB published research on Managing biodiversity in field margins to enhance integrated pest control in arable crops. The researchers reported that non-crop habitats constitute one of the most important sources of biodiversity within farmland. In many arable areas, field margins are the only major non-crop habitat, providing essential resources for beneficial species, and it has been recognised for some time that field margins can play an important role in the development of novel manipulation techniques to enhance the contribution of insect predators and parasitoids as part of Integrated Pest Management (IPM) strategies. The challenge to farmers remains how best to manage non-crop habitat in order to promote beneficial species and maintain pests below economic thresholds.

The abundance and impact of invertebrate pests and their natural enemies is dependent on a number of different factors, including (but not limited to); soil type, crop variety and physiology, agronomy, local weather conditions, and the availability of non-crop resources in the surrounding landscape. These factors and their interactions lead to a high degree of variation within and between fields. The impact of additional resources provided by floral strips is related to pre-existing conditions around the farm, the current levels of pests and natural enemies, and climatic conditions. In landscapes with few resources for beneficial insects, populations may take several seasons to build up following installation of floral margins. This work, carried out during establishment of the floral strips at Strategic Cereal Farms East and West, will create a robust initial dataset on invertebrate diversity and abundance. This will provide a point of comparison in future years as the floral strips establish.

How did the project address this?

Three AHDB Farm Excellence sites are hosting a trial investigating the impact of perennial flower strips on beneficial insect and pest populations within the field margins and within the arable crop. These sites are located at the Strategic Cereal Farm East, the Strategic Cereal Farm West and the Petworth Monitor Farm.

The aim of this work is to identify the main species present, demonstrate the underlying variation in pests and their natural enemies, and investigate the initial impact of the floral strips. This was achieved through three specific objectives;

Objective 1 – Investigate the variation of slugs, cereal aphids and their respective natural enemies across Strategic Cereal Farm East, Strategic Cereal Farm West, and the Petworth Monitor Farm.

The field team monitored slugs and summer aphids, and their natural enemies at a sub-field scale. Fields were selected for monitoring based on the trials undertaken within them (i.e. perennial flower strips), and to capture a range of likely drivers of variation across the farms. All monitoring was carried on 100m transects, with sampling points at 25m intervals. In most fields these are laid out in pairs; one close to the field margin, and one approximately 100m into the crop. This enabled the team to look at the effect of distance into the crop on pest and natural enemy.

Objective 2 – Assess the establishment of the flowering strips, and any encroachment of weeds into the adjacent crop.

Objective 3 – On Strategic Cereal Farm West (SCFW) only; assess the impact of in-field flowering strips on the yield.

Removing land from crop production clearly has an immediate impact on overall yield, however there may be additional impacts in the adjacent crop. Yield assessment in field 43 at SCFW will quantify any losses and/or gains as a result of the floral strip.

Field details

Fields were monitored across the three farms as below:

- **Strategic Cereal Farm West:** 5 fields including: Field 6, Field 7, Field 40, Field 42 and Field 43
- **Strategic Cereal Farm East:** 9 fields including: Big Guinea Row, Bottom 59, Kells, Tom Dixon, Top 59, Wally's, Appletree, Blacksmiths, Meadow
- **Petworth Monitor Farm:** 3 fields including: Field 10A, Field 14A, Field 6A

In three of those fields at SCFW and three at SCFE, a field scale trial was established to look at the impact of flowering strips.The treatments are:

- Farm standard
- Within field and field edge strips
- Field edge flower strips

The additional fields were included to provide greater insight into the between field variation across the sites. Field, cropping and soil type for the three trial fields at the Strategic Farms are provided in Table 10, flower strip trial layout is shown in Figure 13.

Table 10. Perennial flower strips trial site field details

Treatment name:	Farm standard	Field edge flower strips	Within field and field edge flower strips	Farm standard	Field edge flower strips	Within field and field edge flower strips
Strategic Farm	Strategic Farm West			Strategic Farm East		
Field name:	42	40	43	Big Guinea Row	Top 59	Bottom 59
Field size (ha):	32	9	7.5	6.78	10.39	10.61

Soil type:	medium, heavy, very heavy	Medium, very heavy	Medium	Sandy clay loam	Sandy loam	Sandy clay loam
Harvest 2019 crop:	Spring barley/ oilseed rape	Oilseed rape	Oilseed rape	Grass	Grass	Grass
Harvest 2020 crop:	Wheat	Wheat	Wheat	Grass	Grass	Grass

Figure 13. Perennial flower strips trial layout at a) Strategic Cereal Farm West and b) Strategic Cereal Farm East

Figure 14. Sown grass and flower species

Assessments

Throughout this work, we selected assessment methods that can feasibly be undertaken by farmers for themselves.

Objective 1 – Assessment of slugs, cereal aphids, and their respective natural enemies.

- Slugs and ground dwelling natural enemies were assessed in the autumn (late October), and in the summer (around wheat GS60).
- Slugs are monitored using simple bait traps; a teaspoon of bran covered with an inverted plant pot saucer, fixed to prevent it blowing away (Figure 15)

Figure 15. Slug trap using chicken layers' mash as bait, from the AHDB Integrated slug control factsheet

- To monitor natural enemies of slugs and other ground dwelling invertebrates, we used pitfall traps. These consist of a plastic tub (e.g. yogurt pot or pint glass) submerged into the ground so that the open end is level with the soil surface (Figure 16). These are part filled with saline solution to kill and preserve any invertebrates that fall into the tap over a three day period.

Figure 16. Uncovered pitfall trap consisting of a yogurt pot inserted into a length of submerged drain pip in the ground, and partially filled with saline solution to kill and preserver ground dwelling invertebrates.

- Summer aphids (Figure 17) and their natural enemies were monitored using plant counts. Each monitoring point consisted of twenty randomly selected tillers at transect monitoring points.
- On each tiller the number of aphids, diseased aphids, mummified aphids, hoverfly larvae, ladybird larvae, adult ladybirds, or other invertebrates will be counted.
- This assessment is in line with the current recommended threshold assessment for cereal aphids.

Figure 17. Grain aphids *Sitobion avenae* on wheat ear

Objective 2 – Assessment of floral strips and associated weeds

Plant species numbers were counted in 0.1m² quadrats every 5m within the strips and 0.5m from the strip into the crop. Assessments were carried out in June/July using 0.1 m^2 quadrate sampling. On 4 May 2020, the flowering strips were drilled, with a grass and flower mix (see Table 11 and Figure 18).

Figure 18: Flowering strips at Strategic Farm East, June 2020

Table 11. List of sown grass and flower species at Strategic Cereal Farm East

Grass mix – sown at 20 kg/ha		**Flower mix – sown at 6 kg/ha**	
Percentage	**Species**	**Percentage**	**Species**
5	Comment Bent	12.5	Common knapweed
10	Crested Dogstail	15	Wild carrot
20	Sheep's fescue	15	Lady's Bedstraw
20	Slender Creeping Fescue	10	Oxeye Daisy
20	Chewing's Fescue	12.5	Ribwort Plantain
5	Small Timothy	5	Salad Burnet
20	Smooth-stalked Meadow-Grass	1.5	Selfheal
		6	Common Sorrel
		10	Red Campion

What results has the project delivered?

Objective 1 –Investigate the variation of slugs, cereal aphids and their respective natural enemies across Strategic Cereal Farm East, Strategic Cereal Farm West, and the Petworth Monitor Farm.

Slugs

Size (length)	30-70mm
Peak activity	Weather dependent
Adult food	Most crops
Breeding season	Autumn & spring

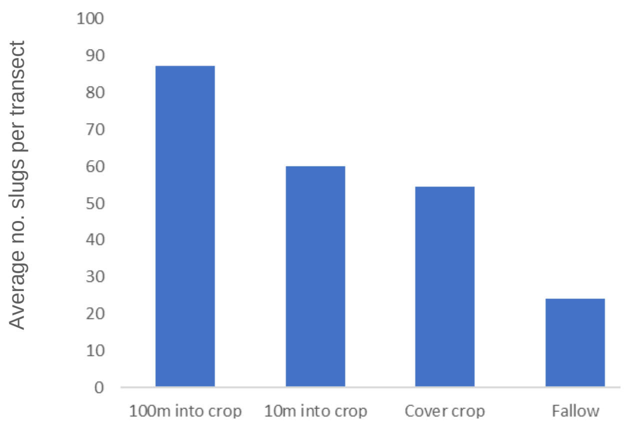
Representative species

Grey field slug, *Deroceras reticulatum*
Most common species recorded.

Description

Findings in 2019/20

- Slugs were found in all the fields at Strategic Cereal Farm West and Petworth Monitor Farm, and all but one field at Strategic Cereal Farm East.
- At Kells at the SCFE, baiting took place shortly after cultivation which is likely to have temporarily reduced slug activity.
- Slugs were present at all sites both close to the field margin and in the field centre; there was a slight trend for higher numbers in the field centre.
- Overall, Strategic Cereal Farm West had the lowest abundance of slugs across all fields. The highest abundance was found at Petworth Monitor Farm, and in one field (Big Guinea Row) at Strategic Cereal Farm East.
- No slugs were recorded during the summer assessment at any of the sites.



Key messages

Slug abundance was relatively low at Strategic Cereal Farm West. Variation was high within and between farms. Slug assessments should always be carried out per field, ideally treating only areas of high activity.

Table 12. Number of slugs per trap at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Figure 19a: Average number of slugs per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019.

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Appletree	Blacksmiths	Meadow
Autumn results	5	5	3	1	7	5	41	31	27	14	0	1	11	2	2	14	x
Summer results	0	0	x	x	0	0	0	0	0	0	x	x	0	0	0	0	0

Units = average number of slugs per trap; threshold for treatment = 4 slugs per trap
The colour indicates whether this is relatively high (red), average (amber) or low (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Ground-dwelling predators

The diversity of ground-dwelling predators changes between the autumn and summer, as different species breed during differ times of year and specialise on different food sources. Rather than focus on individual species, we present functional groups; groups of species similar in their role within the ecosystem (following definitions developed by Cole *et al.* 2002 and grouping spiders into either money spiders or ground predators). The boxes below summarise the main functional groups of natural enemies found in autumn and summer pitfall trapping and summer counts on cereal tillers. In the tables, the row number indicates the total number recorded of that group during the respective trapping periods, the colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study.

Ground beetles - Group 1

Size (length)	8 – 18mm
Adult food	Generalist predator
Breeding season	Autumn winter
Peak adult activity	Spring and summer

Description

Representative species

- *Pterostichus niger (picture)*
- *Pterostichus madidus*
- *Pterosticus melanarius*
- *Poecilus cupreus*
- *Nebria brevicolis*
- *Calathus fuscipes*

Most species are 8-18mm long generalist predators. Hunting at night, they tend to be more active in the spring/summer pushing their way through the undergrowth.

Findings in 2019/20

- These beetles play an important role in predating pest invertebrates.
- Present in all fields monitored, in highest abundance in Strategic Cereal Farm West and fewer in Strategic Cereal Farm East.
- The installation of ‘beetle banks’ are especially beneficial for this group, which can readily migrate between non-crop and crop habitats.

Key message

Often referred to as ‘rain beetles’, these should be easily found in and around your crops.

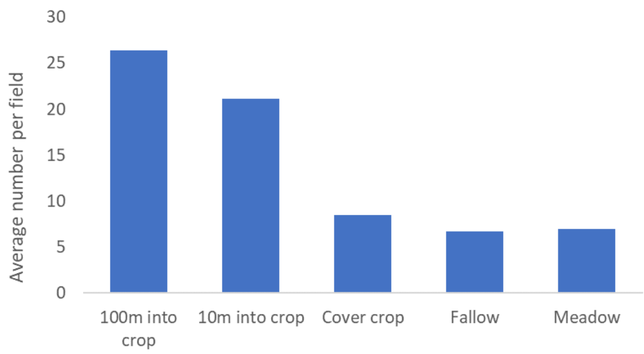


Figure 19b: Average number of group 1 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Table 13. Number of Group 1 beetles collected at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Appletree	Blacksmiths	Meadow
Autumn results	12	12	6	18	43	18	3	13	1	4	2	5	14	2	18	11	x
Summer results	308	103	x	x	161	114	123	121	3	1	x	x	5	48	14	18	7

Units = total number collected

The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Ground beetles - Group 2

Size (length)	15 – 25mm
Adult food	Generalist predator
Breeding season	Spring and summer
Peak adult activity	Spring and summer

Representative species

Description

The largest UK ground beetles, eating slugs, snails and worms. These are easily distinguished from most other beetles by their large size and purple hue.

Findings in 2019/20

- There are several similar species in the UK, but the violet ground beetle was the only one found in this work.
- Unlike most ground beetles, these have a two year life cycle.
- The adults of these species are only active in the spring/summer and were only collected during the summer pitfall trapping.
- Their larvae are also beneficial predators in the soil but were not recorded during this study.

Key message

Their longer life cycle, largely spent as larvae in the soil, can make these beetles vulnerable to intensive cultivations. Reduced ploughing and min-till approaches can help promote group 2 beetles.

Carabus violaceus – the violet ground beetle.

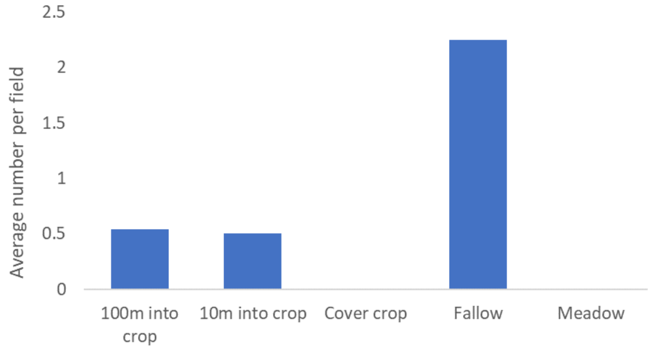


Figure 19c: Average number of group 2 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Table 14. Number of Group 2 beetles collected at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Appletree	Blacksmiths	Meadow
Autumn results	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x
Summer results	2	1	x	x	2	0	0	0	8	0	x	x	0	12	1	8	0

Units = total number collected

The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Ground beetles - Group 3		
Size (length) Adult food Breeding season Peak adult activity	4 – 9 mm Seeds Spring and summer Spring and summer	**Representative species**

Representative species

Amara ovata

Description

These beetles are adapted to foraging in dense undergrowth rather than the open habitat of cropped land.

Findings in 2019/20

- While there are several species in this group, we only found *Amara ovata*.
- Despite living in the crop and eating seeds, these almost never impact crop performance – rather they contribute to weed suppression.
- Unsurprisingly, most were found in the Meadow at Strategic Cereal Farm East, which is ideal habitat for them.

Figure 19d: Average number of group 3 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Key message

These herbivores can contribute to weed suppression.

Table 15. Number of Group 3 beetles collected at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Appletree	Blacksmiths	Meadow
Autumn results	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	x
Summer results	2	0	x	x	0	0	0	0	0	0	x	x	1	1	0	1	15

Units = total number collected

The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Ground beetles – Group 4

Size (length)	3 – 5 mm
Adult food	Collembola
Breeding season	Spring and summer
Peak adult activity	Spring and summer

Description

Very small but fast-moving beetles, active during the day. Often move in short bursts while searching for prey.

Findings in 2019/20

- Group 4 beetles specialise on collembola (springtails). As their name suggests, springtails can propel themselves away from danger. Their predators have excellent eyesight and other adaptions to help catch this difficult prey.
- While collembola are not a pest, group 4 species will consume other pests given the opportunity and their distribution can give an insight into the overall diversity of invertebrates.
- Relatively high abundance was found in the cover crop and associated fallow land. This may be associated with improve hunting ground provided by these habitats.

Key message

These collembola specialists may benefit from resources provided in cover crops.

Representative species

- *Notiophilus biguttatus (pictured)*
- *Bembidion lampros*
- *Leistus fulvibarbis*

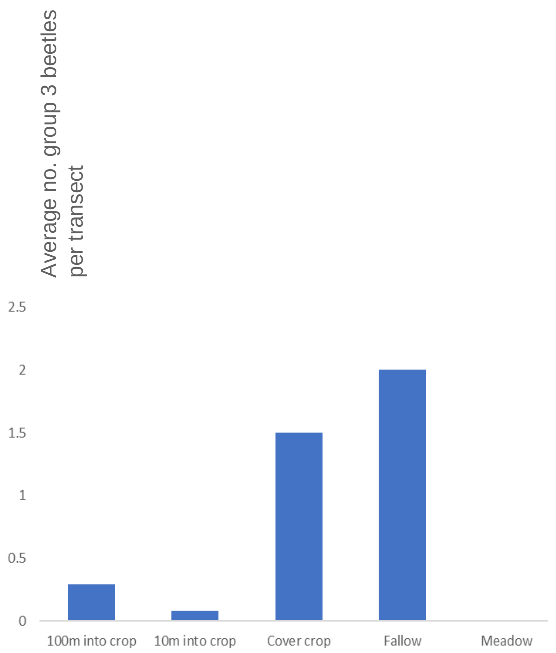


Figure 19e: Average number of group 4 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Table 16. Number of Group 4 beetles collected at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Appletree	Blacksmiths	Meadow
Autumn results	1	0	0	0	0	0	0	0	2	0	0	1	3	1	3	9	x
Summer results	0	0	x	x	0	0	0	0	0	1	x	x	0	0	0	2	0

Units = total number collected.

The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Ground beetles - Group 5

Size (length)	5 – 9 mm
Adult food	Generalist predator
Breeding season	Spring and summer
Peak adult activity	Spring and summer

Representative species

Agonum dorsale

Description

Small generalist predators, active at night. They prefer to hunt in dense undergrowth rather than the open habitat of cropped land, which may be why none were recorded at any of the sites.

Agonum dorsale is not uncommon during the spring in agricultural fields, where moves within the crop canopy searching for aphid prey. For this reason, this species may be found during water trapping planned for spring 2021.

Species found (total autumn/winter)

- No species of this group were found during the study.

Table 17. Number of Group 5 beetles collected at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Appletree	Blacksmiths	Meadow
Autumn results	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x
Summer results	0	0	x	x	0	0	0	0	0	0	x	x	0	0	0	0	0

Units = total number collected

The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Ground beetles - Group 6

Size (length)	3 – 10 mm
Adult food	Generalist predator
Breeding season	Spring and summer
Peak adult activity	Spring and summer

Representative species

- *Trechus obtusus (pictured)*
- *Badister bipustulatus*

Description

Very small to small often flight capable beetles, which search for small soft bodied invertebrates (largely aphids) and insect eggs on the ground or in the crop canopy.

Findings in 2019/20

- Group 6 beetles were found in much greater numbers in the cover crops and associated fallow ground adjacent.
- They consume a range of eggs and small insects, and can make important contributions to pest suppression.
- The dense habitat and associated prey within the cover crops may explain this. These are important predators, and cover crops may provide beneficial habitat to promoting them across the farm.

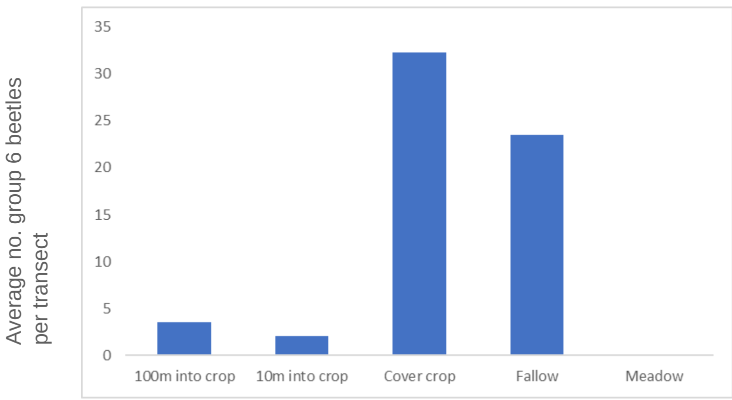


Figure 19f: Average number of group 6 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Key message

These small but important predators appear to benefit from resources provided by cover crops.

Table 18. Number of Group 6 beetles collected at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Appletree	Blacksmiths	Meadow
Autumn results	2	7	2	16	18	1	1	6	1	3	1	17	5	8	152	24	x

Summer results	3	1	x	x	0	1	0	2	0	1	x	x	0	30	8	41	0

Units = total number collected
The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Ground beetles - Group 7

Size (length)	5 – 10 mm
Adult food	Mixed
Breeding season	Autumn and winter
Peak adult activity	Mixed

Representative species

- *Harpalus rufipes (pictured)*

Description
Small to medium in size, these beetles are omnivorous as adults.

Findings in 2019/20
- Very few were collected. These beetles prefer denser habitats while searching for food rather than more open crop habitats.
- Very rarely some species can damage some crops – *Harpalus rufipes* is also known as the strawberry seed beetle for this reason. It rarely causes economic damage and is more likely to be beneficial as a predator.

Key message
Often present in low numbers in arable crops, preferring denser undergrowth, these beetles can contribute to pest management.

Table 19. Number of Group 7 beetles collected at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

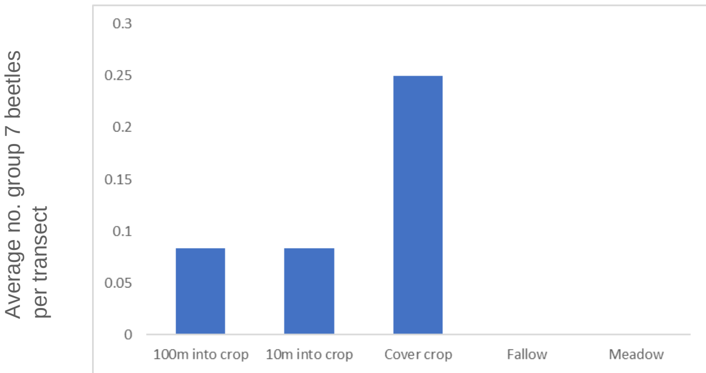


Figure 19g: Average number of group 7 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Appletree	Blacksmiths	Meadow
Autumn results	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x
Summer results	2	0	x	x	0	2	0	0	0	0	x	x	0	0	6	0	0

Units = total number collected
The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Money spiders (Linyphiidae)

Size (length)	Less than 5 mm
Adult food	Generalist predator
Breeding season	Autumn and winter
Peak adult activity	Summer

Representative species

Erigone dentipalpis (pictured)
Lepthyphantes tenuis

Description

In most cases they have grey or black bodies, although some do have distinctive markings. Money spiders usually make a small sheet web and then position themselves underneath the web. Money spider disperse by ballooning; floating on air currents suspended on a thread of silk.

Findings in 2019/20

- Money spiders were recorded in all fields monitored but were most common in the cover crop/fallow fields in the summer trapping.
- More were recorded during the spring.

Key message

Money spiders are important predators as their webs can trap a range of pests.

Table 20. Number of money spiders recorded at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

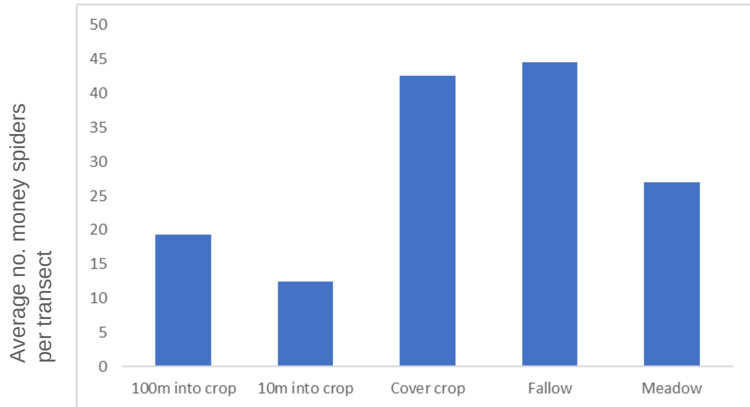


Figure 19h: Average number of money spiders per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Appletree	Blacksmiths	Meadow
Autumn results	1	3	11	21	16	10	3	4	26	13	3	10	14	6	9	9	x
Summer results	41	29	x	x	38	108	47	52	145	36	x	x	32	93	106	224	27

Units = total number collected
The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Other predatory spiders

Size (length)	6-8 mm
Adult food	Generalist predator
Breeding season	Autumn and winter
Peak adult activity	Summer

Representative species

Trochosa ruricola

Description

Ground dwelling spiders, mostly wolf spiders, are active predators on the soil surface. Often seen moving rapidly across the ground, they hunt any small invertebrate they can catch and kill.

Findings in 2019/20

- Spiders prefer areas of dense habitat, relatively undisturbed, and were mainly found in the meadow at Strategic Cereal Farm East

Key message

Ground dwelling spiders make important contributions to pest management, but are vulnerable to disturbance. Reduced cultivations and provision of undisturbed habitat around the farm will improve numbers.

Table 21. Number of predatory spiders recorded at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

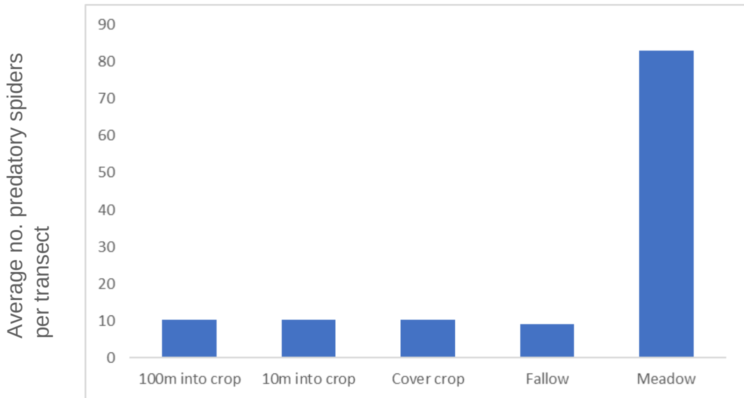


Figure 19i: Average number of ground dwelling spiders per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Appletree	Blacksmiths	Meadow
Autumn results	12	8	19	8	31	17	7	24	18	6	3	8	18	9	10	14	x
Summer results	22	18	x	x	49	41	24	46	9	12	x	x	35	50	30	23	83

Units = total number collected
The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Cereal aphids

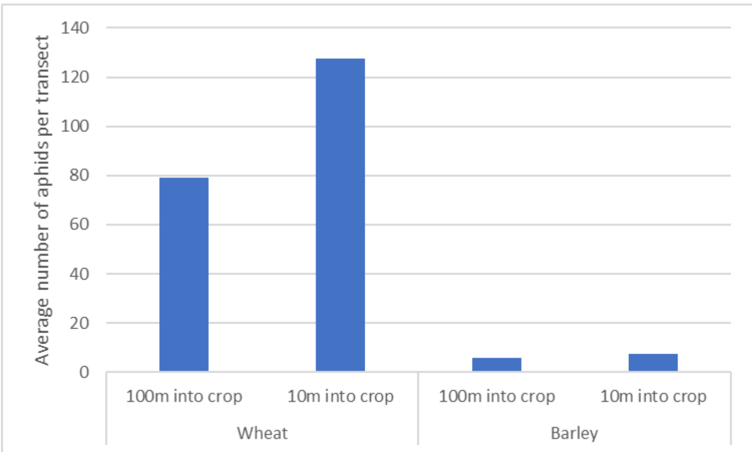
Size (length)	1mm
Adult food	Grasses
Breeding season	Spring to autumn
Peak adult activity	Spring to summer

Representative species

Grain aphids Sitobion avenae on wheat ear

Description
Cereal aphids are made up of four key species; grain aphids (*Sitobion avenae)*,

Of these grain aphids are the most common, and the main vector of barley yellow dwarf virus (BYDV) in the UK. In high numbers, summer infestations can cause economic damage to the crop, and can increase the number of BYDV carrying aphids migrating into emerging crops in the autumn.



Findings in 2019/20

- Aphid abundance was low in 2020; numbers were well below the threshold for treatment.
- Abundance was especially low in barley (Fields 42and 43 in Strategic Cereal Farm West, and Appletree and Blacksmiths in Strategic Cereal Farm East.

Key message

Cereal aphids were recorded in number well below treatment threshold in all fields monitored.

Table 22. Number of aphids recorded at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Figure 19j: Average number of cereal aphids per transect at 100m or, 10m into wheat or barley crops, in July 2020.

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlally' s	Appletree	Blacksmiths	Shrubbery	Paddys
GS60 results	177	223	424	29	12	x	x	194	141	x	109	6	7	219	166

Units = total number recorded on 200 tillers inspected.
The recommended threshold for treatment is 5 or more aphids per ear; or 1,000 per 200 tillers.
The colour indicates whether this is relatively high (red), average (amber) or low (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Aphid mummies – parasitized by wasps	
Description	**Representative species**
Aphid parasitoid wasps lay their eggs inside the aphid. The larvae consume it from within, forming an aphid 'mummy' from which the adult wasp emerges. Adults feed on nectar, pollen and honeydew. The quality and availability of adult food can increase both the lifespan and reproductive success; this is where floral strips can play an important role.	 Mummy of the aphid Sitobion avenae parasited by the parasitoid wasp Aphidus rhopalosiphi (Braconidae - Aphidiinae).

The adults are fairly mobile, but tend to closely follow their aphid prey.

Findings in 2019/20

- The total number of aphid mummies was low in all sites, but they were present in all fields.
- Low numbers are unsurprising given the low numbers of aphids.
- It takes 10-14 days for mummies to form once an egg has been laid inside them. This lag limits the insight we can get from single assessments.
- There was a slight trend for higher abundance at Strategic Cereal Farm East.

Key message

Low numbers of aphids at all sites limited the abundance of their natural enemies.

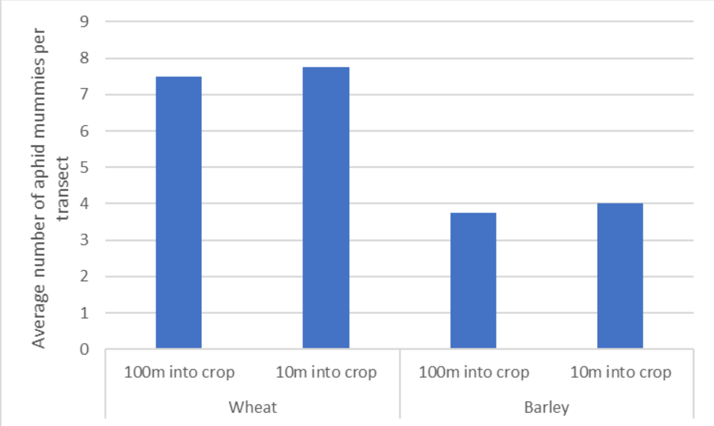


Figure 19k: Average number of cereal aphid mummies per transect at 100m or, 10m into wheat or barley crops, in July 2020.

Table 23. Number of aphid mummies recorded at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wallys	Appletree	Blacksmiths	Shrubbery	Paddys
GS60 results	28	20	13	13	9	x	x	10	15	x	9	2	4	19	12

Units = total number recorded on 200 tillers inspected

The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Aphid predators

Description	Representative species
Aphid predators are very important in supressing aphid populations. Two key predators often found in crops are hoverfly larvae and ladybird larvae. In both cases, the eggs are laid in the crop near to aphid infestations and the larvae consume hundreds of aphids before pupating. The adults, in contrast, rely partly or entirely on	 

nectar and pollen, and a lack of floral resources can limit their contribution.

The adults are strong fliers, so can move across the landscape between floral resources and crops, meaning that the location of the floral resources does not necessarily have a direct impact on local pest infestations. They will, however, often remain relatively close to mixed habitats, which can lead to greater numbers closer to the field margins.

Findings in 2019/20

- The low aphid numbers in 2020 resulted in low aphid predator abundance.
- There was a trend for higher abundance closer to the field margins, as has been found in other studies.
- As with parasitoid wasps, single assessments do not provide data suitable for investigating the full contribution of aphid predators to pest suppression.
- There was a slight trend for higher numbers of predatory larvae at Strategic Cereal Farm West.

Key message

Low numbers of aphids at all sites limited the abundance of their natural enemies.

Predatory hoverfly larvae (above, left) and adult (above right); predatory ladybird larvae (below left) and adult (below right).

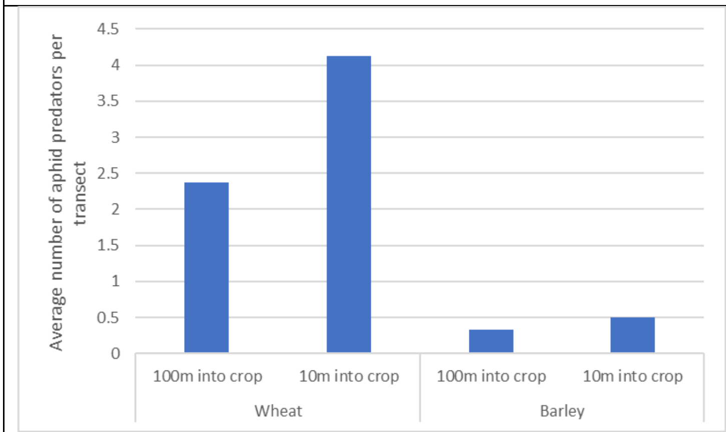


Figure 19L: Average number of cereal aphid predators per transect at 100m or, 10m into wheat or barley crops, in July 2020.

Table 24. Number of aphid predators recorded at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40	Field 42	Field 43	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wallys	Appletree	Blacksmiths	Shrubbery	Paddys
GS60 results	2	18	2	17	2	x	x	3	3	x	4	0	0	12	8

Units = total number recorded on 200 tillers inspected

The colour indicates whether this is relatively low (red), average (amber) or high (green) relative to the other fields sampled in this study. x indicates where no monitoring was carried out in this field, at this timing.

Table 25. Summary table of counts in pest and natural enemies and flower strips trial

		Total	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Appletree	Blacksmiths	Meadow	Shrubbery	Paddys
Slugs	Autumn results	169	5	5	3	1	7	5	41	31	27	14	0	1	11	2	2	14	x	x	x
	Summer results	0	0	0	x	x	0	0	0	0	0	0	x	x	0	0	0	0	0	x	x
Group 1 Generalist predatory ground beetles, eating anything they can catch.	Autumn results	182	12	12	6	18	43	18	3	13	1	4	2	5	14	2	18	11	x	x	x
	Summer results	1026	308	103	x	x	161	114	123	121	3	1	x	x	5	48	14	18	7	x	x
Group 2 Large predatory ground beetles, eating slugs, worms, and other invertebrates	Autumn results	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	x	x
	Summer results	34	2	1	x	x	2	0	0	0	8	0	x	x	0	12	1	8	0	x	x
Group 3 Seed eating ground beetles	Autumn results	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	x	x	x
	Summer results	20	2	0	x	x	0	0	0	0	0	0	x	x	1	1	0	1	15	x	x
Group 4 Small predators, mainly eating collembola (springtails) and other small invertebrates	Autumn results	20	1	0	0	0	0	0	0	0	2	0	0	1	3	1	3	9	x	x	x
	Summer results	3	0	0	x	x	0	0	0	0	0	1	x	x	0	0	0	2	0	x	x

		Total	Field 6	Field 7	Field 40	Field 42	Field 43	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Apple Tree	Blacksmiths	Meadow	Shrubbery	Paddys
Group 6 Very small predatory ground beetles, eating eggs, larvae and other small soft bodied invertebrates.	Autumn results	264	2	7	2	16	18	1	1	6	1	3	1	17	5	8	152	24	x	x	x
	Summer results	87	3	1	x	x	0	1	0	2	0	1	x	x	0	30	8	41	0	x	x
Group 7 Omnivorous ground beetles, preferring dense habitats.	Autumn results	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	x	x
	Summer results	10	2	0	x	x	0	2	0	0	0	0	x	x	0	0	6	0	0	x	x
Money Spiders Generalist predators of small invertebrates, but their webs may catch larger prey.	Autumn results	159	1	3	11	21	16	10	3	4	26	13	3	10	14	6	9	9	x	x	x
	Summer results	978	41	29	x	x	38	108	47	52	145	36	x	x	32	93	106	224	27	x	x
Ground spiders Generalist predators of any invertebrates they can catch and kill on the ground.	Autumn results	212	12	8	19	8	31	17	7	24	18	6	3	8	18	9	10	14	x	x	x
	Summer results	442	22	18	x	x	49	41	24	46	9	12	x	x	35	50	30	23	83	x	x
Cereal aphids	GS60 results	1707	177	223	424	29	12	x	x	x	x	x	194	141	x	109	6	7	x	219	166
Cereal aphid mummies	GS60 results	154	28	20	13	13	9	x	x	x	x	x	10	15	x	9	2	4	x	19	12
Cereal aphid predators	GS60 results	71	2	18	2	17	2	x	x	x	x	x	3	3	x	4	0	0	x	12	8

Units = Please refer to functional group tables. The colour indicates whether this is relatively low, average or high relative to the other fields sampled in this study and coloured to reflect the species. x indicates where no monitoring was carried out in this field, at this timing.

Objective 2 – Assessment of floral strips and associated weeds

Establishment was slow due to exceptionally dry conditions throughout May. Very few of the sown species established, only oxeye daisy, red campion and wild carrot but these could have been present in the soil seedbank. A high number of species were present: 18 in Bottom 59, 8 in top 59 and 20 in Big guinea row. The most frequently occurring species were groundsel, grasses, smooth sowthistle and wild carrot (Table 26). Costs of establishing the flowering strips are provided in Table 27.

Table 26. Frequency of species present (% of quadrats species present in, at levels greater than 5%)

Species common name	Bottom 59	Top 59	Big guinea row
Charlock	0.0	0.0	6.5
Cranesbill	0.0	0.0	3.2
Fat hen	5.6	0.0	6.5
Groundsel	67.6	86.4	95.2
Hedge Mustard	11.3	0.0	0.0
Many seeded goosefoot	8.5	4.5	0.0
Mayweed	2.8	9.1	3.2
Oilseed rape	5.6	4.5	0.0
Oxeye daisy	**1.4**	**0.0**	**6.5**
Red campion	**0.0**	**0.0**	**6.5**
Red-dead nettle	5.6	0.0	0.0
Ribwort plantain	14.1	0.0	6.5
Grasses	83.1	45.5	54.8
Smooth sowthistle	28.2	9.1	11.3
Vipers Bugloss	8.5	9.1	0.0
Wild carrot	**18.3**	**0.0**	**22.6**

Other species present: Black-grass, Bristley ox tongue, common mallow, cow basil, dock, mugwort, phacelia,mscarlet pimpernel, sun spurge, wall speedwell, Willowherb and yarrow

Figure 20. Flowering strips, at field margin of Top 59 field taken June 2020

Table 27. Costings for grass and flower strips establishment

Item	Cost (£/ha)
Preparation of strips operation (4m discs/tines + power harrow + roll)	£100.00/ha
Seed	£589.91/ha
Broadcast operation	£15.00/ha
Rolling operation	£10.00/ha
Total cost of establishment	£714.91

Overall messages

- No two fields were alike in their composition of invertebrate pests and beneficials
- No two floral strips were alike in their plant species composition, although strips within each farm were more similar that between farms reflecting the soil conditions, species selected, and date of drilling
- There was no clear evidence in this study of an impact of distance into the crop on pest or beneficial invertebrate abundance; though there is a lot of evidence from larger studies that the number of beneficials reduces further into the field
- Large differences were observed between contrasting habitat types; the cover crops, fallow land and meadow at Strategic Cereal Farm East were notably different, as were the three grass fields at Strategic Cereal Farm East (Big Guinea Row, Top 59 and Bottom 59)
- Important beneficial predators were collected from all sites
- The floral strips were not yet installed at the time of autumn assessments and had no influence on invertebrates monitored at this time
- The floral strips at Strategic Cereal Farm East were not established at the time of the summer assessments, and again had no influence on the pests and beneficials monitored

- The floral strips at Strategic Cereal Farm West established well and were providing floral resource prior to and during the summer assessments. The ground beetles and spiders monitored do not require these resources – though they will benefit from these habitats in other ways, such as using them as refuge from crop management later in the year, and as winter habitat. The aphid predators will utilise the floral resource, but the numbers recorded were too low to identify any increase in abundance associated with the strips
- The impact of the floral strips on beneficial natural enemies will be looked at in more detail on 2021, when we will undertake repeat monitoring to demonstrate the change in aphid abundance over time and associate impact of natural enemies and proximity to floral strips
- In 2021 will also look again at the ground beetles to observe any changes in species or abundance, and whether the floral strips may have had an impact on diversity and/or abundance.

Action points for farmers and agronomists

The scale of monitoring, and development of identification skills required to make reliable estimates of changes in pest and associated beneficials species abundance is very time consuming. Despite this, there is still a huge benefit in familiarising yourself with the various insects in and around your crop, and some easy ways to investigate and compare different areas. Don't spend a lot of time identifying individual species – the first step is to be able to recognise the common insects in and around your farm.

Action	Description	When
Pitfall trapping	Install two pitfall traps to look at ground beetle and spider 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	Monitor slug abundance over time, and see changes in different locations. Consider what might be driving any differences you see.	Sep – Nov
Review your landscape	Identify all 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 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. Don't expect immediate results – it can take a few years for populations to build up.	Drill in spring or early autumn for flowering the following year.

Links to further information/references

- **AHDB Encyclopaedia of pests and natural enemies** (online)
- **AHDB Integrated slug control factsheet** (online)
- **ASSIST Research** (online)
- **GWCT Wildflower mixes and pollen and nectar strips** (online)

5. Very low inputs

Trial leader: Phil Walker

Start date: May 2020

End date: September 2020

Watch the background video with Brian Barker

Headline

Disease level was too insignificant to have any impact on yield; therefore disease levels were too low to fully evaluate the effect of reduced fungicide input. However, the results suggest in a low disease pressure season there is little benefit in increasing fungicide spend to improve gross margins.

What was the challenge/demand for the work?

The effect of reduced input applications on diseases, crop yields and gross margins. In order to maintain activity of pesticides there needs to be a step-change in the way cereal inputs are used.

This demonstration will incorporate the use of managed lower inputs of all pesticides (insecticides, herbicides, fungicides) and fertilisers to investigate the impact on pest and disease pressure, crop yield and gross margins in a single field (Table 30). Lower inputs (Table 29) were applied to the whole field and the results will be compared to conventionally managed winter wheat elsewhere on the farm.

How did the project address this?

Table 28. Field details for Very Low Inputs demonstration

Field name	Tom Dixon
Size	3.1 ha
Soil type	Sandy loam
Application type	Broadcast

Assessments

- Crop yield
- Disease assessments at key growth stages
- Routine topsoil analysis
- Pests and natural enemies monitoring

Table 29. Applications and costs

Product	Type	Application Rate	Cost
T0 - 11/04/20			
Tempo	PGR	0.05 l/ha	£1.15
T1 - 02/05/20			
Toledo (tebuconazole)	Fungicide	0.5 l/ha	£7.30

3C Chlormequat 750	PGR	1 l/ha	£1.80	
Tempo	PGR	0.05 l/ha	£1.15	
T3 – 15/06/20				
Toledo	Fungicide	0.3l/ha	£4.38	
Other Inputs				
Product	**Type**	**Application Rate**	**Date**	**Cost**
KayNitro Sulphur	Fertiliser	200 kg/ha	20/03/2020	£50.80
SingleTop	Fertiliser	296 kg/ha	14/04/2020	£65.12
SingleTop	Fertiliser	125 l/ha	05/05/2020	£27.50
Azural	Herbicide	3 l/ha	28/10/2019	£6.45
Liberator	Herbicide	0.60 l/ha	31/10/2019	£27.60
Gramitrel (Yara)	Trace Element	1 l/ha	11/04/2020	£4.90
Headland Magnesium Super 80	Trace Element	2l/ha	02/05/2020	£4.48

N.B. Prices drawn from industry averages.

What results has the project delivered?

Disease assessments

The disease pressure on this field was very low, with only 1.0 to 3.3% leaf area coverage of septoria seen across leaf layers 1 to 3 at GS75 (29 June 20). At the same growth stage only a trace level of brown rust was reported. This level of disease is consider too insignificant to have any impact on yield and therefore disease levels were too low to fully evaluate the effect of reduced fungicide input.

Crop yields

The winter wheat crop yield was 9.4 t/ha, this is in-line with conventionally managed second winter wheat yields across the farm and including: 9.3 t/ha (variety Gravity) on Wyverstone Road, 9.0 t/ha (variety Santiago) on Crown field and 10.4 t/ha (variety Siskin) on Rushbottom.

Costings

Table 30. Yield, net margin and cost of production for very low inputs demonstration

Cost of production (per ha)	Tom Dixon - KWS Siskin (Wheat)
Yield (t/ha)	9.43
Price (£/t)	175
Variable costs (Per hectare)	
Total seed costs (£/ha)	49
Total fertilisers, trace elements and biostimulants (£/ha)	167
Herbicides (£/ha)	46

Fungicides (£/ha)	12
Total crop protection (£/ha)	64
Total variable costs (£/ha)	292
Gross margin (£/ha)	1,358
Overheads (Per hectare)	
Total labour, machinery and equipment (£/ha)	307
Total property and energy costs (£/ha)	20
Total administration costs (£/ha)	14
Cost of production and margins (Per hectare)	
Cost of production excluding rent and finance (£/ha)	633
Net margin excluding rent and finance (£/ha)	1,017
Cost of production (per tonne)	
Cost of production excluding rent and finance (£/t)	67

Action points for farmers and agronomists

Similar to the Managed Lower Inputs trial, these results suggest in a low disease pressure season there is little benefit in increasing fungicide spend to improve gross margins. The variety Siskin has a high disease resistance rating (Septoria RL 6.7, Yellow rust RL 9) and fungicide inputs could be managed depending on seasonal variation on disease development and varietal resistance.

Links to further information/ references

- AHDB Recommended Lists
- AHDB Fungicide performance in cereals and oilseed rape
- Combining agronomy, variety and chemistry to maintain control of septoria tritici in wheat (Project number: 2140003105)

6. Repeat baselining

Trial leader: Kate Smith and Damian Hatley

Start date: May 2020

End date: September 2020

Headline

Monitoring soil and crops through the rotation can help explain differences between seasons and inform better management practices.

What was the challenge/demand for the work?

The aim of this work was to monitor soil and crop characteristics through the rotation. The first year of the Strategic Cereal Farm project, known as the baselining year, aimed to determine the starting point of a number of indicators within the farmed environment before any changes were investigated and evaluated. Details of the baselining activities completed at the Strategic Cereal Farm East September 2017 – September 2018 are available online.

The autumn 2017 soils baseline assessments found that, there was clear inter-field and intra-field variability linked to soil texture and management. Based on the Visual Soil Assessment (VSA) method, 14% of the field areas were in 'good' condition and 86% of the field areas were in 'moderate' condition. Based on Visual Evaluation of Soil Structure (VESS) assessments, 81% of the field areas had a 'firm' or 'compact' layer.

In harvest year 2018, a wide range of crop measurements relating to aspects of crop performance were taken which can be useful in predicting and explaining yield, defining both 'source' (photosynthetic area) and 'sink' (tillers, stems, ears, grains) as well as development phases. These assessments found that consistent differences in crops were detectable with simple measures (particularly shoot numbers) which could be associated with differences in soil structure and nutrient status, both between and within fields.

In harvest year 2020 the soils and crop 'baselining' assessments will be repeated in the fields detailed below (Table 31) and results compared to the assessments carried out in 2017, the results have the potential to explain differences between seasons and inform better management practices.

How did the project address this?

Table 31. Field details for repeat baselining

Field name	**Barn Field**	**Retters**	**West Farm**	**Wally's**	**Big Lawn**	**Rushbottom**	**Shrubbery**	**Kells**
Size	34.2 ha	13.2 ha	31.1 ha	8.3 ha	14.9 ha	5.9 ha	12.6 ha	18 ha
Soil type	Sandy loam	Loamy sand	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam

Harvest 2018 crop	1st winter wheat	1st winter wheat	2nd winter wheat	2nd winter wheat	2nd winter wheat	Cover crop/spring linseed	Grass	Spring linseed
Harvest 2020 crop	Spring beans	Spring beans	Spring linseed	1st winter wheat	1st winter wheat	2nd winter wheat	2nd winter wheat	2nd winter wheat

In 2017, electrical conductivity (EC) scanning was used to map soil variability as part of the initial baseline measurements at the farm. The EC maps were used to identify intra field variation, so that areas of contrasting soil texture could be established for separate soil structure assessments (Figure 21); as would be carried out to establish soil management zones by soil type. In 2020, soil assessments have been carried out in these same zones.

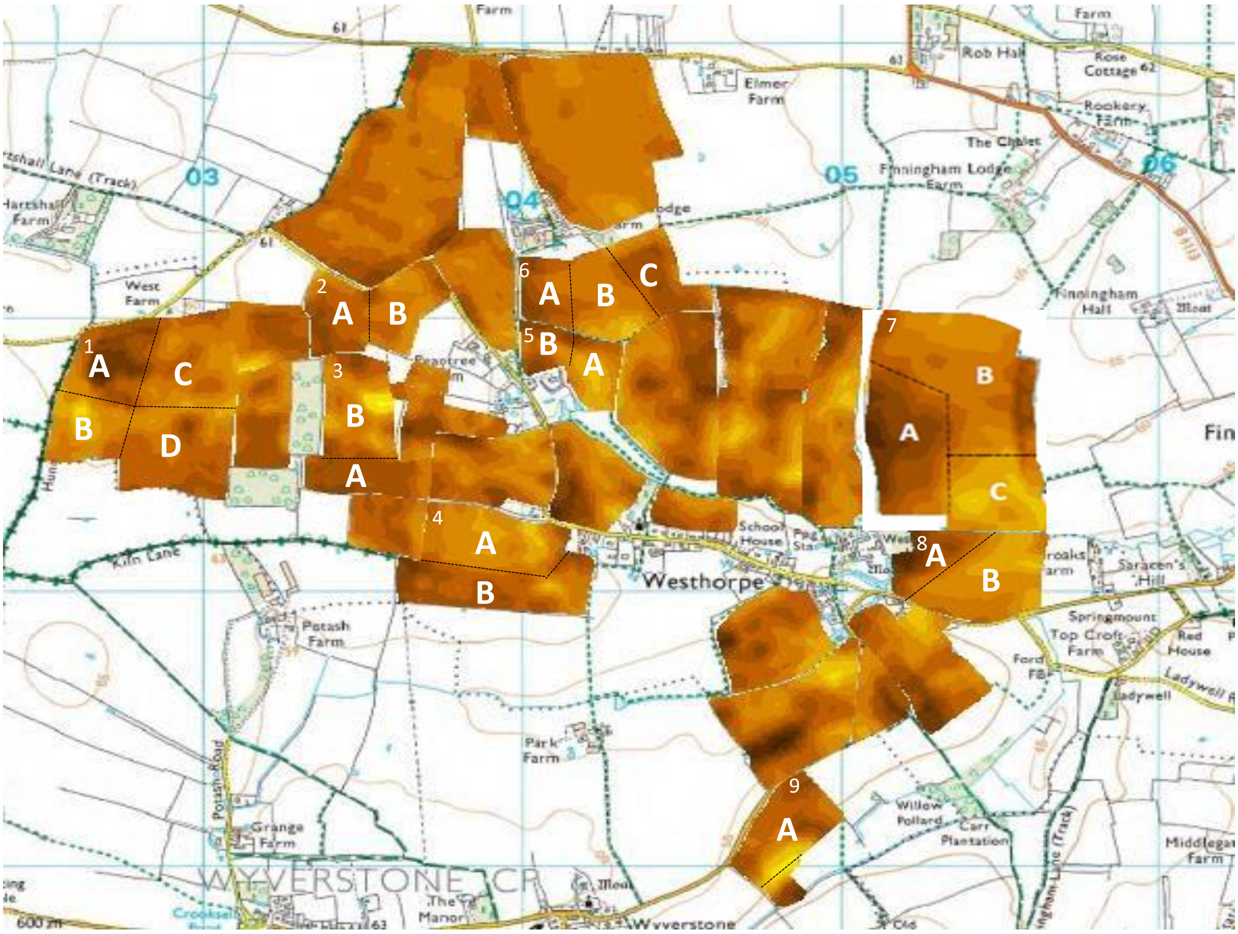


Figure 21. Shallow EC map Westhorpe Lodge Farm. Fields are numbered: West Farm (1); Appletree (2) *not included in baseline study*; Shrubbery (3); Kells (4); Rushbottom (5); Big Lawn (6); Barn Field (7); Retters (8); Wally's (9)

Assessments

- Soil analysis – *taken from each zone within each field*: routine topsoil analysis, structural assessments and earthworms

- Biomass – *taken from one representative area in each field* plant counts: NDVI, green area index, tissue analysis and crop yields

What results has the project delivered?

Soil assessments

The summary of VESS scores from Big Lawn, West Farm and Rushbottom recorded in November 2017 and April 2020 are shown in Table 32, the scores have been colour coded according to the Soil Health Scorecard that is being developed as part of the AHDB/BBRO Soil Biology and Soil Health Partnership (ahdb.org.uk/greatsoils). Here 'traffic light' coding is used to identify properties where further follow-up investigation is required to help guide management decisions. Differences in soil structural condition can be related to soil management, cropping history and soil texture:

- **Big Lawn** - In 2017, compact layers were observed (sq 4) as a result of drilling in wet soil conditions. In 2020, scores remain high with firm / compact soil structure (sq 3-4) containing some angular aggregates (Figure 24) this was recorded following winter wheat drilled in wet conditions (described by Brian Barker (host) as 'borderline to drill').

- **West Farm** – Winter wheat (harvest year 2017) was direct drilled in wet conditions resulting in moderate soil structure in autumn 2017 (sq 3 – measured in the wheat stubble). In 2020, zones of lighter texture were seen to have good soil structure (sq 2) containing a mixture of porous and rounded aggregates; whilst heavier textured zones still indicated a degree of compaction (sq 3).

- **Rushbottom –** In 2017, there was evidence of surface compaction following strip tillage of a cover crop into wheat stubble. However, repeat measurements in spring 2020 showed the soils to be in good structural condition, following ploughing and drilling winter wheat in August/September 2019 (sq 1 & 2 – 'friable/intact' (Figure 22).

Table 32. Visual Evaluation of Soil Structure mean scores and worst ('limiting') layer scores, for 2017 & 2020 (mean of 3 assessments per zone).

Field	Zone	November 2017		April 2020	
		Mean overall score	Limiting layer score	Mean overall score	Limiting layer score
Big Lawn	a	3	4	2	2
	b	2	3	3	3
	c	1	3	3	4
West Farm	a	3	3	2	3
	b	3	3	2	2
	c	3	3	2	2
	d	3	3	3	3

Rushbottom	a	3	3	2	2
	b	2	3	1	1

[a]VESS limiting layer score is the maximum score recorded to 25cm depth. VESS scores have been colour coded according to the Soil Health Scorecard. Scores of 1 or 2 indicate good soil structure (friable/intact) indicating no changes needed; a score of 3 indicates moderate structure (firm) with long term improvements required and scores of 4 or 5 poor soil structure (compact or very compact) with short term improvements required.

Big Lawn (Zone C): VESS score 3 with a 'compact' (score 4) limiting layer - Moderate/compact soil structure

Rushbottom (zone A): VESS score 2 - *Good soil structure*

Figure 22. VESS photos taken post break-up from field areas with examples of moderate and good soil structure VESS scores

The number of earthworms found during assessments carried out in November 2017 and April 2020 are summarised in the Table 33; again the results have been colour coded according to the prototype AHDB/BBRO Soil Health Scorecard.

Overall, with the exception of Wally's Field, the results show that from 2017 to 2020 there has been either no change or an improvement in the total number of earthworms (i.e. both juveniles and adults).

In 2020, most fields have an intermediate earthworm population, whilst in Wally's earthworm numbers are depleted. The largest increase in earthworm numbers was measured in Barn Field and in April 2020 earthworm populations are classed as being active.

Further analysis will be carried out to investigate how earthworm populations from 2017 to 2020 have varied within the different soil texture zones and how this relates to field management.

Table 33. Number of earthworms in a 20 x 20 cm cube of soil; November 2017 and April 2020.

Field	2017		2020	
	Cropping at assessment	Earthworm numbers	Cropping at assessment	Earthworm numbers
Barn Field	Winter wheat	7	Spring beans	14
Big Lawn	Winter wheat	7	Winter wheat	4
Kells	Stubble OW	3	Winter wheat	7
Retters	Winter wheat	9	Spring beans	9
Rushbottom	Cover crop (not grazed)	8	Winter wheat	8
Shrubbery	Herbage Grass	9	Winter wheat	8
Wallys	Winter wheat	8	Winter wheat	3
West Farm	Winter wheat	4	Spring linseed	7

Earthworm numbers have been colour coded according to the Soil Health Scorecard. Red indicates earthworm numbers are depleted, orange that intermediate population size and green active population.

Crop assessments

Crop performance data presented here are for winter wheat (i.e. 5 out of 8 fields assessed) to allow comparison between fields and with published AHDB benchmarking.

Shrubbery and Kells had a low biomass in early spring (GS30-32) whilst the other three fields were consistently above the AHDB benchmark (for 11 t/ha grain yield). This contributed to final grain yields of 7.5 and 7.4t/ha for Shrubbery and Kells, 8.3 and 9.0t/ha for Big lawn and Wally's, whilst Rushbottom yielded 10.4t/ha.

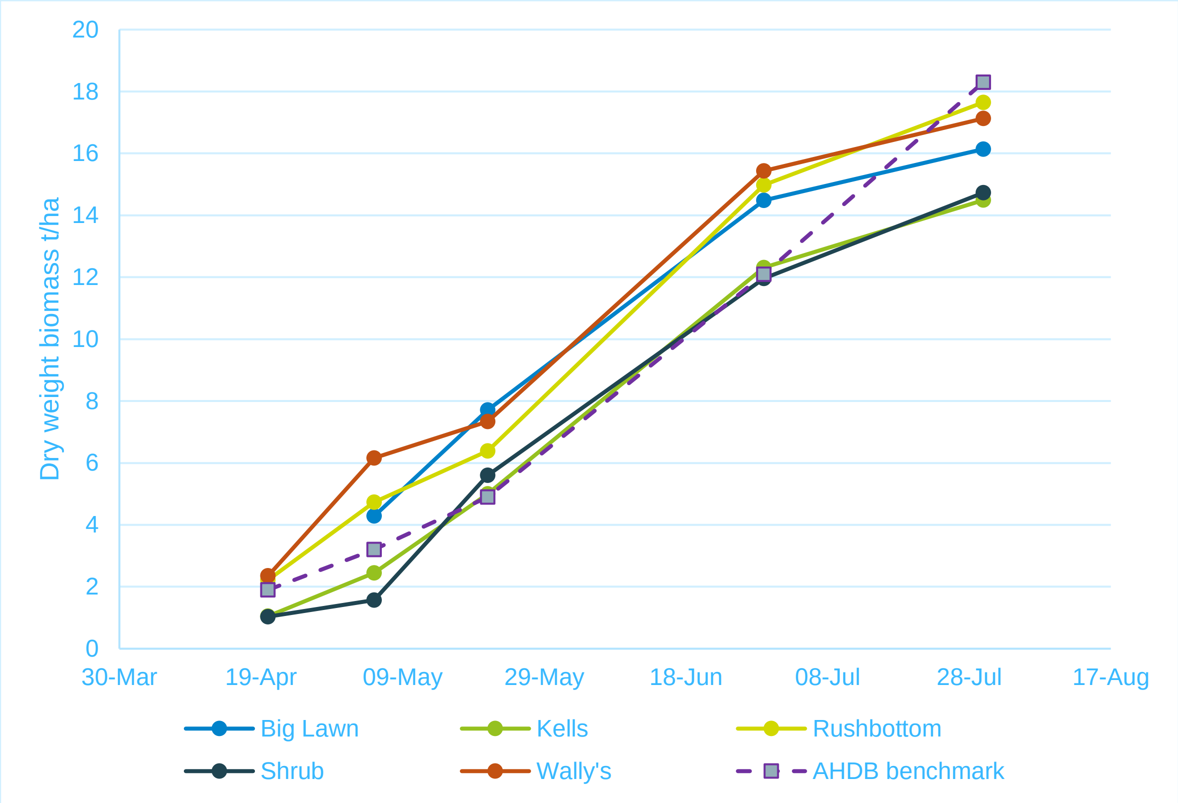


Figure 23. Crop biomass in winter wheat

Satellite NDVI mirrored differences in measured crop biomass (Figure 24) but also gives an indication of in-field variability. It is vitally important that measurement of crop performance indicators are truly representative of fields/zones and consistent between years.

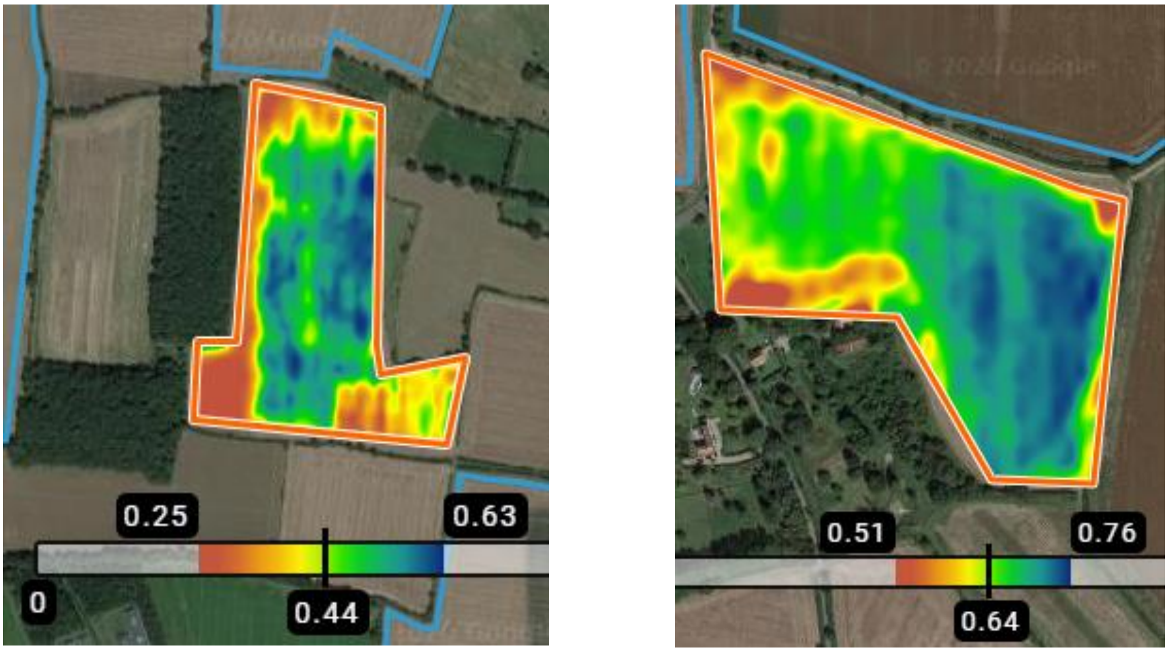


Figure 24. NDVI Shrubbery (left) Rushbottom (right) on 21 April 2020, Growth stage 31/2

Kells and Shrubbery produced significantly less tillers than the other fields although plant numbers were similar to Rushbottom at 200-220 plants/m^2 (all three being second wheats). Big Lawn and Wally's had the highest plant densities with both having more than 300 plants/m^2. By anthesis, differences in tiller losses meant that all fields had ear numbers similar to the benchmark of 500 ears/m^2 (Figure 25).

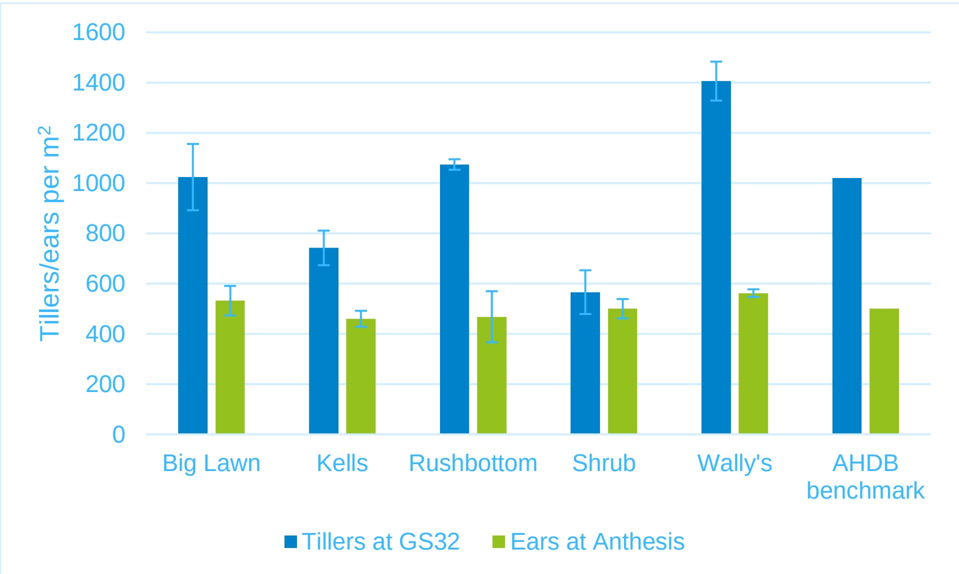


Figure 25. Tiller and ear number in winter wheat crops

Selected nutrient uptakes and whole plant tissue concentrations are shown in Figures 26 to 30 (NB. because these are whole plant concentrations they are not comparable to the values obtained from leaf tissue analysis)

Although total nitrogen uptake by anthesis in late-June was greater than the AHDB benchmark of 250kg/ha, it was broadly similar between fields and years. Uptake in Kells and Shrubbery was much lower in early spring largely as a result of lower biomass. However tissue concentrations in all fields were also much lower in 2020 (particularly in late April & May) which could reflect the inability of crops to take up applied nitrogen in dry conditions.

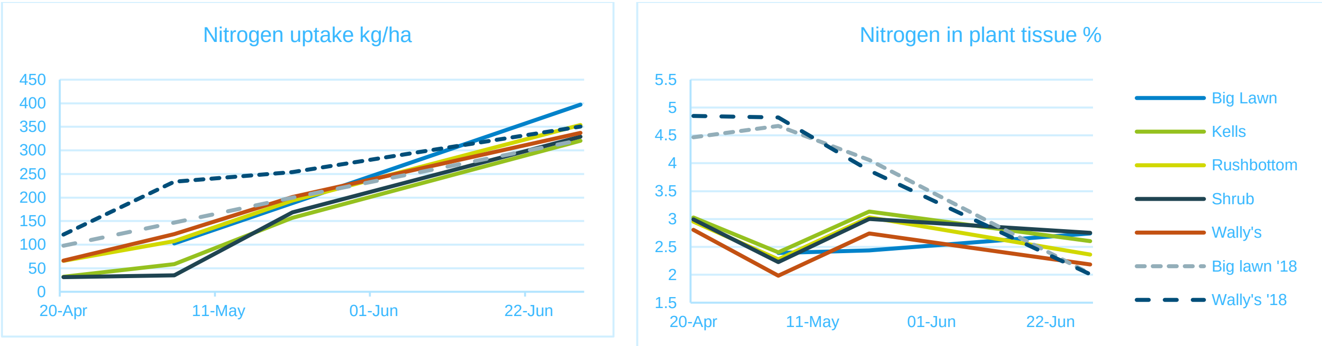


Figure 26. Whole plant tissue nitrogen uptake kg/ha and concentration %

Phosphorous uptake and plant concentrations showed a similar pattern, although total uptake by anthesis was less in 2020 than 2018.The lowest yielding fields (Kells and Shrubbery) had the highest phosphorus concentrations suggesting this was not limiting growth. Tissue concentrations were lowest in Wally's which also had the highest pH (8.4) and lowest soil P (11mg/l) which suggests P availability may have been an issue.

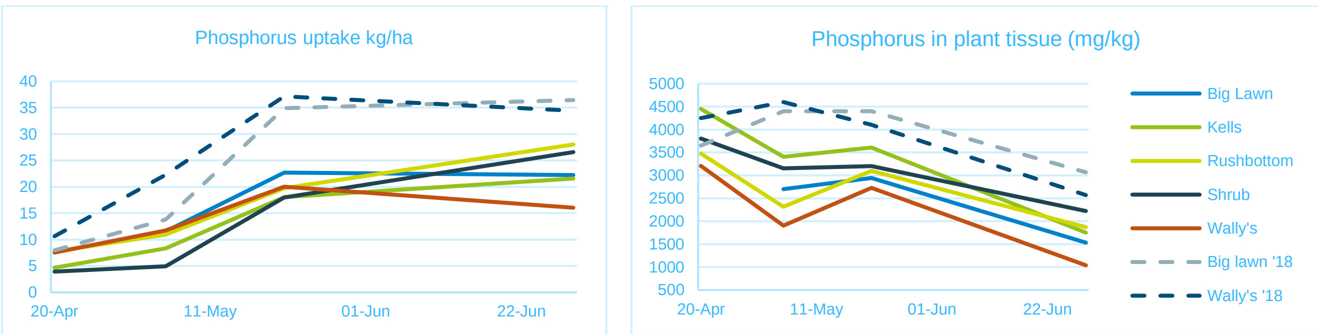


Figure 27. Whole plant tissue phosphorus uptake kg/ha and concentration %

Potassium uptake in Wally's in 2018 was very high, however this was not the case in 2020. Again we saw a decline in tissue concentrations between April and May 2020, with an increase in late May and by anthesis total potassium uptake in 2020 was similar to with 2018.

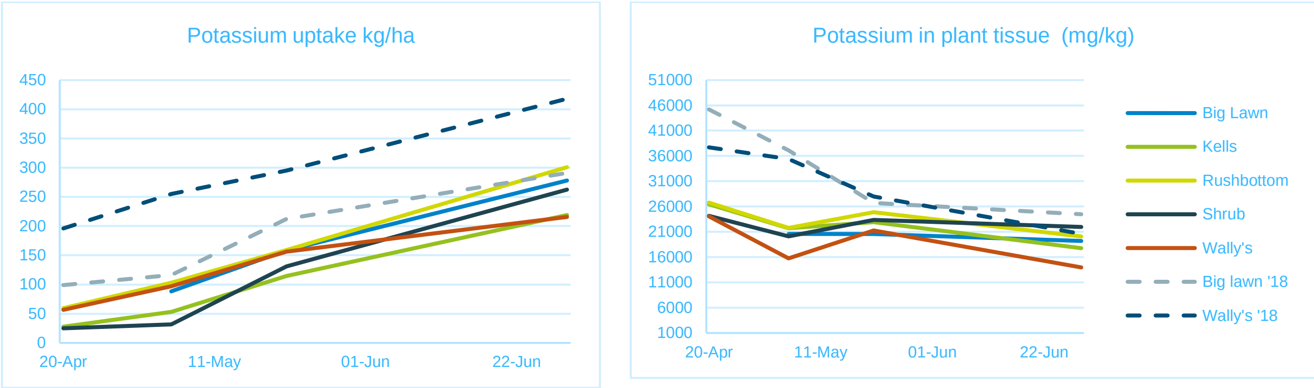


Figure 28. Whole plant tissue potassium uptake kg/ha and concentration %

Magnesium concentrations in 2018 declined from mid-May in 2018, but showed a general rise in 2020.

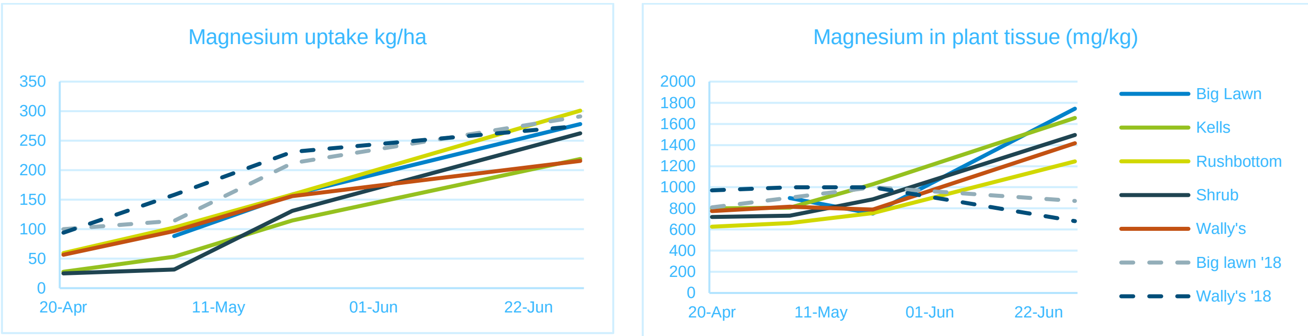
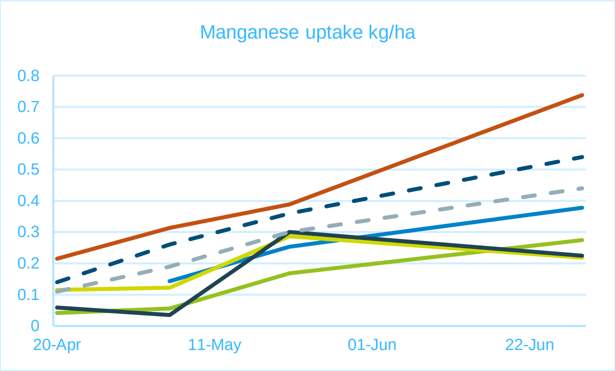


Figure 29. Whole plant tissue magnesium uptake kg/ha and concentration %

Manganese uptake was greatest in Wally's field in both years. In 2020 Wally's was the only field to maintain high Mn concentrations in the spring, exceptionally high Mn concentrations indicate foliar application.



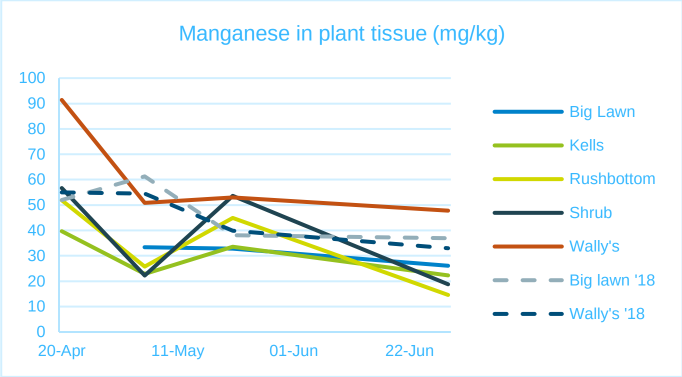


Figure 30. Whole plant tissue manganese uptake kg/ha and concentration %

It is difficult to draw conclusions from data sets which are limited to two separate years. However, by monitoring crops frequently using standard techniques and benchmarking against other fields and industry standards we can begin to understand the causes of variation in crop performance in context. With this variation, it is important to take into consideration different soils, cultivations, agronomy and varieties as well as identifying anomalous fields and areas that require attention where performance is behind, or areas that are performing exceptionally well.

Action points for farmers and agronomists

Monitor field regularly, in a consistent and representative way. Fine tune crop management by comparison to benchmarks or thresholds, through canopy management principles (e.g. adjusting N rates and timings in response to canopy size or shoot number), nutrient status or through estimating yield potential and adjusting investment in inputs accordingly.

Links to further information/ reference

- Visual Evaluation of Soil Structure
- How to Count Earthworms
- AHDB/BBRO Soil Biology and Soil Health Partnership – a range of resources and case studies of the work currently being conducted as part of this research programme
- AHDB Soils resources
- AHDB Winter Wheat Growth Guide

Keep up to date

- Visit ahdb.org.uk/farm-excellence/strategic_cereal_farm_east for the latest information
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We are able to arrange bespoke visits/virtual sessions for interested groups (farmers, growers, stakeholders, supply chains, agronomists etc.) with all of our Strategic Cereal Farms. Please get in touch to arrange your own meeting with the Strategic Cereal Farm East.