AHDB

FARMEXCELLENCE

Strategic Cereal Farm West Harvest 2020 Report

Contents

We are very grateful to Rob Fox and all the team at Squab Hall for their hard work and dedication in carrying out the operations, assessments and analysis at the Strategic Cereal Farm West.

We are pleased to be working with ADAS to carry out the assessments and analysis on the trials at the Strategic Cereal Farm West for harvest 2020.

Many thanks go to RAGT seeds for the provision of the phacelia and oil radish catch crop mix and sourcing of barley seed at the Strategic Cereal Farm West.

1. Timeline of trials

Harvest 2019

Baselining

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 following indicators have been assessed during the first year of the programme, 2018-2019, and will be monitored over the next six years:

- Weather station
- Soil nutrient analysis
- Earthworms
- Electrical conductivity scanning
- Soil physical structure
- Crop biomass
- Weeds
- LEAF Sustainability Review

Trials

- The impact of cultivation depth on soil properties and rooting on winter wheat yields
- The impact of reduced fungicide applications on yield of varieties with different disease resistance ratings
- The impact of cultivation depth on headland areas on soil health and crop productivity
- The impact of nutrient inputs on crop productivity

Harvest 2020 trials

- The impact of cultivation depth on soil properties, rooting and yield
- The impact of perennial flower strips on beneficial insect populations, pests and weeds
- The impact of summer catch crops on soil physical properties and performance of the following crop

Watch an overview of the harvest 2020 season here

Harvest 2021

Repeat baselining

- Soil chemical and biological analysis
- Earthworms
- Soil physical structure

Trials

- The impact of cultivation depth on soil properties, rooting and yield of winter wheat
- The impact of perennial flower strips on beneficial insect populations, pests and weeds
- The impact of reduced fungicide applications on varieties with different disease ratings, for disease control under farm standard, low, biorational and untreated fungicide strategies
- The interaction of cultivation and glyphosate application on autumn blackgrass control

Watch an introduction to harvest 2021 trials and demonstrations here

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

2. Harvest 2020 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 August 2020, the Strategic Cereal Farm weather station recorded a total of 739 mm of rainfall. The maximum temperature recorded was 36°C on 31 July 2020. The minimum temperature recorded was -2.9°C on 26 March 2020.

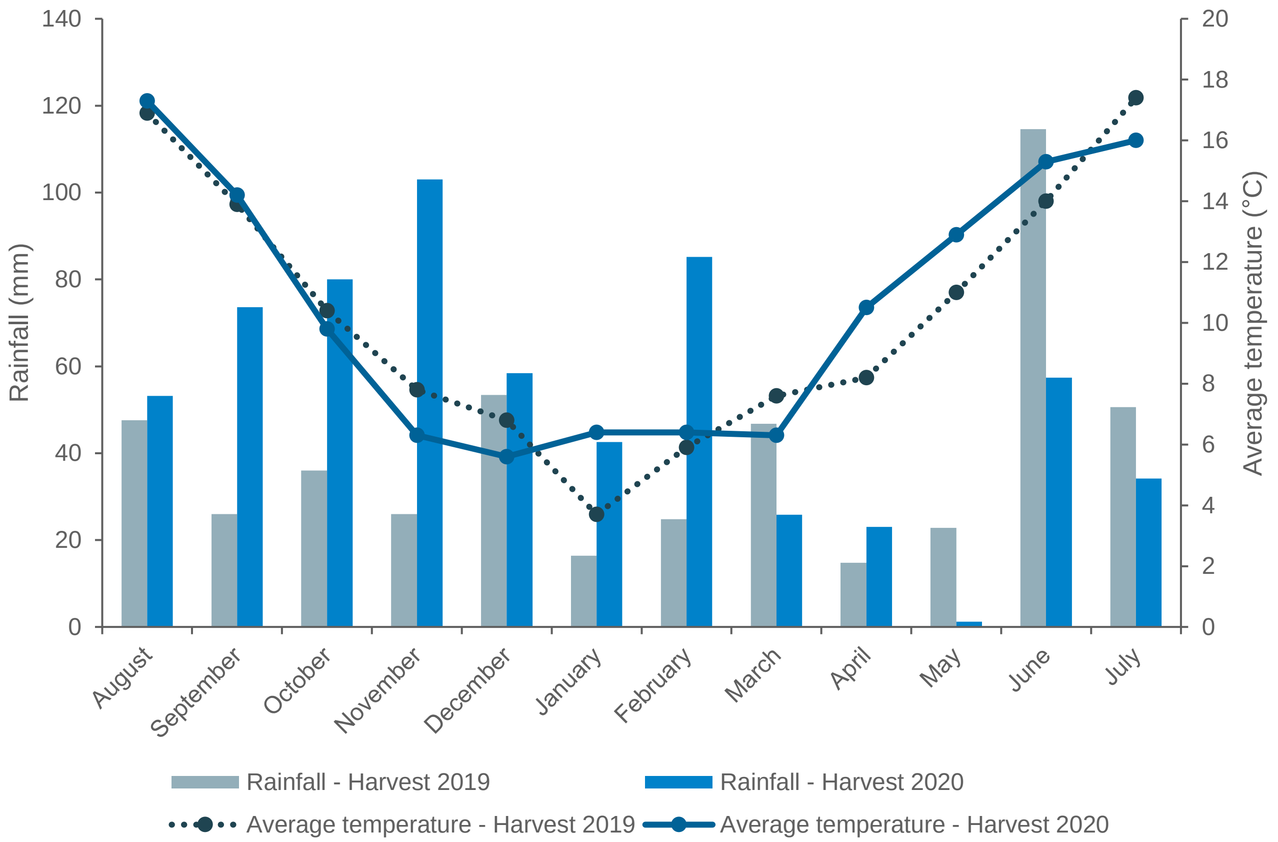

Figure 1. Weather data from weather station at Strategic Cereal Farm West (1 August 2018 – 31 August 2020)

3. The impact of cultivation depth on soil properties, rooting and yield

Trial leader: Anne Bhogal, ADAS

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Start date: 19 October 2018

End date: Ongoing

Video update: Watch online here

Headline

Minimal cultivation and direct drilling can help maintain moisture levels for better OSR establishment, with crops that establish slowly at risk from CSFB attack.

OSR was replaced by spring beans due to poor autumn establishment. Spring bean yields were significantly lower on the shallow cultivation treatment. This treatment had the highest topsoil penetration resistance in the spring. Reducing tillage is a long-term commitment and some crops are more sensitive to changes in tillage intensity than others.

What was the challenge/demand for the work?

There is an increasing need to manage soils sustainably, recognising the importance of soil for providing food and delivering ecosystem services. Soil erosion, loss of organic matter and compaction are some of the main issues affecting arable soils. Additionally, it has been calculated that high yielding crops need to capture all the water in soil down to 1.5 m. Rooting measurements in recent years have shown that many crops have insufficient roots (less than 1 cm^{-3}) to fully access water below 40 cm deep. Limited rooting of crops could be a major limitation to crop yields (White et al. 2015). This is an important issue due to the predicted decreases in summer rainfall in the UK and the sensitivity of anthesis and grain fill growth stages in cereal crops to water limited conditions.

Cereal and oilseed roots cannot penetrate through strong soils. To reach deeper soil depths roots are dependent on exploiting pre-existing cracks, fissures and channels. Furthermore, soil conditions have an impact on pest pressure risk factors. Risk factors associated with cabbage stem flea beetle pressure in oilseed rape crops include drilling into dry and cloddy seedbeds resulting in crops that are slower to emerge, with reduced vigour.

There is a need for UK, farm-based replicated trials to test the impacts of different cultivation practices on soil quality and health, crop rooting and yield, and pest pressure in both the long and short term.

How did the project address this?

A replicated (2) tramline trial with three cultivation depths (5, 15 and 30 cm) was established in winter wheat var. Graham on 19 October 2018. These cultivation treatments were repeated in August 2019 ahead of drilling oilseed rape on 24 August 2019, with an additional direct drill treatment added as shown in Figure 2. Unfortunately, the oilseed rape did not establish well, particularly on the deeper cultivation treatments, and following the very wet late autumn and winter period, this crop was abandoned and the field re-drilled with spring beans, following light cultivation (spring tine working to *c.* 5 cm) across all the treatments. The field was divided into sampling zones to correspond with each treatment area. Within each sampling zone, all soil assessments were undertaken within a 10m radius of the point of median penetrometer resistance, as identified and GPS-located from a penetration resistance survey conducted in spring 2018.

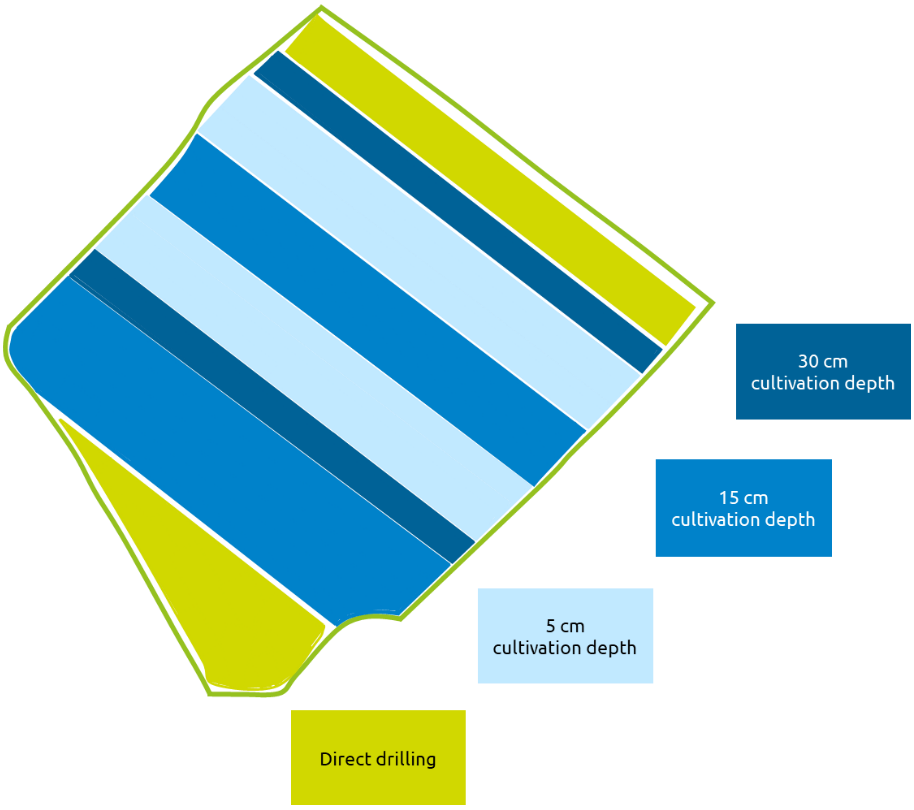


Figure 2. Cultivation trial layout harvest 2020

For harvest 2020, the following assessments were completed:

- Topsoil chemical properties (pH, Ext. P, K & Mg, SOM, Potentially mineralisable N)
- Topsoil VESS
- Earthworms
- Penetration resistance to 50 cm
- Soil moisture 0-15, 15-30, 30-50 cm
- Bulk density at 0-5, 5-10, 15-20 cm

This will allow identification of potential differences in soil properties caused by cultivation but also, by combining this with crop rooting data, it can be better understood how soil properties are improving or restricting crop rooting.

Rooting assessments were also undertaken on all treatments at full establishment of the spring beans (May 2020), using the ‘Shovelomics’ methodology to assess the phenotypic traits of the root crown. Three sample points were assessed per treatment based on the median penetration resistance defined in the previous year.

Whilst the trial was in oilseed rape, cabbage stem flea beetle (CSFB) adult feeding damage was estimated in BBCH Growth Stages 13 and 15. In November/ December ten plants from five locations in each of the treatment tramlines were destructively sampled and dissected for CSFB larvae.

What results has the project delivered?

Oilseed rape establishment (autumn 2019)

Poor plant establishment and fewer plants were found in the deeper cultivation treatments (15 and 30cm) than the shallow cultivation (5 cm) and direct drill treatments (Table 1). These differences were statistically significant (*P*<0.05) at growth stage BBCH13, and are probably the consequence of dry weather conditions at drilling, with additional moisture lost following the deeper cultivations leading to poorer establishment.

Table 1. Oilseed rape establishment

Treatment	Establishment at BBCH13 (plants/0.5m rod)	Establishment at BBCH15 (plants/0.5m rod)
Direct drill	10.6	8.5
5 cm cultivation	8.2	7.6
15 cm cultivation	2.9	4.5
30 cm cultivation	4.2	4.9

In general, more CSFB adult feeding damage (as % leaf loss area) was found in the treatments with deeper cultivations (15 and 30cm cultivations) than the 5 cm cultivation of direct drill treatment (Figure 3). This is most likely due to slower growth on these treatments and inability of the crop to outgrow feeding damage, rather than a greater number of beetles feeding in these areas. Moreover, the same level of CSFB adult feeding damage can appear larger on smaller plants. However, it is important to note that differences in leaf area lost between treatments were not statistically significant, on either occasion.

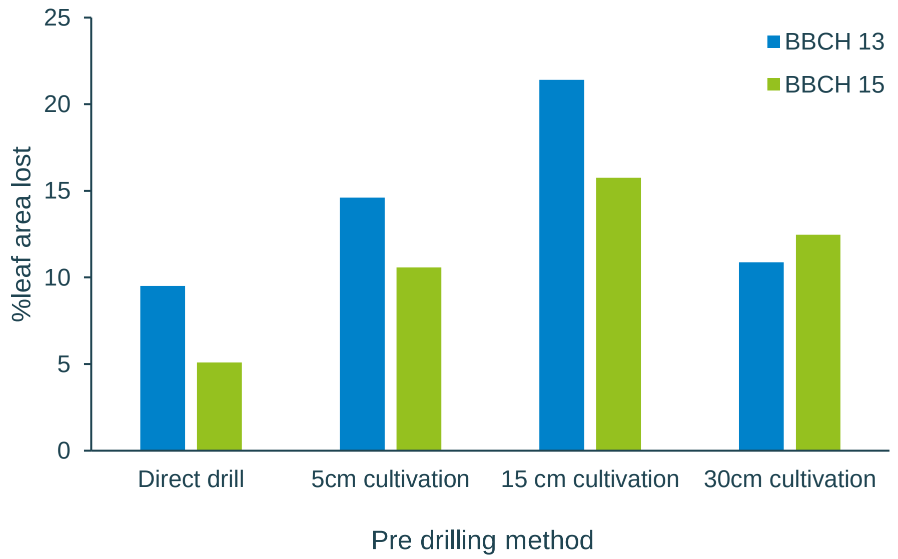


Figure 3. CSFB adult feeding damage as % leaf area lost

Fewer larvae were found on the deeper cultivation treatments (15 and 30cm) compared to the shallow cultivation (5cm) and direct drill treatments, in both November and January ($P<0.05$; Figure 4). This suggests that adults preferentially laid eggs at the base of the larger plants, resulting in higher larvae pressure in the direct drill and shallow cultivation treatments. Alternatively, this may have been due to the pronounced difference in the plant size between treatments, with the direct drill and 5cm cultivation treatments having much larger plants (Figure 5); as it is possible for more larvae to occupy a larger plant.

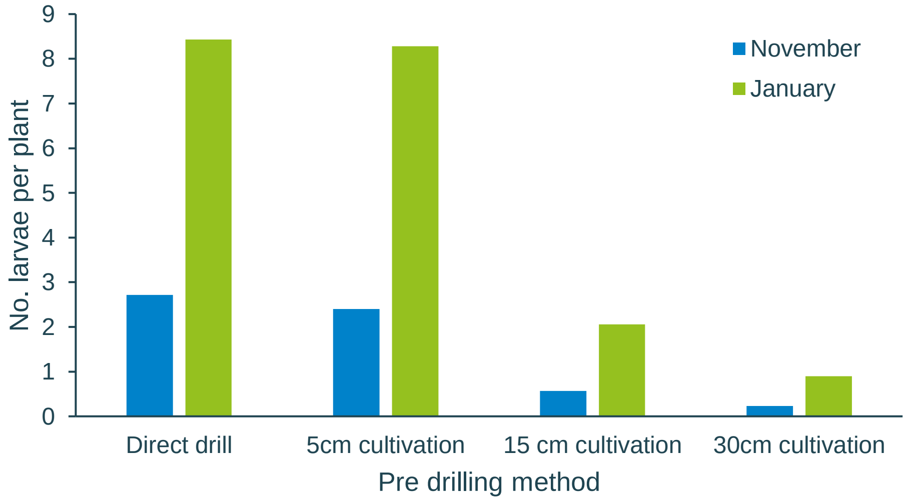


Figure 4. Number CSFB larvae per plant in November 2019 and January 2020

Figure 5. Oilseed rape plants at November larvae count. Left plant: 30 cm cultivated treatment; Right plant: direct drilled treatment

Topsoil properties

Topsoil properties measured in spring 2020 were evaluated according to the draft Soil Biology and Soil Health Partnership scorecard (Table 2). There were no significant differences in topsoil properties as a result of the different cultivation treatments, except for extractable P concentrations which were significantly lower on the deep cultivation treatment, probably a result of dilution due to soil mixing below the sampling depth of 15cm.

Table 2. Soil health scorecard results, spring 2020

Treatment (cultivation depth)	Direct drill	5 cm	15 cm	30 cm
pH	8.0	7.4	7.4	7.7
Ext. P (mg/l)	20	18	19	16
Ext. K (mg/l)	205	208	164	162
Ext Mg (mg/l)	810	623	688	785
SOM (% LOI)	4.8	4.5	4.2	4.5
PMN (mg/kg)	59	51	26	53
VESS (limiting layer)	3	3.5	3.5	4
Earthworm number (per pit)	3	2	3	1

No action needed   Monitor   Investigate

Note: benchmarks are subject to review. Results are an average of the two replicate tramlines per treatment (except on the direct drill treatment, where only one tramline was sampled).

- pH: target pH > 6.5 for arable soils; see ahdb.org.uk/rb209 for specific crop advice
- Ext. P, K & Mg: No nutrients were limiting to crop production; Ext. Mg levels were elevated;
- SOM: ≥ 4 and 5% is 'typical' for medium and heavy textured soils, respectively; texture is borderline heavy (37-40% clay), so SOM levels are close to typical values
- VESS: A score of 4 indicates poor soil structure ('compact') and 3 indicates moderate soil structure ('firm') https://www.sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure
- PMN: Potentially Mineralisable Nitrogen (a measure of microbial activity) – levels appeared lower on the 15cm cultivation treatment, but this was not statistically significant and may be a result of sampling variability.
- Earthworms: Total number of adults and juveniles; >8/pit = 'active' population for arable soils; <4/pit = 'depleted'; very low numbers recorded across the field

Effect of cultivation on bulk density, penetration resistance and crop rooting

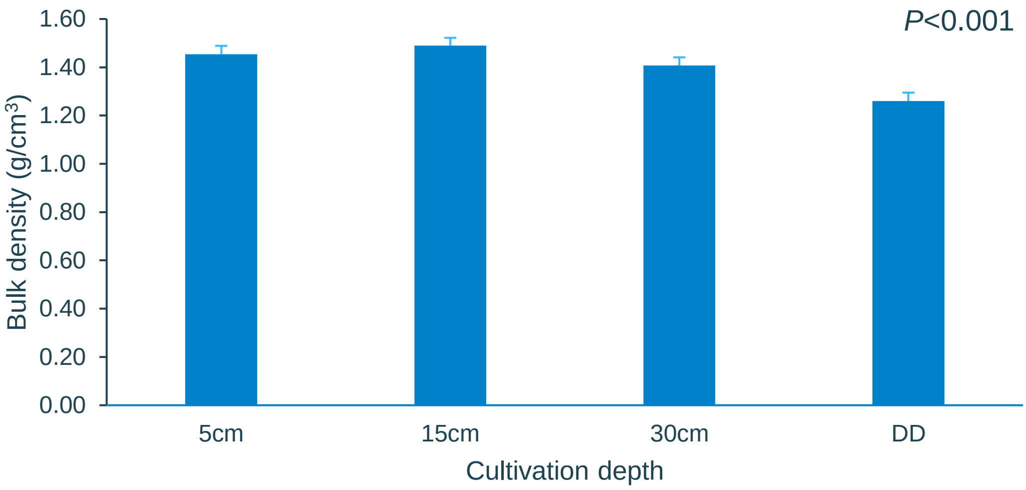
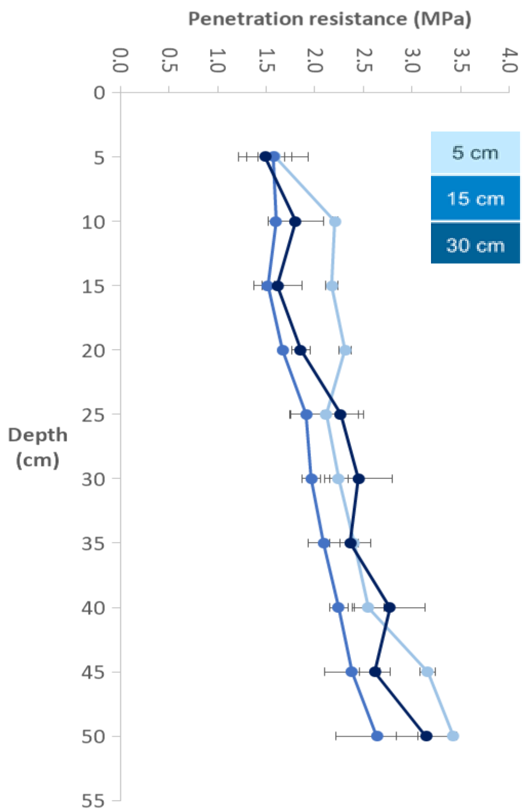


Figure 6. Topsoil bulk density (average of measurements taken at 0-5cm, 5-10cm and 15-20cm)

Topsoil bulk density was significantly lower in the direct drill treatment compared to the other cultivation treatments (Figure 6; average of 3 measurement depths). Where soils had been cultivated in autumn 2019 bulk density values were greater than the ‘trigger value’ for a topsoil containing 4-5% organic matter (i.e. > 1.3 g/cm^3; Merrington et al., 2006). Bulk density values above trigger values generally indicate that further investigation is required to determine whether or not a change in management is needed to reduce soil compaction.



There was no significant difference in penetration resistance due to cultivation treatment (although this was not measured on the direct drill treatment), except at 15-20cm depth where resistances tended to be higher in the shallow cultivation treatment (Figure 7). These measurements were undertaken in early May when the soil was dry, which may explain why resistances were relatively high (> 1.5 MPa on all treatments, indicating potential restriction to root growth).

Measurements of spring bean root traits at this time, suggested plants in the direct drill treatment had a lower number of roots which were more densely concentrated in the top few centimetres of soil (as shown by the steeper root angle, higher branching density, but a lower root spread; Table 3).

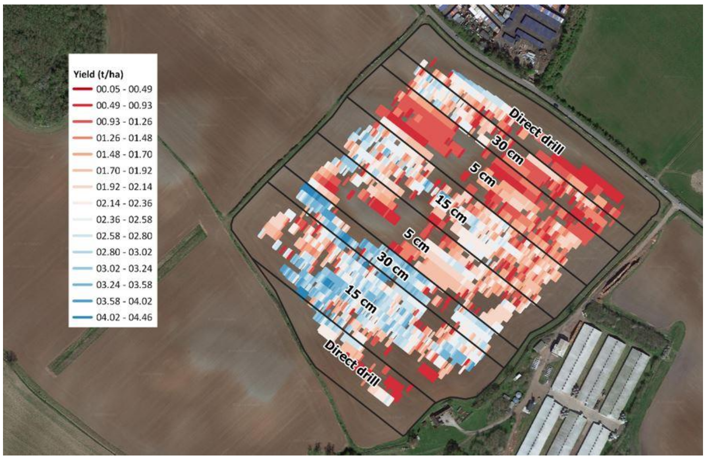
Figure 7. Penetration resistance profiles

Table 3. Spring bean early root traits

Treatment (cultivation depth)	Direct drill	5cm	15 cm	30cm
Root angle (degrees)	43	36	30	34
Branching density (score 0-4)*	3.2	3.3	2.6	1.9
Root number (per plant)*	19	29	25	24
Root dry weight (g/plant)	1.6	1.4	1.3	1.3
Maximum root spread (cm)*	8.5	8.1	9.3	9.3
Depth to max. root spread (cm)	3.8	6.0	7.5	9.8

**differences were statistically significant at P<0.05*

Crop yield



Yield map data were analysed using ADAS Agronomics. Data were first cleaned to remove headlands, anomalous combine runs (header not full or spanning two treatment areas) and locally extreme data points. They were corrected for any offset created by changes in combine direction. A statistical model was fitted to the data to account for spatial effects along and across rows, and effects associated with the treatment(s). The average measured yield for the 30cm treatment was 2.22 t/ha. Apparent treatment differences from this yield were then estimated, after correcting for spatial variation within the field. For the 15cm, 5cm and direct drill treatments, a yield decrease of 0.09, 0.70 and 0.53 t/ha was estimated compared to the 30cm (Table 4). The statistical model indicated that the size of the yield differences for the 5cm treatment was statistically significant.

Table 4. Modelled yield effects compared to the 30cm depth cultivation (estimated treatment effect with 95% confidence limit)

Treatment	30cm	15cm	5cm	DD
Mean yield, t/ha	2.22			
Estimated treatment effect, t/ha	-	-0.09 ± 0.51	-0.70 ± 0.50	-0.53 ± 0.58

Costings

Per Hectare	Direct Drill	5 cm	15cm	30cm
Yield (t/ha)	0.67	0.73	1.82	2.22
Price (£/t)	210	210	210	210
Variable costs (Per hectare)				
Total seed costs (£/ha)	63	63	63	63
Total fertilisers (£/ha)	11	11	11	11
Total crop protection (£/ha)	100	100	100	100
Total variable costs (£/ha)	174	174	174	174
Gross margin (£/ha)	-34	-21	208	292
Total labour, machinery and equipment (£/ha)	117	128	164	197
Total property and energy costs (£/ha)	34	34	34	33

Total administration costs (£/ha)	14	14	14	14
Total overheads (excluding rent and finance) (£/ha)	166	176	211	244
Cost of production and margins (Per hectare)				
Cost of production excluding rent and finance (£/ha)	340	350	386	418
Net margin excluding rent and finance (£/ha)	-200	-197	-3	48
Per Tonne				
Cost of production excluding rent and finance (£/t)	508	479	212	188

Action points for farmers and agronomists

This trial shows the importance of moisture at drilling OSR. Minimal cultivations and direct drilling can help maintain moisture levels for better OSR establishment. Crops that are establishing slowly are at risk from CSFB attack.

Reducing tillage is a long-term commitment and some crops are more sensitive to changes in tillage intensity than others.

The cultivation trial is in the second year of reporting, the impact of cultivation treatments on soil quality and crop performance are best assessed over the long term, which we have the opportunity to do over the remaining four years of the Strategic Farm programme. In 2021 we will be doing this in a winter wheat crop, adding in measurements of soil carbon storage to depth.

Links to further information and references

- **Research Review No. 43:** Management of cereal root systems (online)
- **Student Report No. SR41:** Quantifying rooting at depth in a wheat doubled haploid population with introgression from wild emmer (online)
- **Practical information** on soil management and soil assessment methodologies can be found online: ahdb.org.uk/greatsoils
- **Soil Biology and Health Partnership project:** ahdb.org.uk/greatsoils
- **AHDB Factsheet :** How to count earthworms (online)

4. Pests and natural enemies and flower strips

Trial leader: Mark Ramsden, ADAS

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Start date: May 2019

End date: Ongoing

Video update: Watch online here

Headline

All fields exhibited different species abundance, and no field could be considered 'average'. Management options 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 Integrate 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 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 West, the Strategic Cereal Farm East and Petworth Monitor Farm.

At the Strategic Cereal Farm West, a total of five fields were monitored, nine fields were monitored at Strategic Cereal Farm East, and three at Petworth Farm. In three of those fields at SFW (Figure 8) and three at SCFE, a field scale trial was established. 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 Strategic Farm West are provided in Table 5, flower strip trial layout is shown in Figure 8. The seed mix shown in Figure 9 was sown in May 2019.

Table 5. Perennial flower strips trial site field details

Treatment name:	Farm standard	Field edge flower strips	Within field and field edge flower strips
Field name:	42	40	43
Field size (ha):	32	9	7.5
Soil type:	Medium, heavy, very heavy	Medium, very heavy	Medium
Harvest 2019 crop:	Spring barley/ oilseed rape	Oilseed rape	Oilseed rape
Harvest 2020 crop:	Wheat	Wheat	Wheat

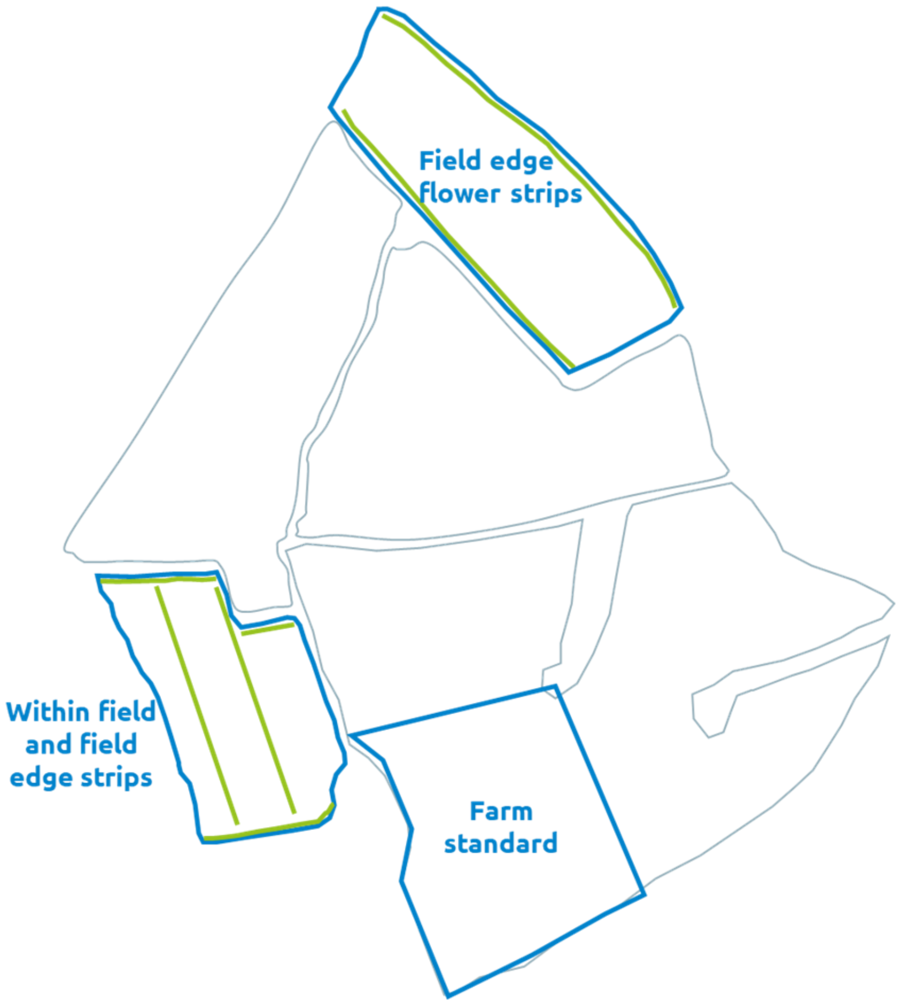


Figure 8. Perennial flower strips trial layout

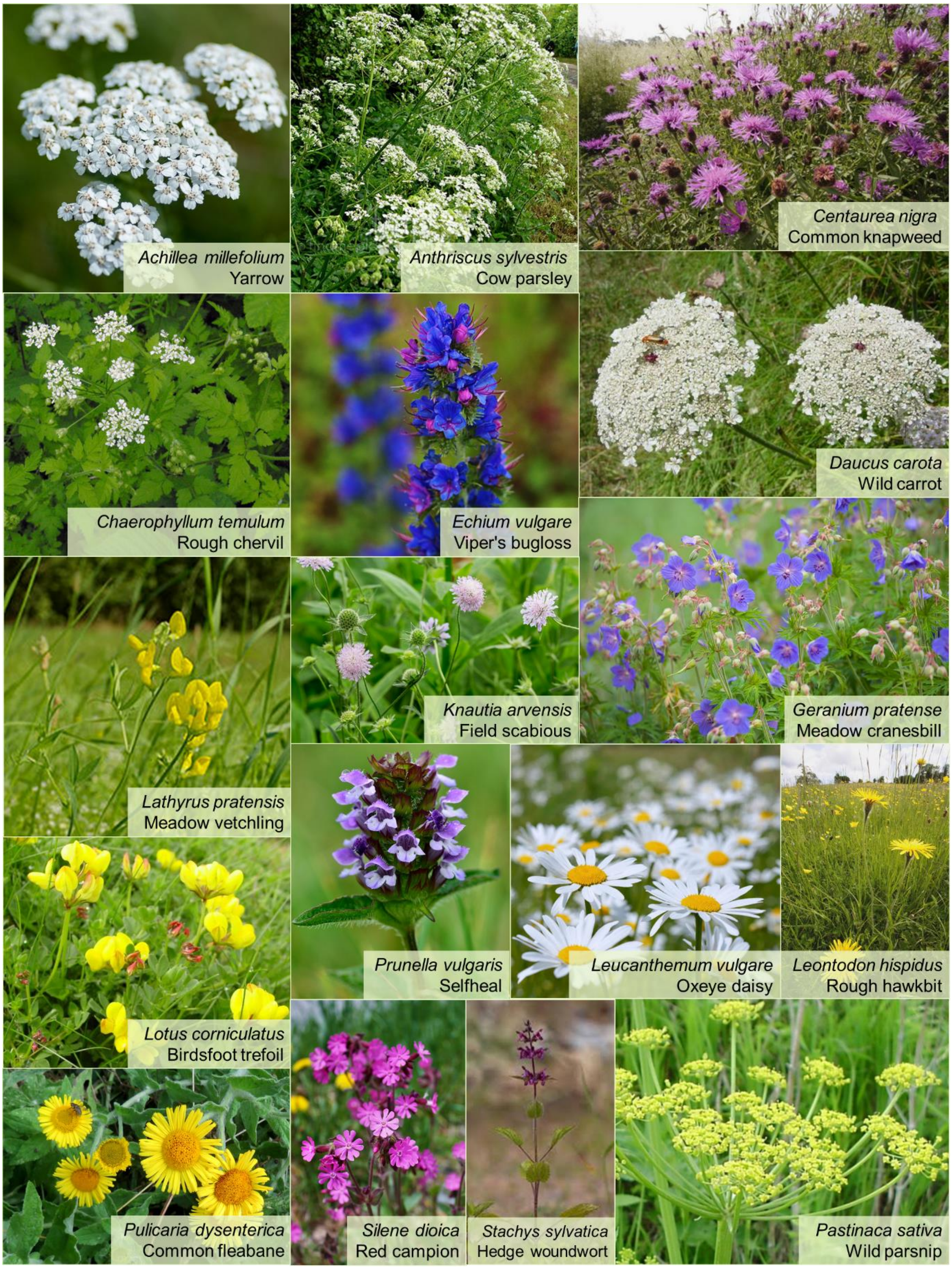


Figure 9. Seed mix sown in flower strips

An aerial photograph, taken in June 2019, of the field sown with flowering strips within the field and on the field edges is shown in Figure 10.

Figure 10. Within field and field edge strips, photo taken in June 2019

Figure 11. Photographs of the flowering strips, taken in June 2020

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

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 are monitoring 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 is 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 enables the team to look at the effect of distance into the crop on pest and natural enemy.

- 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 12)

Figure 12. 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 13). These are part filled with saline solution to kill and preserve any invertebrates that fall into the tap over a three day period.

Figure 13. Uncovered pitfall trap consisting of a yogurt pot inserted into a length of submerged drain pipe in the ground, and partially filled with saline solution to kill and preserver ground dwelling invertebrates.

- Summer aphids (Figure 14) 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 14. Grain aphids *Sitobion avenae* on wheat ear

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

Monitoring took place to assess the establishment of the sown species within the strips, and the appearance of weeds in the floral strips and encroachment into the crop. Assessments were carried out in June/July using 0.1 m^2 quadrate sampling (Figure 15).

Plant species numbers were counted in 0.1m^2 quadrats every 5m within the strips and 0.5m from the strip into the crop.

Figure 15. Assessment of plant species numbers

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

Removed 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.

Yield maps produced during 2020 harvest in Field 43 were used to assess the average yield in comparable areas of the field to estimate the yield loss associated with installation of in field floral strip.

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

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, baiting took place shortly after cultivation which is likely to have temporarily reduced slug activity.
- Slugs were present 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 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.

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.

Representative species

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

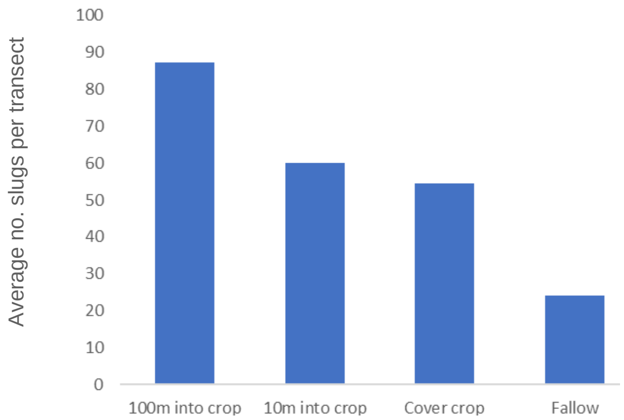


Figure 16a: Average number of slugs per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019.

Table 6. Number of slugs per trap at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Apple Tree	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 low (green), average (amber) or high (red) relative to the other fields sampled in this study. White boxes indicate where sampling did not occur.
Non-trial site fields have been used to understand the abundance of species in the wider environment

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

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.

Representative species

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

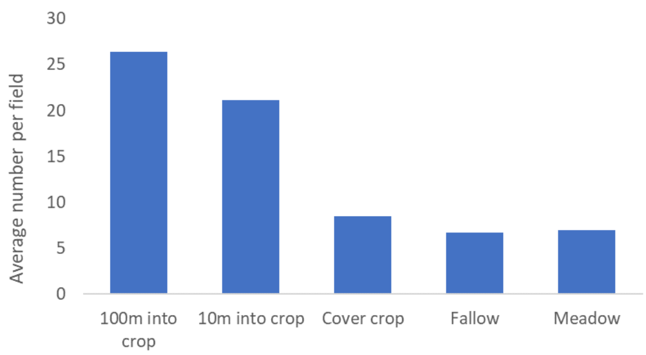


Figure 16b: Average number of group 1 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Table 7. 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 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Apple Tree	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. White boxes indicate where sampling did not occur.
Non-trial site fields have been used to understand the abundance of species in the wider environment

Ground beetles - Group 2

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

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.

Representative species

Carabus violaceus – the violet ground beetle.

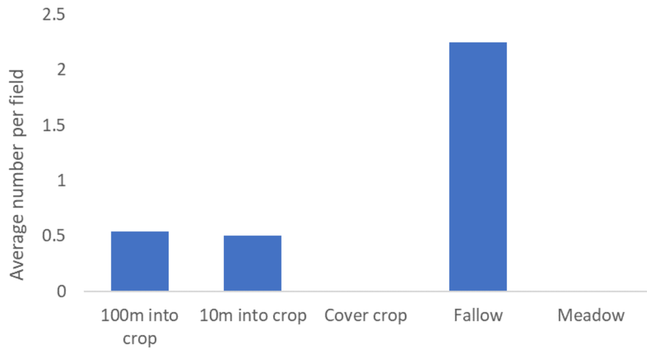


Figure 16c: Average number of group 2 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Table 8. 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 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Apple Tree	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. White boxes indicate where sampling did not occur.
Non-trial site fields have been used to understand the abundance of species in the wider environment

Ground beetles - Group 3

Size (length)	4 – 9 mm
Adult food	Seeds
Breeding season	Spring and summer
Peak adult activity	Spring and summer

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.

Key message

These herbivores can contribute to weed suppression.

Representative species

Amara ovata

Figure 16d: 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.

Table 9. 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 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Apple Tree	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. White boxes indicate where sampling did not occur.
Non-trial site fields have been used to understand the abundance of species in the wider environment

Ground beetles – Group 4

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

Representative species

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

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.

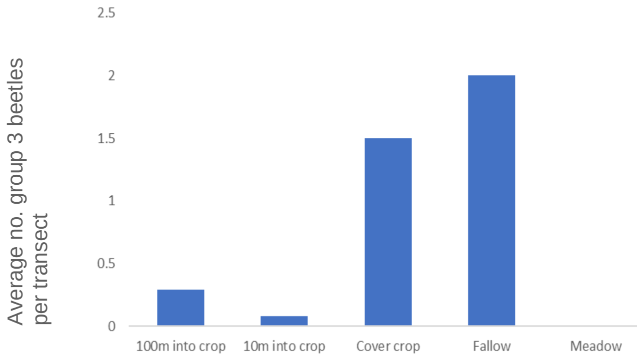


Figure 16e: Average number of group 4 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Table 10. 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 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Apple Tree	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. White boxes indicate where sampling did not occur.
Non-trial site fields have been used to understand the abundance of species in the wider environment

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 11. 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 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Apple Tree	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. White boxes indicate where sampling did not occur.
Non-trial site fields have been used to understand the abundance of species in the wider environment

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.

Key message

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

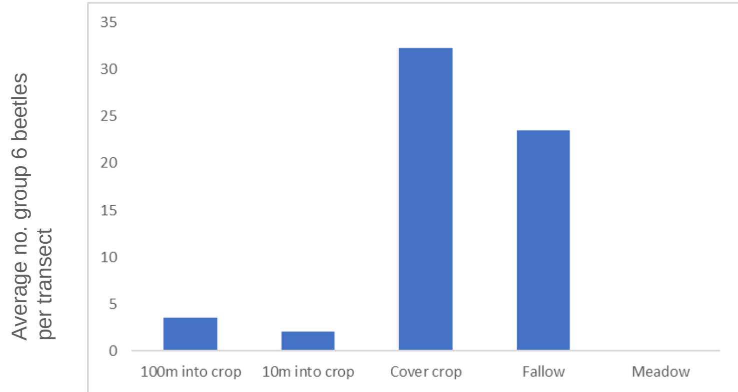


Figure 16f: Average number of group 6 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Table 12. 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 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Apple Tree	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. White boxes indicate where sampling did not occur.
Non-trial site fields have been used to understand the abundance of species in the wider environment

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.

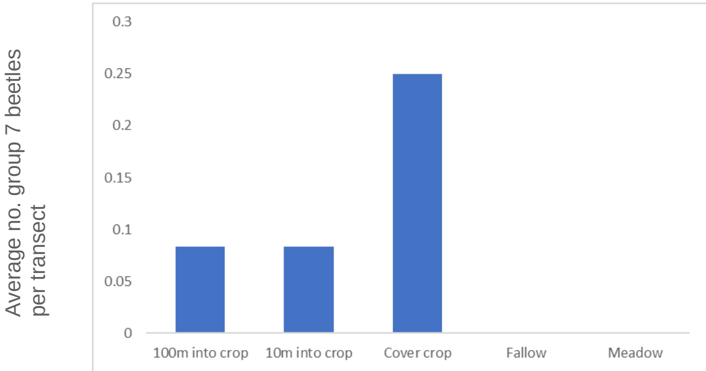


Figure 16g: Average number of group 7 ground beetles per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Table 13. Number of Group 7 beetles collected at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Apple Tree	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. White boxes indicate where sampling did not occur.

Non-trial site fields have been used to understand the abundance of species in the wider environment

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.

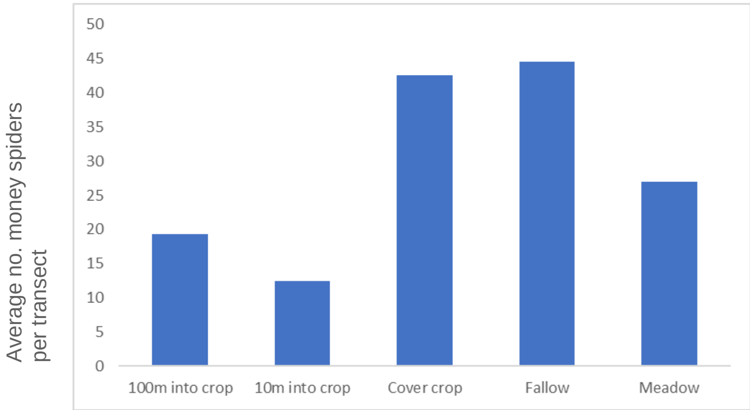


Figure 16h: Average number of money spiders per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Table 14. Number of money spiders recorded at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Apple Tree	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. White boxes indicate where sampling did not occur.
Non-trial site fields have been used to understand the abundance of species in the wider environment

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 SFE.

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.

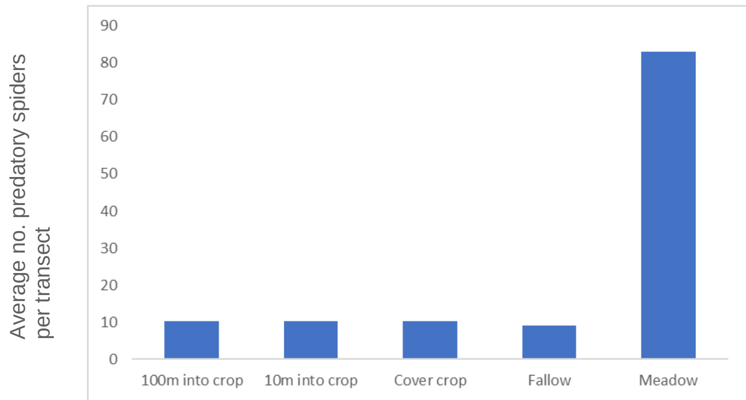


Figure 16i: Average number of ground dwelling spiders per transect at 100m into establishing crops, 10m into establishing crops, in cover crops or in fallow land, in October 2019 and July 2020.

Table 15. Number of predatory spiders recorded at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Walys	Apple Tree	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. White boxes indicate where sampling did not occur.

Non-trial site fields have been used to understand the abundance of species in the wider environment

Cereal aphids

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

Description

Cereal aphids are made up of four key species. 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 42 and 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.

Representative species

Grain aphids Sitobion avenae on wheat ear

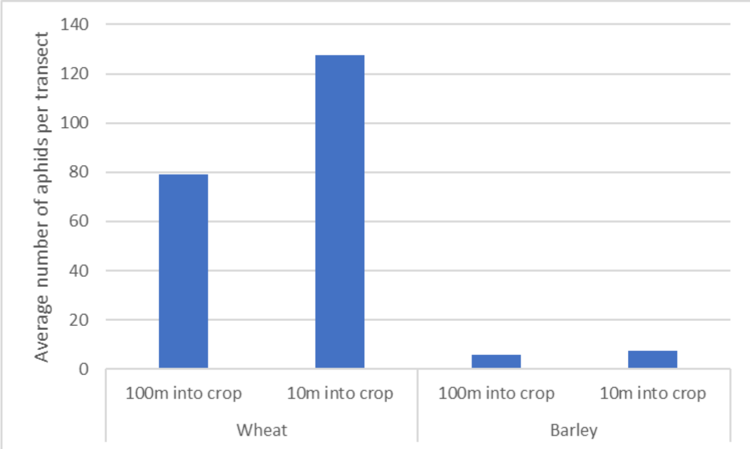


Figure 16j: Average number of cereal aphids per transect at 100m or, 10m into wheat or barley crops, in July 2020.

Table 16. Number of aphids recorded at Strategic Cereal Farm East, Strategic Cereal Farm West and Petworth Monitor Farm

Field	Field 6	Field 7	Field 40 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wallys	Apple Tree	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. White boxes indicate where sampling did not occur.
Non-trial site fields have been used to understand the abundance of species in the wider environment

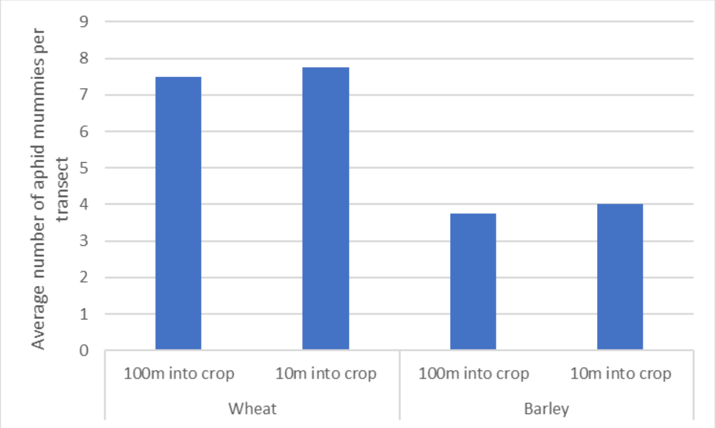
Aphid mummies – parasitized by wasps	
Description Aphid parasitoid wasps lay their eggs inside the aphid. The larvae consume it from within, forming an aphid 'mummy' from which the adult wasp emerges. Adults feed on nectar, pollen and honeydew. The quality and availability of adult food can increase both the lifespan and reproductive success; this is where floral strips can play an important role. 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.	**Representative species**  Mummy of the aphid Sitobion avenae parasited by the parasitoid wasp Aphidus rhopalosiphi (Braconidae - Aphidiinae).  **Figure 16k:** Average number of cereal aphid mummies per transect at 100m or, 10m into wheat or barley crops, in July 2020.

Table 17. 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 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wallys	Apple Tree	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. White boxes indicate where sampling did not occur.
Non-trial site fields have been used to understand the abundance of species in the wider environment

Aphid predators

Description

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.

Representative species


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

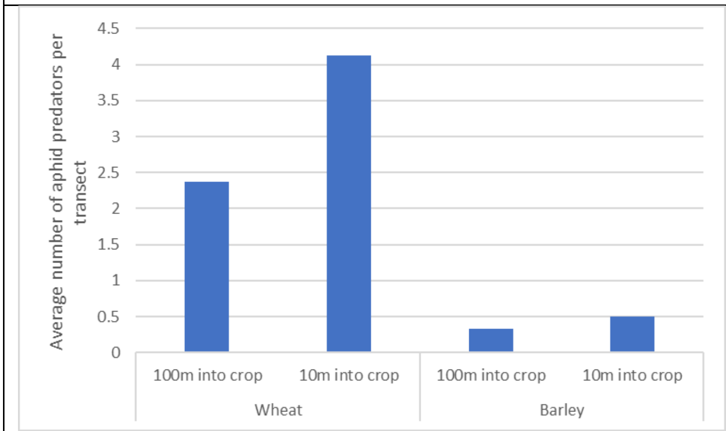



Figure 16l: Average number of cereal aphid predators per transect at 100m or, 10m into wheat or barley crops, in July 2020.

Table 18. 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 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wallys	Apple Tree	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. Non-trial site fields have been used to understand the abundance of species in the wider environment

Table 19. Summary table of counts in pest and natural enemies and flower strips trial

		Total	Field 6	Field 7	Field 40 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	Field 10A	Field 14A	Field 6A	Big Guinea Row	Bottom 59	Kells	Tom Dixon	Top 59	Wlalys	Apple Tree	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 (Farm standard)	Field 42 (Field edge flowering strips)	Field 43 (In-field & field edge flowering strips)	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 (red/green) – species dependent, average (amber) or high (green/red) – species dependent, relative to the other fields sampled in this study
Non-trial site fields have been used to understand the abundance of species in the wider environment

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

A wide range of species were recorded (Tables 20, 21 and 22) with many of the sown species present in a high proportion of the quadrats. Common knapweed, rough chervil, meadow vetchling, rough hawkbit and common fleabane were not recorded this year. There were fewer sown species present in Field 40 compared to Field 43. Field 42 was unsown with the flower mixture, but there were a wide range of species present reflecting the rich biodiversity on the farm.

Table 20. *Field 43 - Frequency of species present (% of quadrats species present in, at levels greater than 5%). Sown species in* ***grey***

Species	field edge strips	0.5m from margin	within field strips
Annual meadow grass	11.1		9.5
Birdsfoot trefoil	**66.7**		**38.1**
Black-grass		5.6	
Cleavers		33.3	2.4
Cock's foot	91.7		92.9
Common-field speedwell		5.6	2.4
Cow parsley			**2.4**
Cranesbill		**25.0**	
Creeping thistle			2.4
Crimson clover	8.3		11.9
Dandelion	11.1		7.1
Fat hen		11.1	
Fescue spp	22.2		7.1
Field Scabious			**7.1**
Foxtail grass	8.3		7.1
Grass spp.	8.3		2.4
Groundsel		13.9	
Hedge woundwort			**7.1**
Knapweed	**33.3**		**47.6**
Mayweed	8.3	2.8	4.8
Musk Mallow			2.4
Oxeye daisy	**75.0**		**78.6**
Red campion	**16.7**		**33.3**
Red Clover	13.9		
Ribwort plantain	5.6		
Ryegrass	50.0		45.2
Selfheal	**25.0**		
Spear thistle	13.9		2.4
Vipers bugloss	**5.6**		**7.1**
Wild carrot	**77.8**	**2.8**	**57.1**
Wild parsnip	**2.8**		**7.1**
Yarrow	**50.0**		**88.1**

Table 21. *Field 40 - Frequency of species present (% of quadrats species present in, at levels greater than 5%). Sown species in **grey***

Species	Field edge strips	0.5m from margin
Birdsfoot trefoil	**47.6**	**1.2**
blackgrass		17.9
Bristly oxtongue	16.7	13.1
Charlock		35.7
Cleavers		29.8
Cock's foot	9.5	
Cranesbill	**3.6**	**50.0**
Creeping buttercup	54.8	4.8
Creeping thistle	11.9	
Dock	14.3	
Fescue spp	44.0	3.6
Grass	13.1	
Greater plantain	39.3	4.8
Groundsel	2.4	25.0
Knapweed	8.3	
Lady's bedstraw	28.6	3.6
Meadow grass	38.1	
Oxeye daisy	67.9	2.4
Prickly sow thistle	25.0	
Red Clover	8.3	
Scarlett Pimpernel	9.5	
Selfheal	**8.3**	
Spear thistle	13.1	6.0
White clover	31.0	3.6
Wild carrot	**19.0**	**6.0**
Willow herb	7.1	
Yarrow	**42.9**	**2.4**
Yorkshire fog	11.9	

Table 22. *Field 42 - Frequency of species present (% of quadrats species present in, at levels greater than 5%).*

Species	Field edge	0.5m from margin
Bird'sfoot trefoil	61.1	
Black-grass	22.2	
Black Medic	16.7	
Bristly oxtongue	5.6	
Buttercup	11.1	
Charlock		5.6
Cleavers		55.6
Cranesbill		16.7
Creeping thistle	11.1	
Dandelion	16.7	
Dock	11.1	
Fescue spp	77.8	5.6
Field Madder	11.1	16.7
Field Pennycress	38.9	16.7
Grass	5.6	
Greater plantain	22.2	
Groundsel		16.7
Knotgrass	5.6	
Lady's bedstraw	11.1	
Mayweed	11.1	
Meadow grass	61.1	
Mouse-ear	11.1	
Oxeye daisy	38.9	
Prickly sowthistle	27.8	
Red campion	22.2	
Red Clover	72.2	
Ribwort plantain	5.6	
Ryegrass	55.6	
Scarlett Pimpernel	5.6	
Selfheal	5.6	
Shepherd's Purse		5.6
Smooth Hawksbeard	5.6	
Smooth Sow thistle	27.8	
Speedwell		11.1
Timothy grass	11.1	
White clover	22.2	
Wild carrot	38.9	
Willow herb	5.6	
Yarrow	44.4	

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

The estimated yield loss due to area of the field taken out of production for the infield strips was estimated from full header width data collected at harvest either side of the strip (yields 1 and 2 in the table below).

Table 23. Yield results adjacent to the floral strips in Field 43 Strategic Cereal Farm West

Field 43	Area (m^2)	Yield 1 (t/ha)	Yield 2 (t/ha)	Average yield (t/ha)
Flower strip1	1908	6.1	6.7	6.4
Flower strip2	1404	6.3	6.4	6.3

The estimated yield loss due to the total area of field taken out of production for installation of the floral strips is 2.1 tonnes. Using an estimate of 6.35 t/ha across the entire 7.02ha field, this is a reduction of around 5%. There was no evidence that the floral strips had either a positive or negative impact on the crop yield immediately adjacent to them.

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, though 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; although 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.
- At Strategic Cereal Farm East the floral strips were not established 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 there are 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, 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 compare changes in different locations. Consider what might be driving any differences you see.	Sep – Nov
Review you 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 and 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. The impact of summer catch crops on soil physical properties and performance of the following crop

Trial leader: Anne Bhogal, ADAS

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Start date: May 2020

End date: Ongoing

Video update: Watch online here

Headline

In seasons like 2019/20 where the weather and soil conditions prevent crop establishment growing a catch crop provides soil cover and captures useful amounts of nitrogen.

What was the challenge/demand for the work?

The aim of this trial is to assess the impact of a summer catch crop on soil nitrogen supply, soil structure and the performance of the following crop in the rotation. The trial will:

- Compare the impact of contrasting summer catch crop mixes compared to leaving the land fallow on soil nitrogen supply and following crop yields
- Assess the impact of contrasting summer catch crops compared to leaving the land fallow on soil structural condition

How will the project address this?

The trial is being conducted on a heavy textured soil (clay loam: c.60% clay) at Ewefields Farm, Chesterton. Two contrasting catch crop treatments were drilled on 11 May 2020 following light cultivation of the whole field (Figure 17) and compared with a weedy stubble control treatment (Table 24). There are two replicates of three treatments, with plots covering a 30 m tramline width and up to 500 m in length. The catch crops were destroyed using glyphosate in July 2020 and the field lightly cultivated ahead of drilling winter wheat in September 2020. Penetrometer resistance will be measured across each tramline in November 2020 and the location of the median point of resistance will be GPS recorded, with all soil assessments (Table 25) taken within a 10 m radius of this point. The performance of the winter wheat (establishment and yield) following the different catch crops will be monitored throughout the 2020/21 season.

Table 24. Catch crop treatments

Treatment number	Summer catch crop
1	Stubble (control)
2	Farm standard (barley @ 145 kg/ha & beans @ 225 kg/ha)
3	Commercial mix (designed for soil structure & nutrient retention): Phacelia (20%) and Oil radish (80%) @ 15 kg/ha

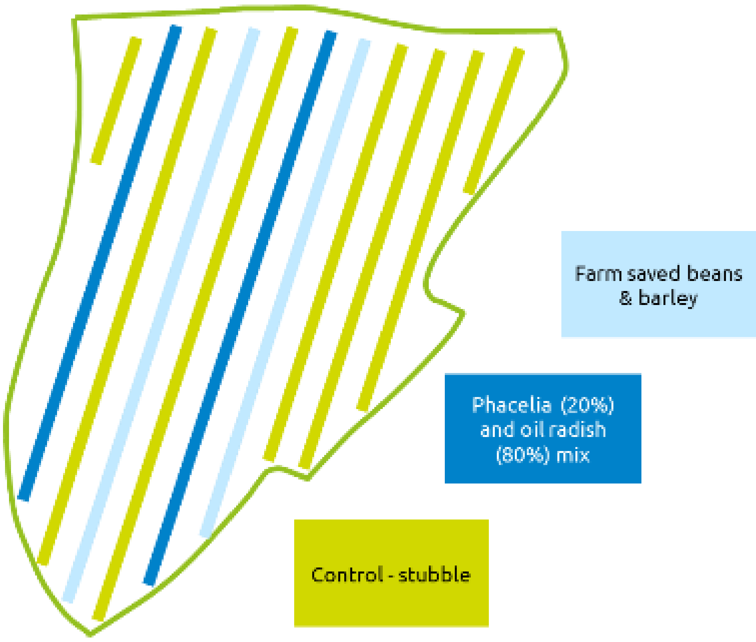

Figure 17. Catch crop trial layout

Table 25. Timeline of assessments on catch crop trial

May 2020	• Catch crop drilled • Topsoil sample (0-15 cm) analysed for pH, extractable P, K & Mg, total N, organic matter and soil texture • Catch crop establishment NDVI
June 2020	• Catch crop establishment NDVI
July 2020	• Catch crop establishment NDVI • % cover of each species in the mix (and other non-drilled species) • % dry matter and total nitrogen (N) uptake • Soil mineral nitrogen (0-90 cm) • Catch crop destroyed
September 2020	• Winter wheat drilled • Winter crop establishment NDVI
October 2020	• Winter crop establishment NDVI
November 2020	• Soil structure (Penetrometer, VESS, bulk density) & earthworm counts • Weed assessments
March 2021	• Soil nitrogen supply (soil mineral nitrogen 0-90 cm + above ground biomass N) • Soil structure (Penetrometer, VESS, bulk density) & earthworm counts • Weed assessments
August 2021	• Winter wheat yield and N uptake

What results has the project delivered?

Catch crop performance

The catch crops were slow to establish due to drilling into a dry seedbed, but following rainfall in June (Figure 1) they rapidly grew to give c. 90% cover by July, with weed and volunteer growth on the stubble treatment also producing c. 70% cover (Table 26 & Figure 18). By the time of destruction in July, the beans/barley catch crop had produced almost 3 t/ha dry matter and taken up 90 kg/ha nitrogen (N). Phacelia/radish was slightly lower at 2.5 t/ha dry matter and 78 kg/ha N uptake. The weeds/volunteers (largely charlock & wild radish) on the stubble treatment produced almost 2 t/ha dry matter, but with a lower N uptake (Table 26).

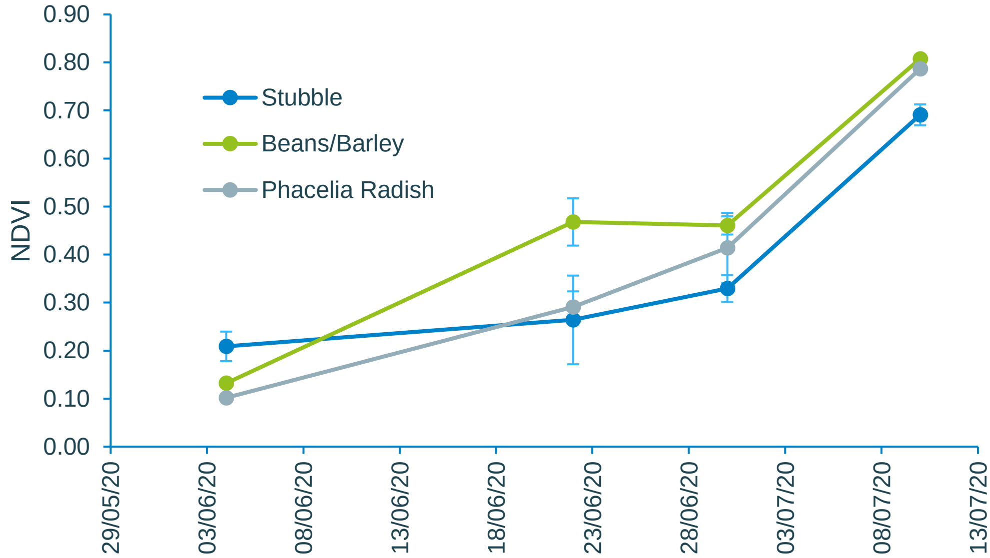

Figure 18. Catch crop ground cover (NDVI)

Table 26. Catch crop performance (July 2020)

Treatment	% Cover*	Dry matter production (t/ha)	Total N uptake (kg/ha)*
Stubble control	70	1.9	49
Beans/Barley	93	2.7	91
Phacelia/Radish	88	2.5	78

*Differences between treatments were statistically significant at P<0.05

Beans/Barley catch crop

Phacelia/Oil radish catch crop

Weedy stubble treatment

Figure 19. Photographs of the treatment tramlines, July 2020

Soil mineral N (SMN) was measured shortly after destruction of the catch crop, together with soil moisture content. SMN decreased in the order Stubble > Beans/Barley > Phacelia/Radish, although differences between treatments were small and not statistically significant (< 10 kg N/ha; Table 27). The topsoil was also slightly drier where the catch crop treatments had been grown. Soil N supply (catch crop N + SMN) ahead of drilling the winter wheat therefore ranged from c.90 kg/ha where no catch crop had been grown to c. 130 kg/ha following a Bean/Barley catch crop mix (*P*<0.05; Figure 20).

Table 27. Soil mineral nitrogen (SMN) and topsoil moisture content following the different catch crop treatments

Treatment	SMN (kg/ha to 90cm)	Topsoil moisture content (%)
Stubble control	44	37
Beans/Barley	41	34
Phacelia/Radish	35	35

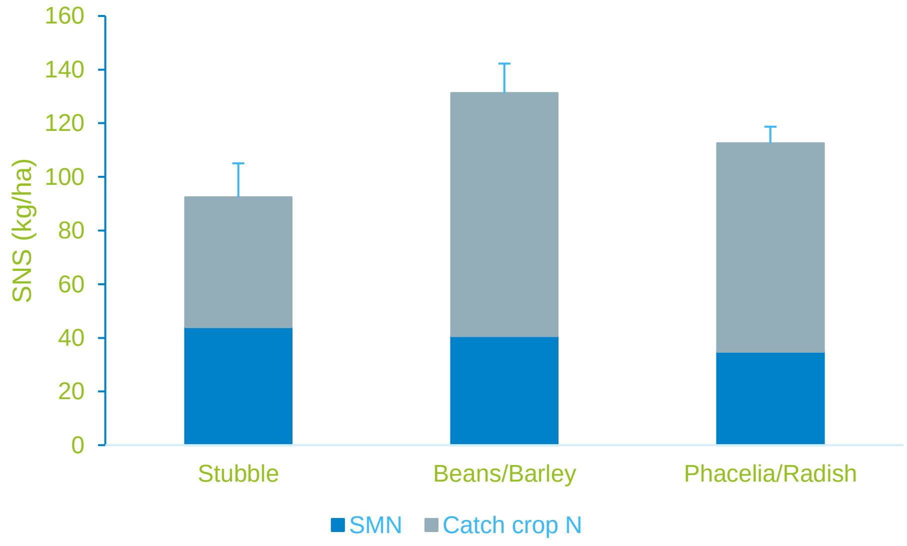

Figure 20. Soil nitrogen supply (SNS) prior to drilling the winter wheat crop. Differences between treatments were statistically signficant at *P*<0.05.

Action points for farmers and agronomists

- In seasons like 2019/20 where the weather and soil conditions prevent crop establishment, consider growing a catch crop over the summer
- Catch crops provide more consistent cover than leaving a soil fallow and capture useful amounts of nitrogen

Links to further information and references

- **Maximising the benefits from cover crops through species selection and crop management (Maxi-Cover crop)** (online)
- **AHDB Rotations Partnership** (online)

Keep up-to-date

- Visit ahdb.org.uk/farm-excellence for the latest information
- Follow #strategicfarm on Twitter

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