March 2025

# Annual Project Report

# (Harvest 2024)

## On-farm trials at

## Strategic Cereal Farm East

## CONTENTS

# 1. Introduction

Host Farmer: David Jones

Location: Morley Farms, Wymondham

Duration: 2023–2029

AHDB Strategic Cereal Farms put cutting-edge research and innovation into practice on commercial farms around the UK. Each farm hosts field-scale and farm-scale demonstrations, with experiences shared via on-farm and online events to the wider farming community.

# 2. Cultural Weed Management (work package 1)

Trial leader: Nathan Morris, NIAB

Start date: October 2023

End date: September 2024

## 2.1 Headlines

The use of cultural weed control methods, namely interrow-hoe and weedsurfer, were due to be trialled in conjunction with chemical weed control options. Due to inclement weather, the trial design was not able to be implemented and instead the machinery was demonstrated in alternative fields. The contribution of these alternative non-chemical approaches requires long-term testing and tailoring to determine its full potential in an integrated weed management approach. The importance of evaluating, tailoring and adopting alternative, non-chemical, weed management options for Italian Ryegrass is highlighted by the recent identification of a case of glyphosate in this species.

Significant weed seedbank sampling was carried out to determine the baseline weed pressure and diversity in the seedbank. The abundance of weed seeds in the seedbank acts as a reminder that the above ground weeds are only the tip of the iceberg of weed pressures and that careful management should take place with regards to tillage and rotation to ensure the weeds are kept to a manageable level.

## 2.2 What was the challenge/demand for the work?

The presence of weeds within crops are frequently cited as being the greatest threat to crop production (Oerke, 2006), however effective crop protection, notably from synthetic herbicides, has been vital in ensuring yield penalties are minimised. For arable growers in the UK, the most frequent problems are from grass-weeds including black-grass (*Alopecurus myosuroides*) and Italian ryegrass (*Lolium multiflorum*). Both of these weeds have now developed widespread herbicide resistance (Hull *et al*, 2014) leading to challenges for on-farm agronomy to keep populations at manageable levels. This has seen a re-focus on the use of cultural and alternative techniques, as part of an Integrated Weed Management (IWM) approach. To date, the research focus has largely been on *A. myosuroides*; for this weed, we have a good level of understanding of the contribution of each weed control component at the population level. However, the same level of detailed understanding does not yet exist for *L. multiflorum*.

A recent PhD study (Smith, W., 2025) has identified several challenges and demonstrated the potential for inter-row cultivation ('IRC') to help manage *A. myosuroides*. The study showed that in isolation the IRC treatments didn't provide a total solution but that alongside conventional herbicide treatments they contribute significantly to sustainable weed control by buffering good and bad years for herbicide control and by providing late-season (spring) control of plants surviving autumn herbicides where resistance to contact herbicides has developed. The challenges experiences during the study highlight the need to tailoring and adapt the IRC to suit the individual farm and also made clear the need for multiple passes to optimise the effectiveness. The key challenge to adoption identified in the study was around labour availability in a critical spring window making the IRC approach best suited to farms with a diversity of cropping and hence a better spread of workload though the year. The published study entirely involved A. myosuroides control in this study we are expanding the knowledge base to understand it's potential for L. multiflorum management.

This study involves 'stacking' alternative non-chemical weed control approaches as we are used to thinking about herbicide 'stacks' which is a novel approach and we intend to show that just as has been demonstrated with herbicide programmes it is the case that a diverse non-chemical weed control approach bring robustness in control.

## 2.3 How did the project address this?

This WP will begin to build the detailed information on Italian ryegrass (IRG) needed to deliver IWM strategies.

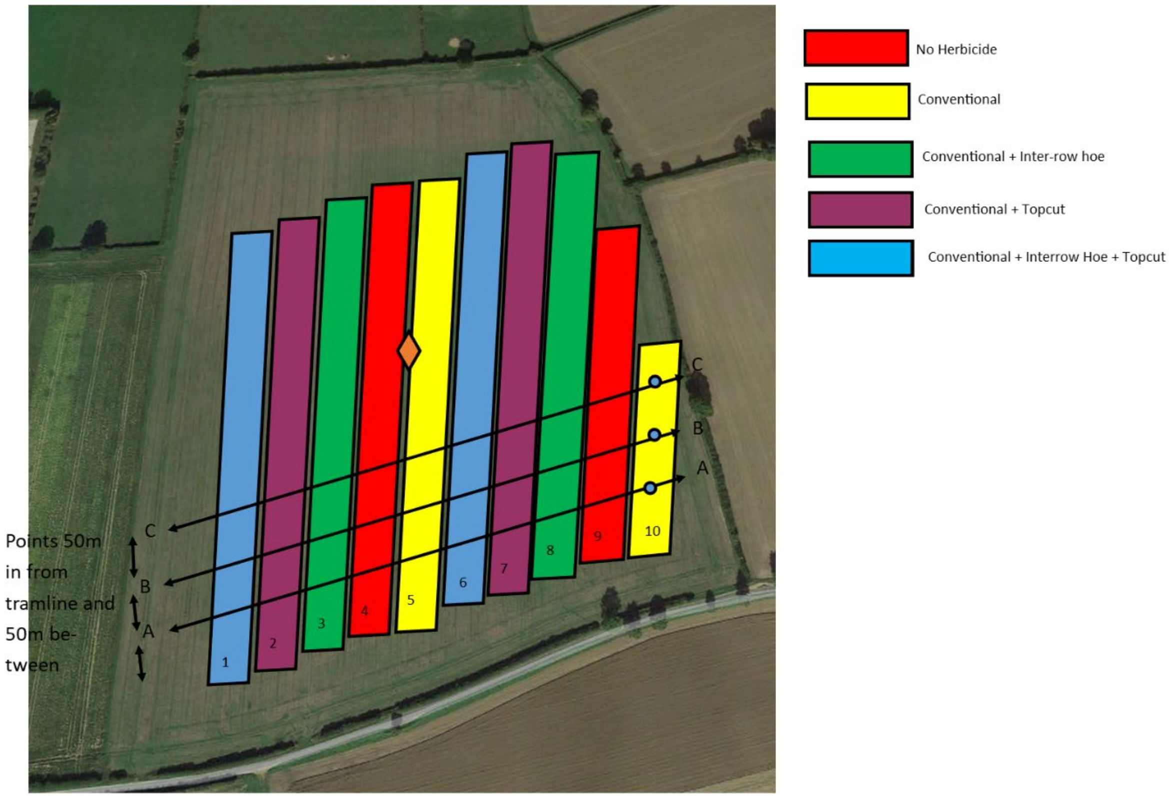
This work package has three approaches. The first was a long-term trial, based on stacking non-chemical control methods with standard chemistry based on Flufenacet and Pendimethalin to assess their effectiveness over time on IRG populations. The two non-chemical controls were the interrow cultivator (the ‘robocrop’ provided by our collaborators Garford farm machinery) and a weedsurfer which is a harvest weed seed control (HWSC) approach cutting weed flowering stems and flower heads above the crop as they mature. Unfortunately, due to weather constraints, the weedsurfer could not be deployed and was instead used in separate fields for demonstration purposes.

The long-term nature of the study demonstrating the role of non-chemical weed control, options and the value of ‘stacking’ non-chemical weed control is required (as demonstrated by long-term studies on HWSC in Australia) for the non-chemical approaches and as part of the long-term approach the first year involved a detailed baselining of the weed seedbank in the study field. In addition, the baseline seedbank assessments in this study help to illustrate and promote key concepts in integrated weed management. Understanding that; a) the size of the weed seed bank is much larger than the weed seedling population present in any field, b) that the weed seedbank consists not just of target weeds but a wide range of other weeds and arable plants and c) understanding the vertical structure of the seedbank can help to optimise cultivation strategies for following crops is critical for understanding the impact of your management decisions for IWM.

The weedsurfer exploratory work was conducted in different cereal crops that were heavily infested IRG sites at Morley. These demonstrations allowed the team to look at approximate crop damage and an initial assessment of the effectiveness of this tool, its strengths and weaknesses on farm.

As well as the long-term options stacking and weedsurfer demonstration, this work package also wanted to look at the effect of environmental schemes on weed pests. Two sites at Morley in contrasting environmental management schemes were closely monitored for their IRG and blackgrass populations through the spring and summer and seedbank samples were taken from 3 particularly infested locations. This first year will form the base for continuing monitoring through the SF East programme. The ultimate evaluation of how the contrasting implementation of environmental schemes and approach to re-establishing an arable crop once the scheme has finished will be given once the fields are taken back into the arable rotation the baseline seedbank and assessments of weed seed shed during the course of the environmental scheme are essential to interpreting any findings.

## 2.4 Methods




*Cultural weed control long-term trial – Seedbank sampling*

Soil seedbank sampling formed a significant part of the work conducted during the 2023-24 season. With the plan in mind to deliver a long-term trial we took 30 soil samples at the depths of 0-5,5-10 and 10-20 cm in a grid pattern across the long-term trial site. These depths are chosen to match up with weed seed biology; weed seeds in the top 5cm soil horizon are readily germinable and contribute directly weed seedling density whereas weed seeds buried deeper than 5cm to form the longer-term seedbank. The 5-10 cm depth is intended to capture weed seeds buried as a result of superficial soil cultivations (those ideally promoted for stale seedbed creation) and deeper, below 10cm samples characterised weed seed buried by primary cultivation approaches whether inversion or non-inversion.

Prior to drilling of spring barley March 2024, Hacketts at Morley farms had previously been cropped with Sugar Beet in 2023 with a first and second wheat in 2021 and 2022. Approximately 60% of this soil went into trays in the polytunnel, on farm (Picture 1 & 2.). This was then irrigated and monitored at 30 days intervals for IRG germination. These were then counted, plucked and removed, the soil was remixed and returned for a further 30 days before the next assessment was conducted. We repeated this over the course of 5 months.

Picture 1. Soil seedbank samples arranged in the polytunnel

Whilst this yielded some interesting results, we had some concerns regarding the effectiveness of our methodology utilising the polytunnel – for example we had issues with consistency of watering in the early stages and swings in temperature which we had no way to control. Therefore, taking advantage of the residual soils remaining we had, we set up an identical trial which was based at NIAB Park Farm and the glasshouses there. The trial was replicated with the advantage of having a controlled environment with greater flexibility and reliability of watering to maximise germination.

Picture 2. Soil seedbank samples arranged in the NIAB park farm glasshouse

Picture 3. Carrying out crop and weed plant counts in the winter wheat crop

*Cultural weed control long-term trial, Hacketts field, Morley Farms – Plant counts & weed control methods*

Plant counts and observations formed a significant part of our work this year (Picture 3.). On Hacketts, long-term trial site, we conducted IRG counts utilising quadrats counts to build up a picture of the IRG population across treatments which will form part of the background information in the coming years of the experiment. In mid-May we also conducted counts prior to and after the pass with the interrow-hoe. As planned, we had passes in all four planned strips.

Unfortunately, as drilling was delayed and with wet conditions hampering field work, we judged that as the crop grew and filled out into the interrow space, further passes would cause significant crop damage. Therefore, further interrow hoe passes were dropped form the programme.

*Weedsurfer exploratory work*

Adapting to the season and the low IRG population in Hacketts we selected two contrasting scenario fields to conduct some limited exploratory work. Looking at the weedsurfer we captured IRG ears/crop ears using raised table 0.25m$^2$ quadrats prior to weedsurfing and recorded the number of ears remaining or damaged after its use.

*Environmental Schemes & weed burdens*

The sites under environmental schemes, Perownes and Rayns had 8 locations identified in each with substantial IRG or blackgrass populations. Rayns was first put into an environmental scheme in 2022 and was drilled with a legume mix and left fallow. Perownes, in contrast, was drilled with an AB15 mix in 2023 as part of a pilot SFI scheme and is managed through a once per year hay cut. Perownes was also identified for this due to the substantial blackgrass population. Of these, Perownes and Rayns, three of the locations with the highest population also had soil seedbank assessments conducted on them. These locations were initially sampled (in Year 1) and seedbank and plant populations of weeds that has been targets in the arable crops before the (Black-grass and Italian Ryegrass. The proposal is for continual monitoring of not just these weeds in the rotation prior to the environmental scheme phase (Italian Ryegrass in Rayns, Black-grass in Perownes) but also grassweed such as Brome species which might build-up during the environment scheme itself.

## 2.5 Results

*Cultural weed control long-term trial ('Hacketts field')– Seedbank sampling, plant counts and control methods*

The soils seedbank work conducted has generated some interesting results; In Hacketts the only apparent weed is Italian Ryegrass but in seedbank samples about a dozen weed species are present. Weed seedling densities across the site were approximately 18 seedlings per $m^2$ however the seedbank density was equivalent to ~119,000 seed per $m^2$ to a depth of 20cm. These observations are reminders of the important principles of weed management. Firstly, the seedbank contains the vast majority of weed individuals in any field and thus weed management needs to focus on managing seedbanks over the long-term rather than in-crop weed control. Secondly, a diversity of weed species are present in all fields rather than single weed species. The vertical distribution of weed seeds observed in these data sparked enquiry. The seedbank structure in Hacketts is unusual in that in most fields we observe higher seedbank densities nearer the surface because seed buried at depth loose viability year on year (at a rate of about 70 to 80%) whereas the surface soil layer(s) are topped up with fresh shed weed seed. In Hacketts we observe the opposite as a result of the combination and interaction of timing and nature of primary cultivation with annual difference in the number of Italian Ryegrass seeds shed. This observation demonstrates how valuable seedbank sampling to understand the vertical structure of the seedbank can be. This has informed our study approach for the 2024/25 season; we have decided to focus on this aspect of vertical seedbank distribution and how tillage and rotation may affect this by selecting 5 sites across Morley farms with an identified IRG problem and how these soil seedbank populations change according to management

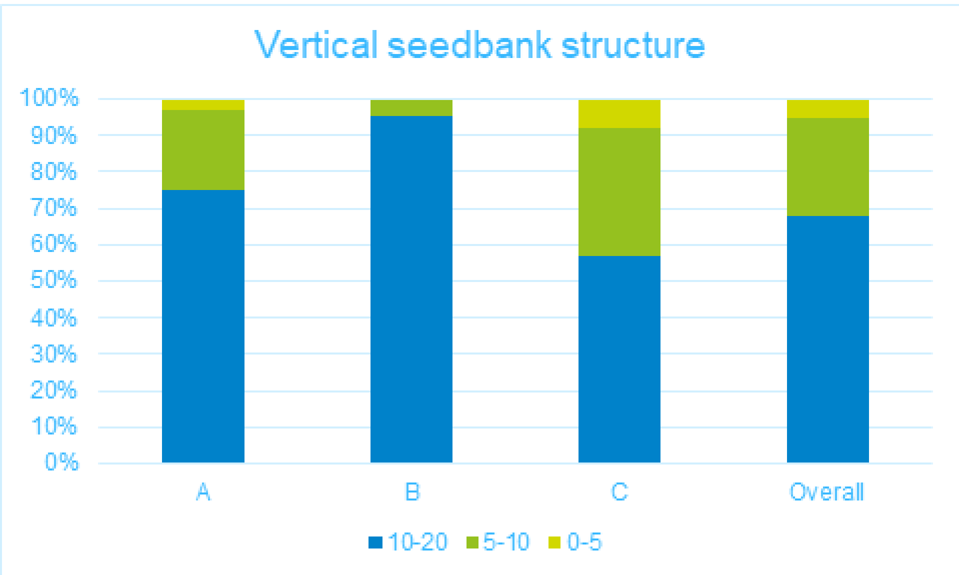



Figure 1. Long-term study baseline vertical seedbank structure

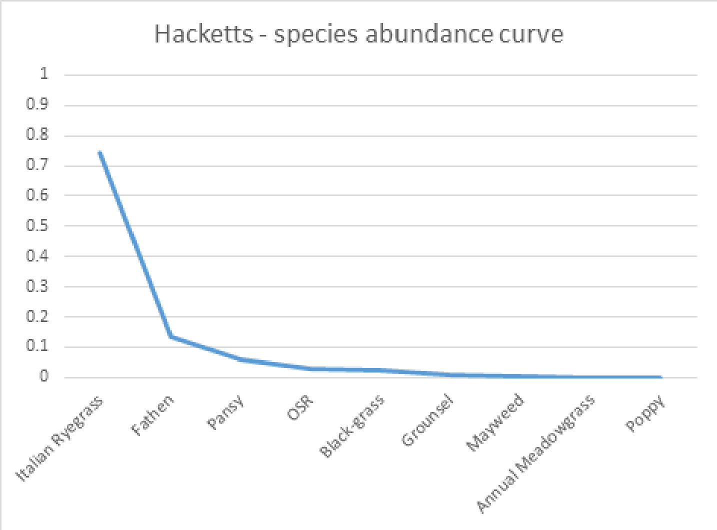



Figure 2. Species abundance curve (see Magurran, A.E. (1988). Diversity indices and species abundance models. In: Ecological Diversity and Its Measurement. Springer, Dordrecht. https://doi.org/10.1007/978-94-015-7358-0_2)

Table 1. Recorded IRG and SB ear populations in June 2024, Hackets

| Treatments | IRG heads /m2 | Spring Barley ears /m2 |
|---|---|---|
| Conventional | 0.7 | 537.1 |
| Conventional + Interrow hoe | 2.0 | 560.2 |
| Conventional + interrow hoe + Topcutter | 0.2 | 514.4 |
| Conventional + Topcutter | 2.9 | 528.0 |
| No Herbicide | 2.2 | 574.4 |

From table 1 – Italian Ryegrass headcounts are summarised. Headcount assessment give a robust measure of potential weed seed return and so are a crucial assessment for monitoring over the long term and compliment the seedbank data. This is a split field rather than a small-scale randomised plot study and therefore some caution is needed (since there will have been background differences in the weed population) and combining annual assessments over time with the seedbank baseline will be needed. The first year of the experiment is promising in that it appears to demonstrate ethe concept of stacking non-chemical approaches neatly with the lowest seed return occurring in the splits where both IRC and topcut approach were deployed to compliment conventional herbicide-based control. Contrasting the conventional herbicide-based approach (0.7 heads per $m^2$) with an untreated plot (2.2 heads per $m^2$) we observed ~68% reduction in seed return which is a sobering reminder of how far short of sustainability a conventional, herbicide only based, control approach is for management of Italian Ryegrass on this farm.

*Weedsurfer exploratory work*

We found that the weedsurfer had some limitations to its use. One issue was with targeting IRG heads in a spring barley. We observed that the weed seed heads were often at or below the crop height, leading to significant damage to the SB ear.

We also found that weed seeds were distributed in a wide arc around the machinery raising the question of is this action simply distributing the weeds into the surrounding area (we will explore weed seed viability in future work).

Crop damage through driving the machine through the weed infested area was also significant, this would be a challenge if operating a CTF system or if attempting to avoid unnecessary soil compaction. Additionally, this passing through the crop could potentially be ensuring soil seed contact from any cut and distributed weed seed.

*Environmental Schemes & weed burdens*

In year 1(2024) the baseline assessment of seedbank for key weeds in the environmental scheme fields showed a contrasting seedbank vertical structure to the data from Hacketts. This vertical distribution with the very highest abundance of seed closest to the surface is as one would expect in an uncultivated field. Fresh seed shed is increasing seed numbers at the surface while the lack of cultivation combined with natural seedbank decay reduces seed abundance deeper ion the profile. The contrast between Hacketts and the uncultivated environmental scheme is a useful one.

The relatively high abundance of seeds at the surface in these samples implies a continued 'top-up' of freshly shed seeds within the environmental scheme and this observation is reinforced by flowering head counts at the two locations taken in June at peak maturation. In Perownes (Black-grass) there were an average of 167 heads per $m^2$ and in Raynes (Italian Ryegrass) there were an average of 40 heads per $m^2$ clearly, we are observing a level of continued fresh seed return from key arable weeds within the environmental scheme habitats – the seedbank number imply a relatively high rate of fresh shed seed loss in this habitat but nevertheless for the study fields at least these environmental schemes managed in the way that they are currently do not seem to be offering a robust IWM approach – the real test will be in the reversion of the habitat from environmental scheme into the arable rotation and here the vertical distribution of the seedbank implies that careful consideration of the cultivation strategy for this reversion will be key.

Table 2. Seedlings recorded (average of 3 locations) in seedbank samples from environmental schemes

| Location | Perownes (black-grass) | Raynes (Italian rye-grass) |
|---|---|---|
| Surface (0-5) | 177.0 | 5.0 |
| 5 to 10cm | 3.7 | 0.7 |
| Deep (10 to 20cm) | 2.7 | 0.0 |

**Next steps**

- The long-term cultural weed control trial will remain the same for the 2024/25 trial year, with the intention to use the alternative, non-chemical, approach and the conventional herbicide control only, adding two passes with the interrow-hoe cultivation and combining the conventional with both inter-row cultivation and weedsurfer.
- Weed seedbank sampling and analyses will focus on how field history has shaped the vertical structure of the seedbank and explanation of how cultivation strategies can be adapted to minimise weed pressure in crops that are established.
- 4 additional fields plus a repeat sample location in the Hacketts field have been selected for weed seedbank sampling. These fields represent a range of cultivation methods. This will expand the scope of the research to include other weed control management practices (e.g. varying tillage, alternative rotations).
- So far, the weed seedbank sampling has been quite labour and equipment intensive. This season we will look at a range of weed seed bank measuring methods – testing the scientific viability of high-tech through to farmer-friendly approaches.
- The additional weed seedbank sampling will look at both the abundance and diversity of weed seeds in the seedbank.
- As part of an overall theme of gathering basic weed biology data to compare to our depth of knowledge on black-grass we will be launching a new novel piece of work in Italian Ryegrass looking at seed maturation timing in different crops to aid decision making for non-chemical control especially the application of HWSC approaches.

## 2.6 Action points for farmers and agronomists

Consider the interaction of primary cultivation and season (with respect to weed seed return) to understand where the highest weed pressure exists in the seedbank (in terms of its vertical structure) in order to tailor cultivation for the next cropping season. Where the greatest pressure comes from weed seed buried by ploughing for example (as we have observed in the Hacketts field) consider minimising soil movement to prevent bringing those seeds to the surface.
A number of weed species are present in all fields, although they may be hidden in the weed seedbank. Understanding the complete picture is important when considering weed management.

Crop choice (e.g. switching from winter cereal to late spring drilled crop) can be used as a cultural control option for one challenging weed species but care should be taken that this does not lead to another weed taking control.

It's important to look at both the abundance and the diversity of the weed seedbank ultimately a diverse weed seedbank without dominance by a single aggressive weed species (such as Black-grass or Italian Ryegrass) reflects a sustainable and balanced cropping system.

**Links to further information/references**

https://ahdb.org.uk/knowledge-library/how-to-manage-weeds-in-arable-rotations-a-guide
https://ahdb.org.uk/knowledge-library/the-encyclopaedia-of-arable-weeds

# 3. BYDV Risk Management (work package 2)

Trial leader: D. J. Coston and M. Ramsden

Start date: 31/08/2023

End date: 31/08/2024

## 3.1 Headlines

This work package explores how variety choice and use of decision support systems (DSS) influence aphid and BYDV risk and their management in crops of winter wheat. Two fields were selected, one with a variety marketed as exhibiting resistance to BYDV, and one a susceptible variety. Within each field both DSS were used to inform on BYDV risk and the need for insecticide application. Two DSS were used in this trial. T-sum, a publicly available model which calculates the time to reach 170 day degrees above 3°C associated with aphid flight activity, and the ADAS-Crop BYDV Assessment Tool (ACroBAT) which also incorporates information on the financial aspects of BYDV management, aphid numbers and proportion of aphids carrying the virus.

The risk of spread of BYDV was monitored using the T-Sum and ACroBAT DSS and field observations were undertaken of aphid and natural enemy abundance. The number of aphids observed regionally was relatively low compared with previous yearly averages. As both models reported low risk of BYDV, and travelling on the wet soil risked damage to the crop, no insecticides were applied to any of the treatments in either field. The yield data showed ~1tn/ha increase in Dead Horse field (cv. Dawsum) compared to Chapel Bell (cv. Grouse), although differences in field variability may have contributed to this result. This trial will run again in 2024/25 to collect longer term data in years of varying aphid and weather pressure.

## 3.2 What was the challenge/demand for the work?

There are a wide range of insect pests that can affect UK crops. Some cause plant injury due to direct feeding of the adults or larval stages, others pose a risk to crop yields through transmission of viruses within the crop. In cereal crops, aphids are an important potential direct and indirect pest, in particular the bird cherry-oat aphid (*Rhopalosiphum padi*), the grain aphid (*Sitobian avenae*) and the rose-grain aphid (*Metopolophium dirhodum*). Of these the bird cherry-oat aphid and the grain aphid are the most significant as they are the primary vectors of Barley Yellow Dwarf Virus (BYDV). BYDV is a complex of plant viruses belonging to the *Luteovirus* genus and can have significant impact on the yield of wheat, barley, oats, rye and triticale.

In the UK and much of Europe the primary method of managing BYDV in cereals has for a long time been the application of pyrethroid insecticides during the autumn and winter, to minimise the spread of BYDV within a field. Overdependence on applications of insecticide with limited modes of action (MOA) is selecting for aphid populations with insecticide resistance. Grain aphid populations are known to exhibit moderate levels of pyrethroid resistance in the UK. While there is limited information on the efficacy of approved insecticides in managing bird cherry-oat aphid populations, a more sustainable approach to BYDV management is needed.

- ## 3.3 How did the project address this?

As part of the Agriculture and Horticulture Development Board's (AHDB) Strategic Farm East (SFE) project a combination of management strategies were proposed to help manage BYDV. These included the use of varieties bred to perform well under BYDV pressure, and marketed as resistant or tolerant to BYDV, although resistance to BYDV is a breeders' claim and has not been verified in RL tests. These varieties can be selected by the grower as the first in-field IPM decision to manage BYDV. The use of decision support systems (DSS), helps to interpret aphid activity at field, farm and regional level, giving greater confidence in decisions to avoid unnecessary applications, and/or improves targeted timing of insecticide applications where the risk is of spread of BYDV is high.

In the UK there is currently one DSS for BYDV in cereals, the T-Sum. This model calculates the time to reach 170 day degrees above 3°C associated with aphid flight activity and is freely available on the IPM Decision platform[1] and the AHDB website[2]. The T-Sum DSS predicts the start of the second generation of aphids, responsible for secondary viral transmission in the field, indicating when crops should be inspected for these pests. The T-Sum recommends field scouting

[1] https://platform.ipmdecisions.net/

[2] https://ahdb.org.uk/bydv

and where infections are high treatment should be considered (IPM Decisions). It does not predict spray timing but when the crop should be assessed for aphids. Using the T-Sum model helps provide a measure of risk of BYDV transmission, and targets in-field monitoring, however the model assumes all aphids are carrying BYDV, and that aphid populations are unaffected by rainfall, abundance of natural enemies, and other factors known to influence the risk of BYDV. A new DSS under development by ADAS and AHDB known as ADAS-Crop BYDV Assessment Tool (ACroBAT) incorporates information on the financial aspects of BYDV management, aphid numbers and proportion of aphids carrying the virus. ACroBAT provides a more informed guidance on the risk of BYDV infection, and initial assessments have shown this improves effective management (White *et al* 2023 AHDB report No. 646).

The SFE BYDV work package (WP2) explores how variety choice and use of DSS influence aphid and BYDV risk and their management in crops of winter wheat. Two fields were selected, one with a variety marketed as exhibiting resistance to BYDV, and one a susceptible variety. Within each field both DSS were used to inform assessment of BYDV risk and need for insecticide application. This work has been done in collaboration with an EU funded Horizon Europe project, IPMWORKS (Grant number 101000339), and this trial form part of a series of IPM comparison studies across Europe, demonstrating the impact of IPM approaches in different scenarios.

- **3.4 Methods**

Activities in WP2 focus on collecting, analysing and presenting data to demonstrate the impact of agronomic practices relevant to the management of aphids and associated BYDV in winter wheat at AHDB SFE. The ADAS Line Trials Agronomics approach was used, selecting and managing suitable tramlines within selected fields to make robust comparisons of alternative treatment options.

Start of season proposed treatments:

1. Using the TSUM model to direct assessment of aphid numbers
2. Using the ACroBAT model to direct assessment and treatments
3. No insecticide application

Assessments were planned in each tramline treatment for aphids, their natural enemies, and BYDV infection during the growing season, along with the final crop yield (Table 1). The set of treatments were applied in two fields, each drilled with a different variety and within field treatments planed for alternating tramlines. The two fields used in 2023/24 were “Dead Horse” (DH) drilled with a Dawsum (a variety showing susceptibility to BYDV) and “Chapel Bell” (CB) drilled Grouse (a variety marketed as “resistant” to BYDV).

Table 1. Assessments done in both treatment fields

| Monitoring effort | Target | Detail | Timings | Locations |
|---|---|---|---|---|
| Yellow water traps | Aphids and their natural enemies | Aphid ID to species and Natural enemy ID to genus | Oct-Dec biweekly Jan – Feb monthly | 6 traps per tramline, distributed equally, at same spacing across all treatments |
| BYDV tissue assessment | BYDV | 5 leaves from 3 points at each trap location | Mid-December and GS30 | As per yellow water traps. |
| BYDV visual assessment | BYDV | % of plants exhibiting BYDV symptoms per $m^2$ | At GS 30 | As per yellow water traps. |
| Yield assessment | Crop yield | Data collected from combine yield data, analysis using ADAS Agronomics software. | Harvest | Each tramline included in the study. |

**Consultation of Decision Support Systems**
*T-Sum:* The T-Sum model was run by ADAS using the IPM Decisions platform with all information provided by The Morley Agricultural Foundation.

*ACroBAT:* The ACroBAT model is functional, but the user interface is not yet complete. As such, manual data entry is required to run the model and extract the forecast risk (Table 2). The input data used was compiled from multiple sources. A measure of regional aphid abundance was taken from the Rothamsted Insect Survey's aphid bulletin[3] . ACroBAT requires daily data on regional aphid abundance, whereas the survey data provides total aphids caught over a seven-day period. For input into the model, the most recent weekly data (x) was converted to daily data (x/7) as an estimate of daily aphids. Data on the proportion of aphids carrying BYDV was generated from work by Dr Martin Williamson (Rothamsted Research) where samples from four sites in the Insect Survey's suction trap network (Brooms Barn, Suffolk; Hereford, Herefordshire; Starcross, Devon; York, North Yorkshire) were screened for the BYDV and Cereal Yellow Dwarf (CYD) virus[4]. The proportion of aphids carrying BYDV is calculated from the results of aphids sampled from the Brooms Barn suction trap at the time of crop emergence. The weather data was extracted from the IPM Decisions Weather Service to run both the T-Sum and ACroBAT models.

[3] https://insectsurvey.com/
[4] https://ahdb.org.uk/knowledge-library/the-uk-aphid-monitoring-network

Table 2. Parameters used when running the ACroBAT model

| Model parameter | Attributed value |
|---|---|
| Seed rate DH | 140kg/ha, 280 seeds/$m^2$ |
| Seed rate CB | 154kg/ha, 310 seeds/$m^2$ |
| Drilling date - Dead Horse (Dawsum) | 27/10/2023 |
| Drilling date - Chapel Bell (Grouse) | 28/10/2023 |
| Mean winter temp | 6.3°C |
| Aphid infectivity | 18.75% |
| Treatment costs | £4.5 |
| Yield | 9.5ton/ha |
| Grain value | £195/tonne |

### 3.5 Results

Both fields were drilled in the last week of October (Table 2) and emerged on the 17th of November. Rainfall throughout October and shortly after crop emergence (Figure 1) led to high soil moisture levels in both fields and limited access for farm machinery. The risk of spread of BYDV was monitored using the T-Sum and ACroBAT DSS and field observations were undertaken of aphid and natural enemy abundance. Local aphid populations were assessed via the Rothamsted Insect Survey suction trap network (LINK) from the Brooms barn trap which is the nearest trap to the Morley Agricultural Foundation (Figure 2). Insecticide application decisions were agreed with the host farmer based on variety, DSS outputs, field and regional observations, as well as consideration of the soil conditions.

The number of aphids observed regionally was relatively low compared with previous yearly averages. Aphid counts in the fields at times predicted by the T-Sum model were very low with only a single bird cherry-oat aphid recorded in each field (Table 3 and Table 4). The ACroBAT model also forecasted a low risk of BYDV throughout the period from crop emergence until late November. As both models reported low risk of BYDV, and travelling on the wet soil risked damage to the crop, no insecticides were applied to any of the treatments in either field.

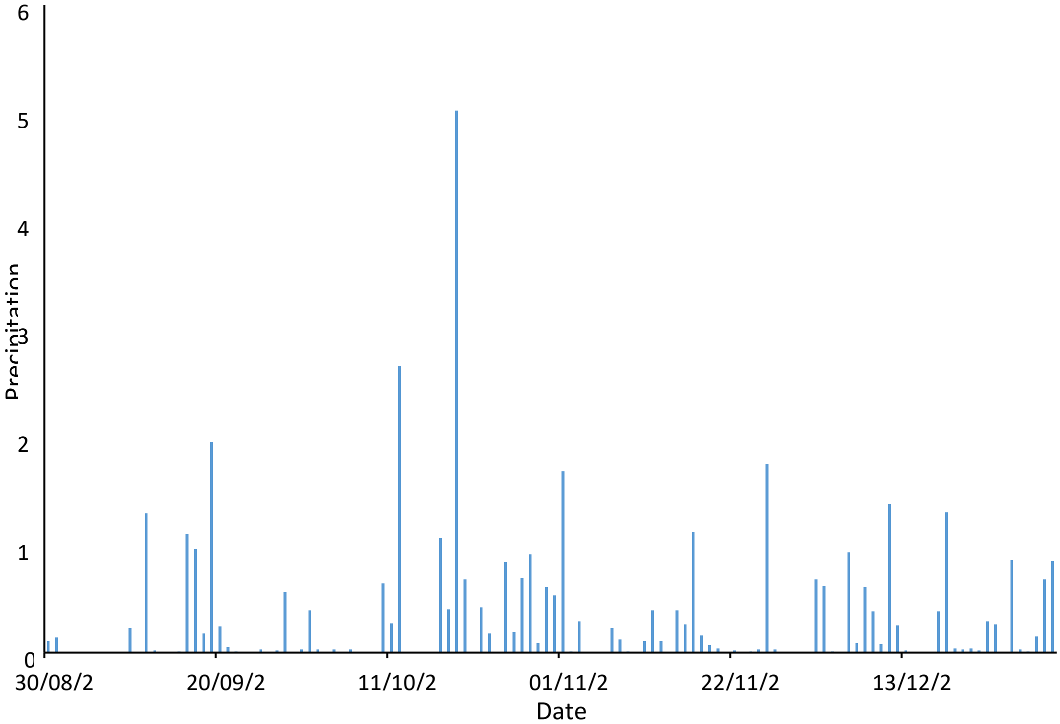



Figure 1. Rainfall at the Morley Agricultural Foundation. Extracted from Open Metio on the IPM Decisions Weather Service

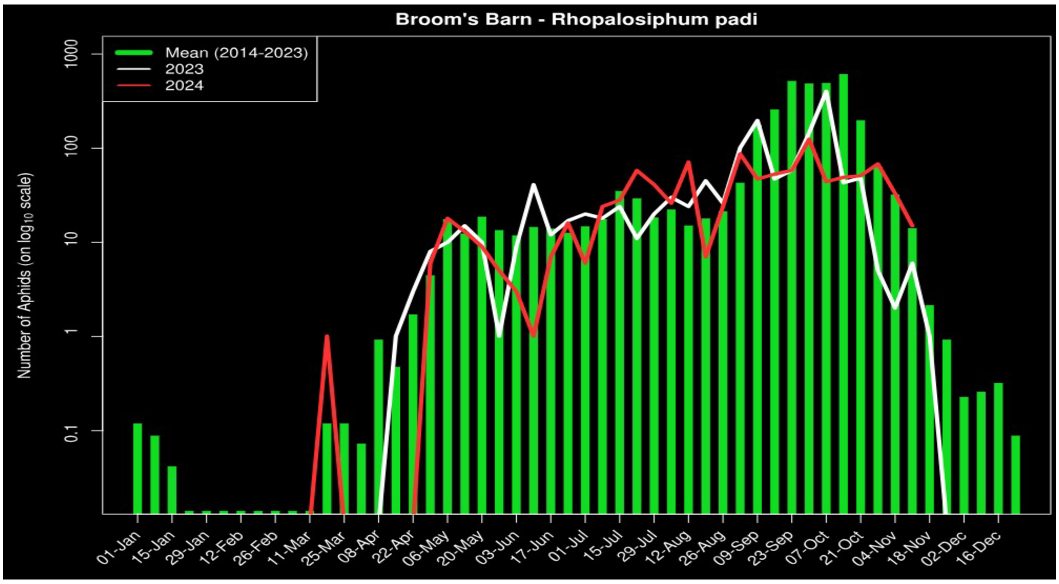



Figure 2. Aphid numbers from the Broom's Barn suction trap. Extracted from the Rothamsted insect survey website (https://insectsurvey.com/) 26th of November 2024

**In field aphid and natural enemy monitoring**

Low numbers of aphids were caught in yellow water traps in both fields (Table 3 and Table 4). The same was seen for the rest of the yellow water trap catches with low numbers across all traps (Figure 3 and Figure 4).

Table 3. Aphid numbers observed in yellow water traps in Dead Horse (DH) Field

| Date | Bird cherry-oat aphid | Grain aphid |
|---|---|---|
| 03/11/2023 | 0 | 0 |
| 06/11/2023 | 0 | 0 |
| 09/11/2023 | 0 | 0 |
| 16/11/2023 | 1 | 0 |
| 17/11/2023 | 0 | 0 |
| 20/11/2023 | 0 | 0 |
| 24/11/2023 | 0 | 0 |
| 27/11/2023 | 0 | 0 |
| 01/12/2023 | 0 | 0 |
| 04/12/2023 | 0 | 0 |
| 08/12/2023 | 0 | 0 |
| 11/12/2023 | 0 | 0 |
| 16/02/2024 | 0 | 0 |
| **Grand total** | **1** | **0** |

Table 4. Aphid numbers seen in yellow water traps in Chappel Bell (CB) Field

| Date | Bird cherry-oat aphid | Grain aphid |
|---|---|---|
| 03/11/2023 | **1** | **0** |
| 06/11/2023 | **0** | **0** |
| 09/11/2023 | **0** | **0** |
| 16/11/2023 | **0** | **0** |
| 17/11/2023 | **0** | **0** |
| 20/11/2023 | **0** | **0** |
| 24/11/2023 | **0** | **0** |
| 27/11/2023 | **0** | **0** |
| 01/12/2023 | **0** | **0** |
| 04/12/2023 | **0** | **0** |
| 08/12/2023 | **0** | **0** |
| 11/12/2023 | **0** | **0** |
| 16/02/2024 | **0** | **0** |
| **Grand Total** | **1** | **0** |

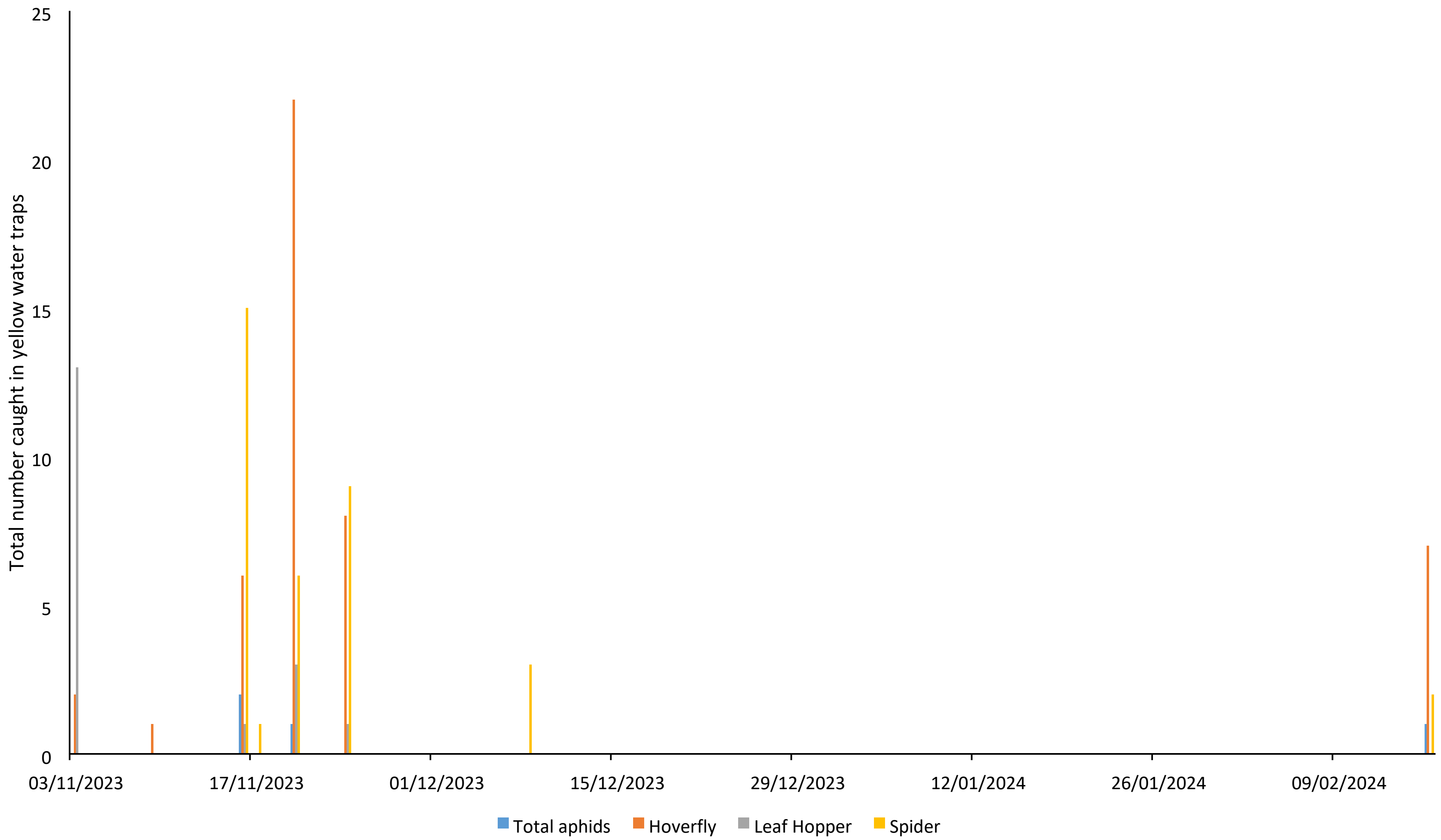



Figure 3. Total number of invertebrates caught in all yellow water traps during November, December and January. Data from Dead Horse (DH) field drilled with Dawsum. Data was pooled as no insecticide treatment was applied

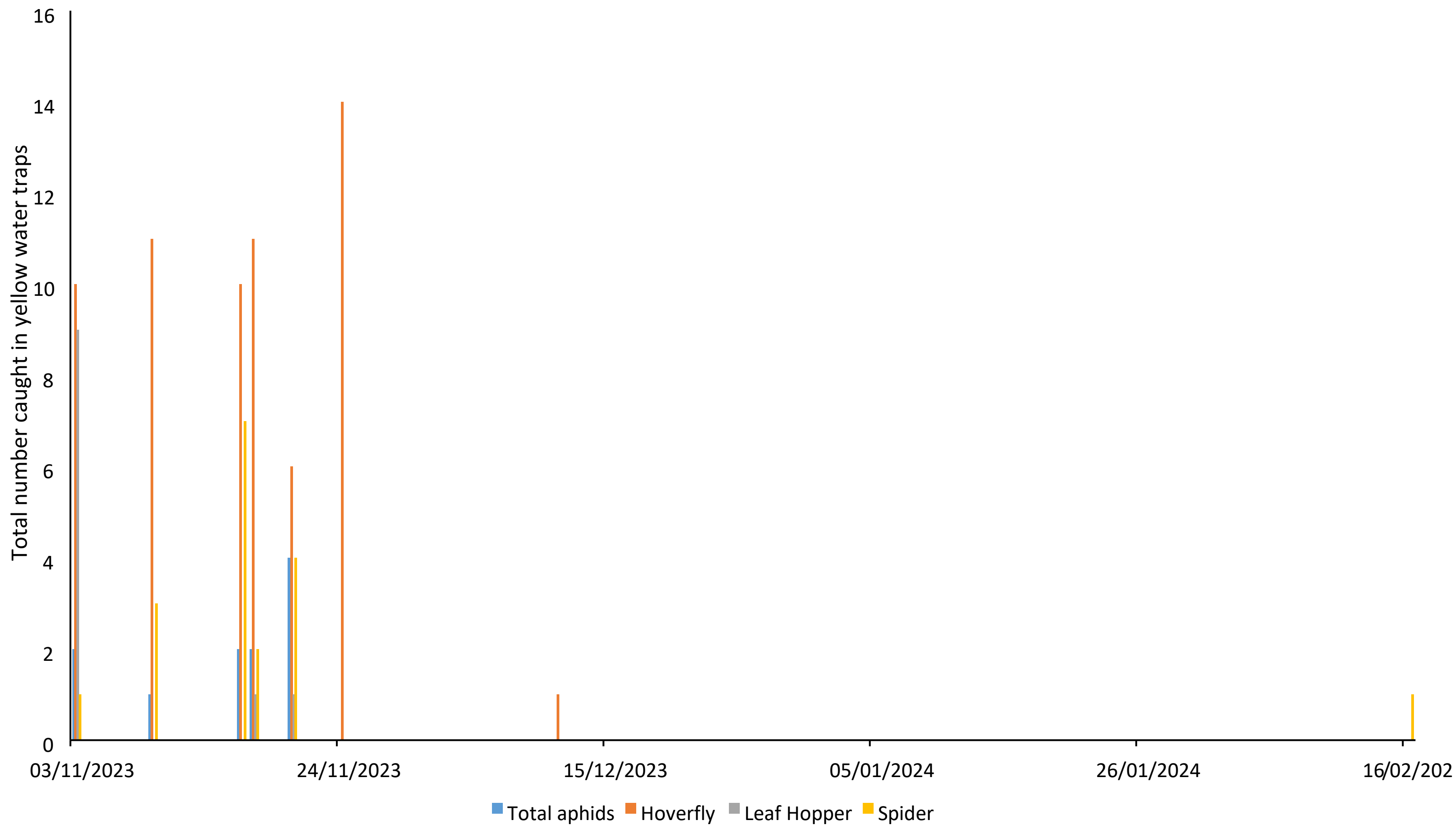



Figure 4. Total number of invertebrates caught in all yellow water traps during November, December and January. Data from Chapel Bell (CB) drilled with Grouse. Data was pooled as no insecticide treatment was applied

**In field BYDV assessment**

Water traps were installed in each treatment and acted as the centre point for tissue sampling. Fifteen leaves were collected within a 2m radius around each water trap on the 20th of December 2023 and the 9th of April 2023. Due to adverse conditions, and poor establishment of the crop, tissue samples were not collected from CB during the first tissue sampling as it was believed the crop would fail and sampling would not be an efficient use of resources. Plants were selected at random, to be a representative sample of the area and tested for BYDV by NIAB using ELYSA protocols. A low number of samples returned positive results for BYDV presence in December in DH and no samples returned positive results in April in either DH or CB (Table 5). Visual assessment of the proportion of plants exhibiting BYDV symptoms was made on the 16th of April 2023 (Figure 5). Poor establishment of the crops and waterlogging in some areas made BYDV assessment challenging (Figure 6), as many plants were showing symptoms of stress similar to those of BYDV at GS30 (Figure 5). The discrepancy between tissue samples and visual assessments could also be influenced by the possibility of other similar viruses present in the region. The Wheat Dwarf Virus (WDF), for example, is known to be present in the UK and can be transmitted by leaf hoppers (*Psammotettix sp*)[3]. Although not identified to species several leaf hoppers were caught in the yellow water traps (Figure 3 and Figure 4). Any varietal resistance or tolerance to BYDV would not necessarily provide resistance or tolerance to other cereal viruses.

Table 5. BYDV tissue sample results showing test results from tissue samples collected from Dead Horse (DH) field (NEG = Negative, POS = Positive)

| Sampling point | 20 December 2023 | 9 April 2024 |
|---|---|---|
| 1A | NEG | NEG |
| 1B | NEG | NEG |
| 2A | NEG | NEG |
| 2B | NEG | NEG |
| 3A | POS | NEG |
| 3B | NEG | NEG |
| 4A | POS | NEG |
| 4B | POS | NEG |
| 5A | NEG | NEG |
| 5B | NEG | NEG |
| 6A | NEG | NEG |
| 6B | NEG | NEG |

[3]https://planthealthportal.defra.gov.uk/pests-and-diseases/uk-plant-healthriskregister/downloadExternalPra.cfm?id=4098

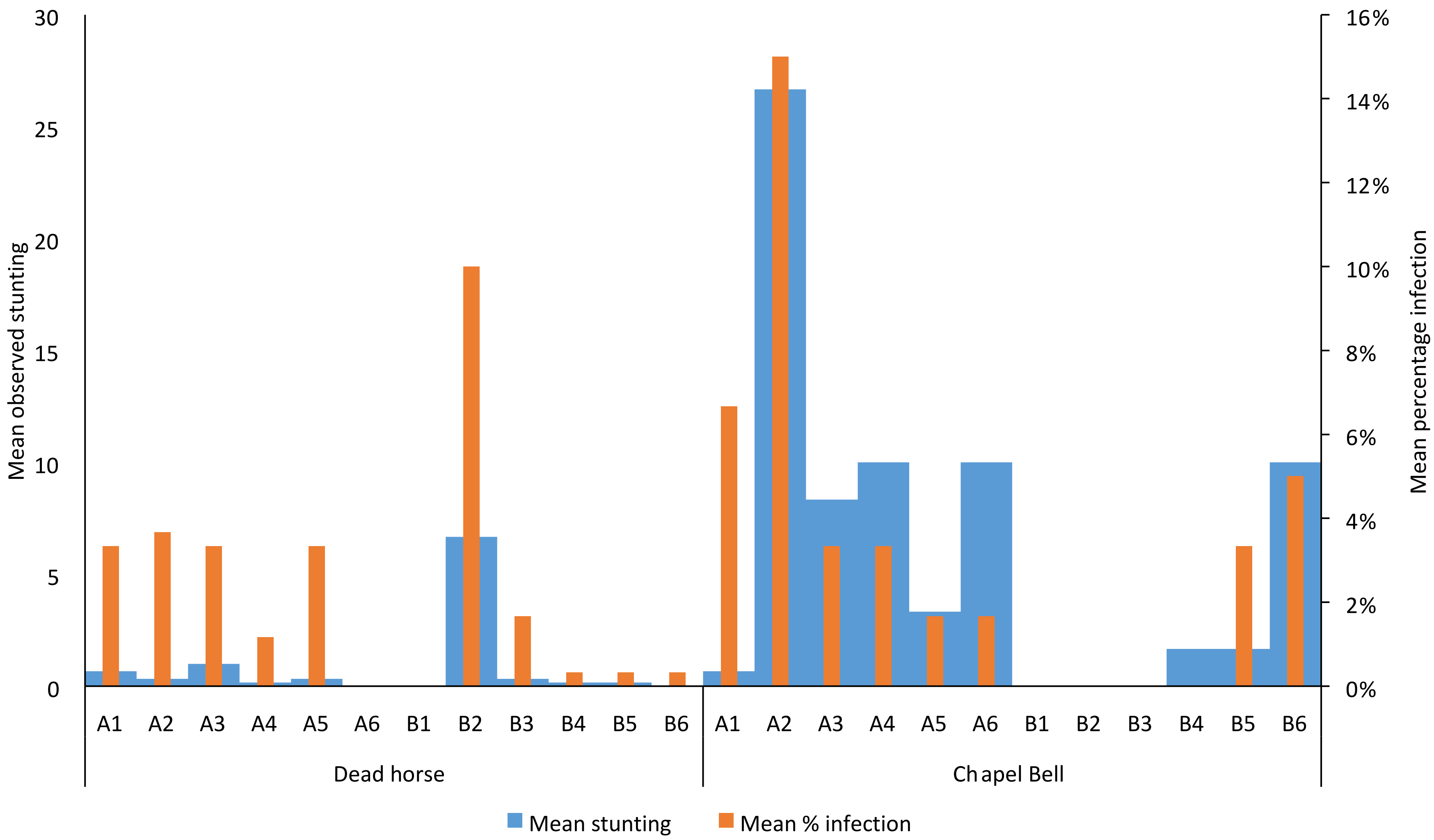



Figure 5. BYDV assessments on 16 April 2023 in both Dead Horse and Chapel Bell showing levels of observed stunting (blue) and the percentage area exhibiting infection (orange)

Figure 6. Poor establishment (NIAB, December 2023)

**2023/2024 season Decision support tools**

***T-Sum***

The T-Sum model was run in IPM Decisions and based on the crop emerging in both fields on 17 November 2023. The risk reported was low between emergence and 6 December 2023, which was the last date of in-field aphid observations (Figure 7). The T-Sum model was reset at this date and reported no risk of winged aphids until the end of January 2024. At this time, the decision was made with the host farmer that no insecticide applications would be made, and use of the model was stopped. Overall, the T-Sum model, supplemented with in field observations, supported no insecticide applications during the 2023-24 season at this location.

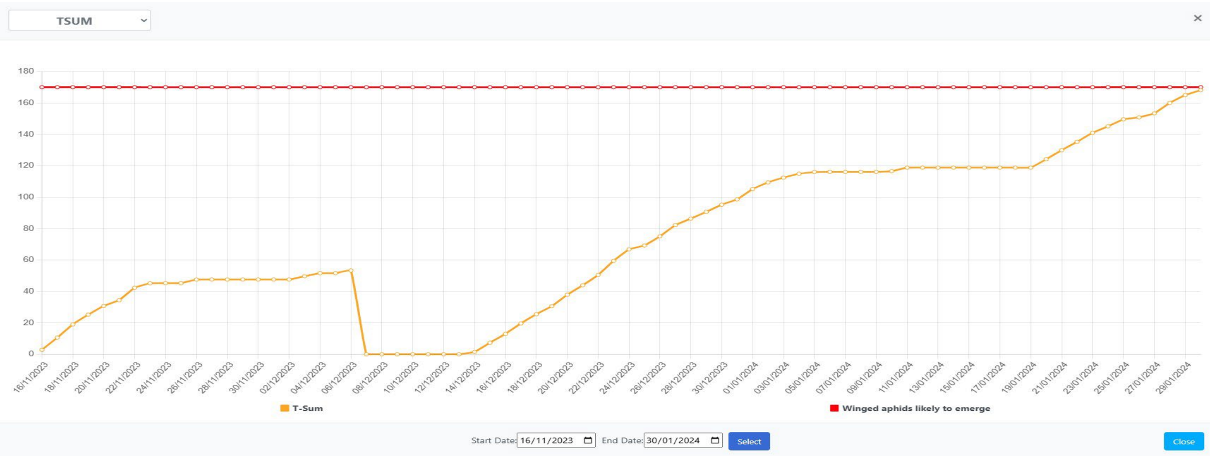



Figure 7. Timeline output generated from T-Sum giving the 170 threshold (red) and the model output for aphid flight (orange)

**ACroBAT**

The ACroBAT decision support tool incorporates detail on the agronomy of the farm/ field, aphid numbers and proportion of aphids carrying BYDV. All aphid data is collated from the Rothamsted Insect Survey. With the proportion of aphids carrying BYDV from additional work carried out by Dr Martin Williamson (Rothamsted Research). The proportion of aphids carrying the virus is then taken from further information provided by Dr Williamson from the Brom's Barn suction trap. The fields in the 2023/2024 season were drilled on the 27th and 28th of October and used data on virus infection from the aphids caught in the Broom's Barn suction trap between the 23rd and the 29th of October 2023 (Aphid bulletin No. 30). A total of 16 aphids were tested of which three were positive for BYDV and none were positive for CYDV (no other viruses were screened for). This produced a starting percentage infection of ~19% of aphids carrying BYDV.

Running the ACroBAT model for the full season, beginning at the end of August did not generate a risk level above "very low", and supported no insecticide applications during the 2023-24 season at this location (Figure 8 and Figure 9). The ACroBAT model also predicts the crop emergence based on the weather conditions and did accurately predict the timing for both fields (13th November 2023).

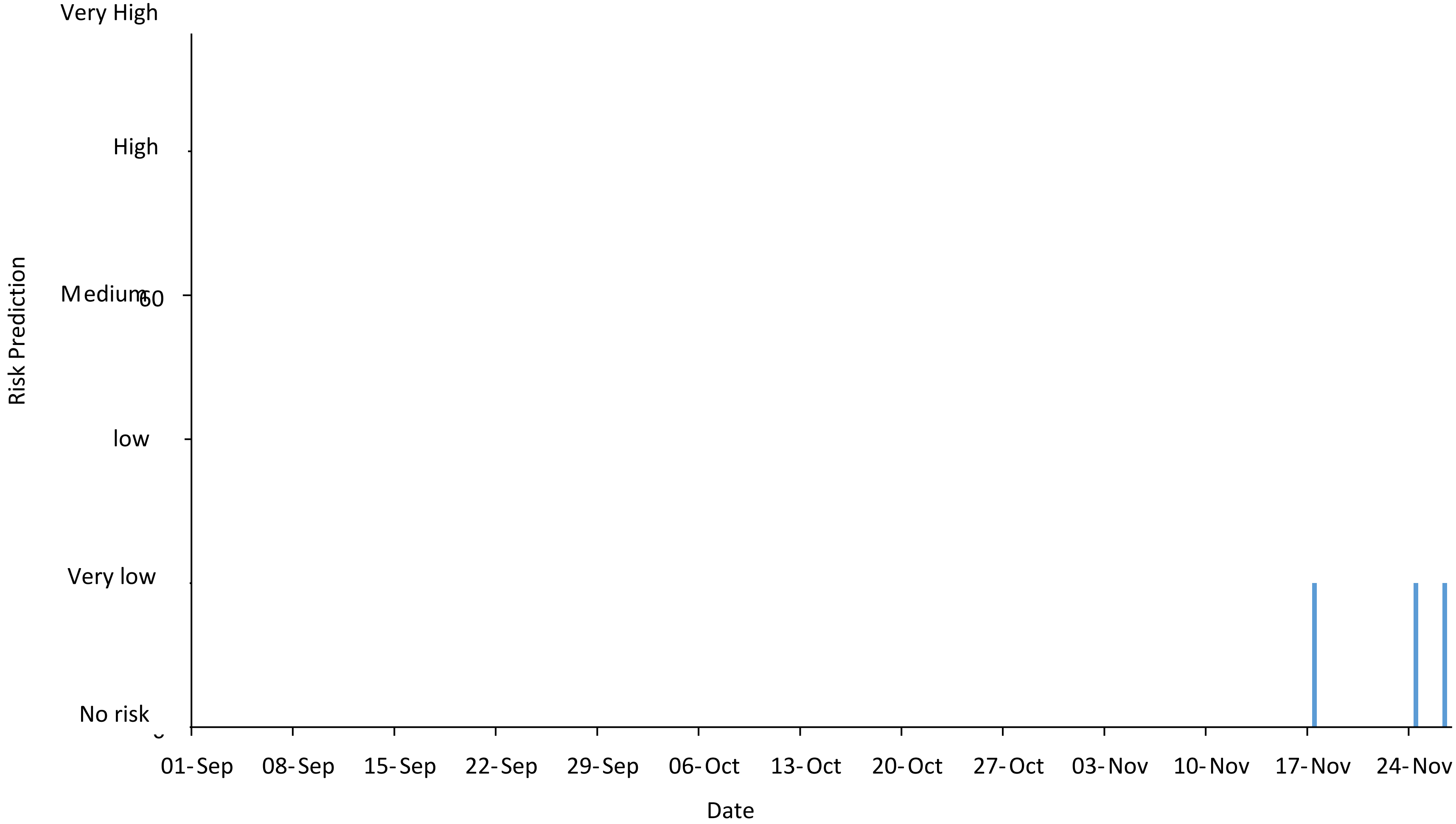



Figure 8. Dead Horse BYDV risk level as predicted from the ACroBAT model. Set on a categorical scale (i.e. No risk to very high risk)

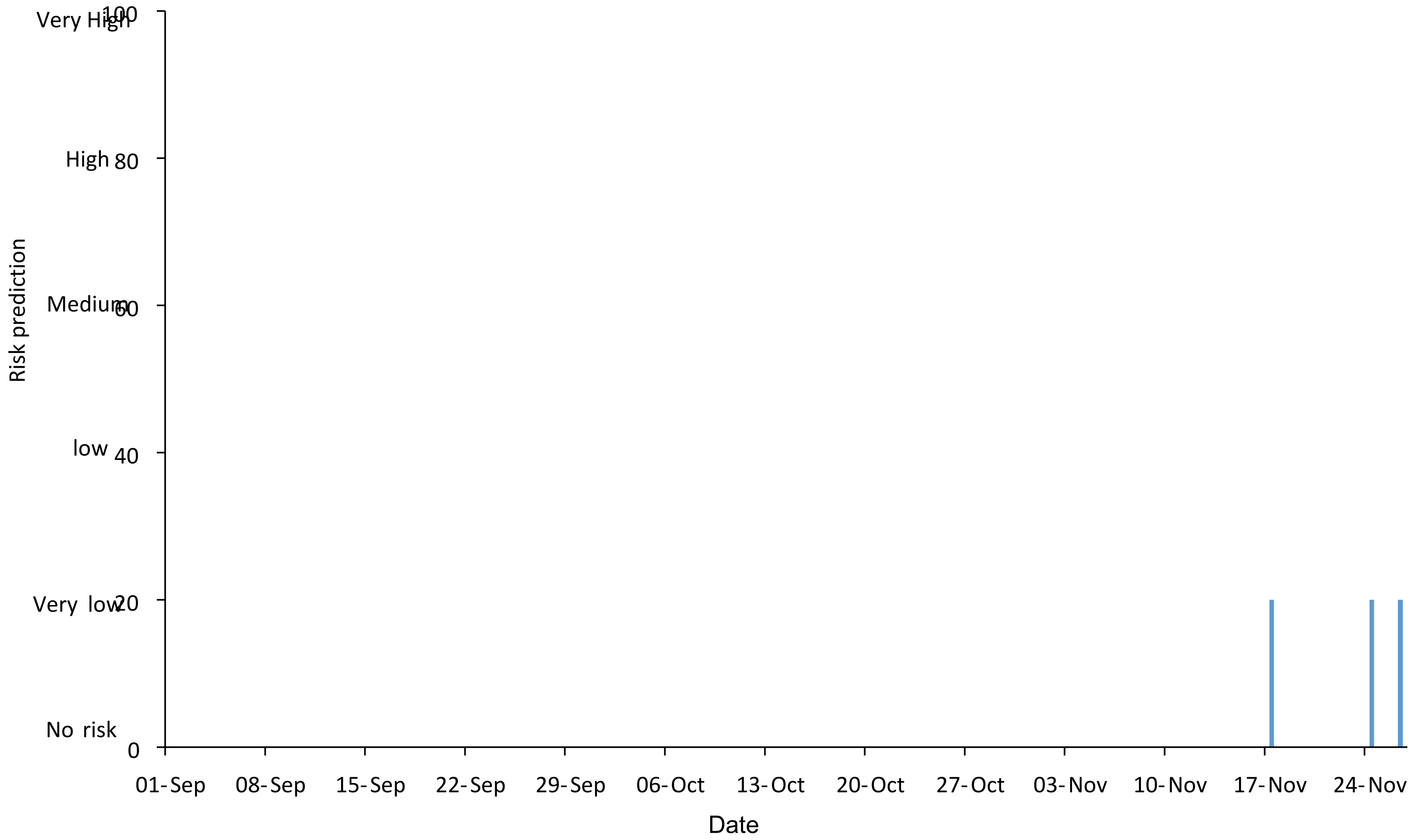



Figure 9. Chapel Bell risk level as predicted from the ACroBAT model. Set on a categorical scale (i.e. No risk to Very high risk)

**Yield data analysis**

Yield data for both fields were extracted by ADAS and cleaned to remove data points with anomalously low or high yield (Figure 10 and Figure 12). Additional cleaning removed the yield data from the headlands, as it can be unreliable due to changes in combine speed and direction (Figure 11 and Figure 13). Due to the lack of treatment applications the two fields were considered single treatments and the variation in yield from the two varieties was examined. However, as the physical characteristics of the field can have a large effect on yield, it is not appropriate to directly compare crop performance of different treatments between fields.

Chappel Bell:

The average yield in Chappel Bell (cv, Grouse) was estimated to be 6.39t/ha. In this field there was a history of groundwork resulting from the instalment of a pipeline running through the middle of the field, which affected the uniformity of the field. Patchy establishment, partly due to the pipe line and partly due to inclement weather, lead to yield in Chappel Bell being highly variable.

Dead horse:

The average yield in Dead horse (cv. Dawsum) was estimated to be 7.94t/ha. Crop establishment was also affected in this crop by the weather, though to a lesser extent than in Chappel Bell. While the variety Grouse is expected to have a lower yield potential compared with Dawsum in the absence of high BYDV pressure, the difference in yield between these two fields is due to a combination of factors in addition to variety.

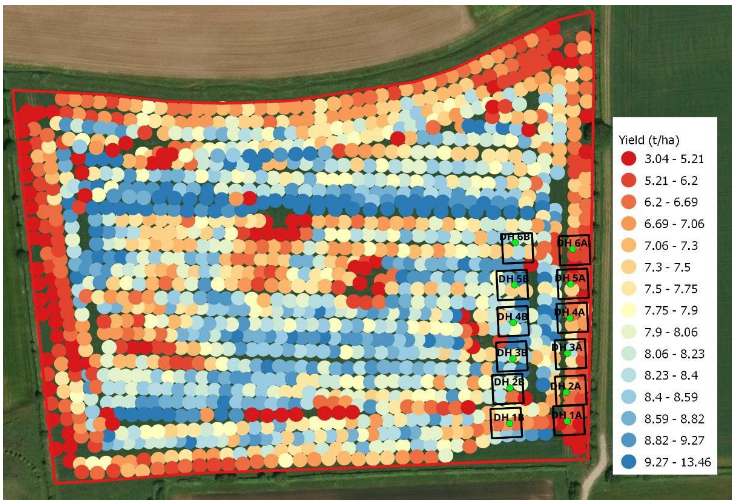



Figure 10. Lightly cleaned combine yield data mapped onto Dead Horse (cv. Dawsum). The black boxed areas indicate the locations of the tissue sampling and yellow water trap assessments during the season

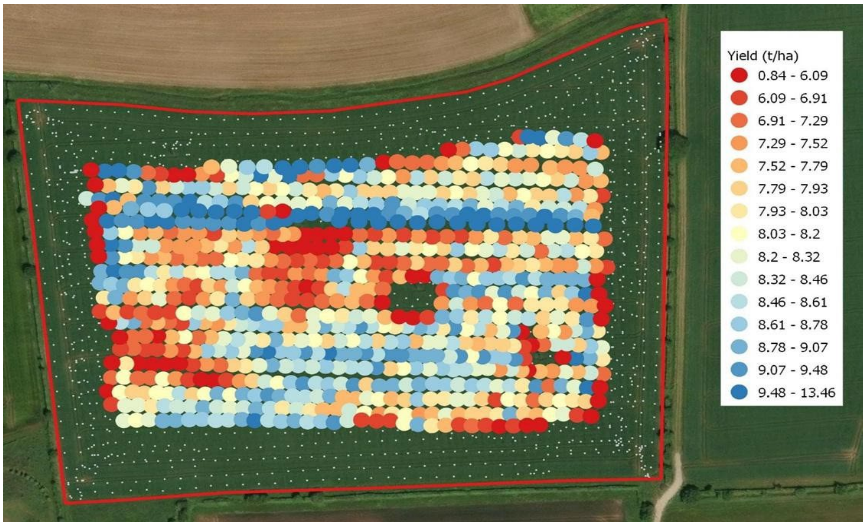



Figure 11. Cleaned yield map for Dead horse field (cv. Dawsum)

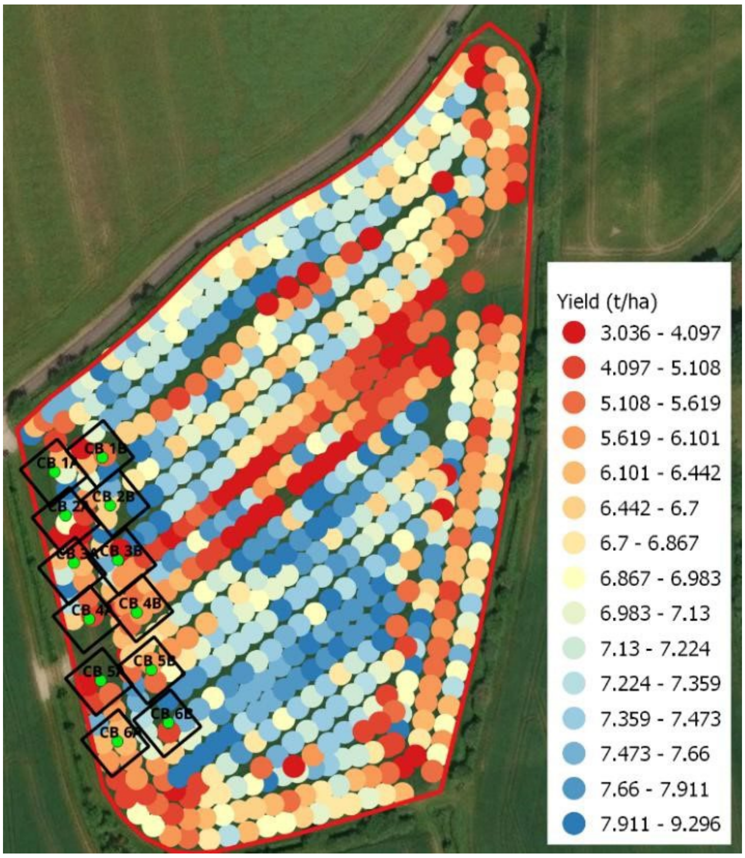



Figure 12. Lightly cleaned combine yield data mapped onto Chapel Bell (cv. Grouse). The black boxed areas indicate the locations of the tissue sampling and yellow water trap assessments during the season

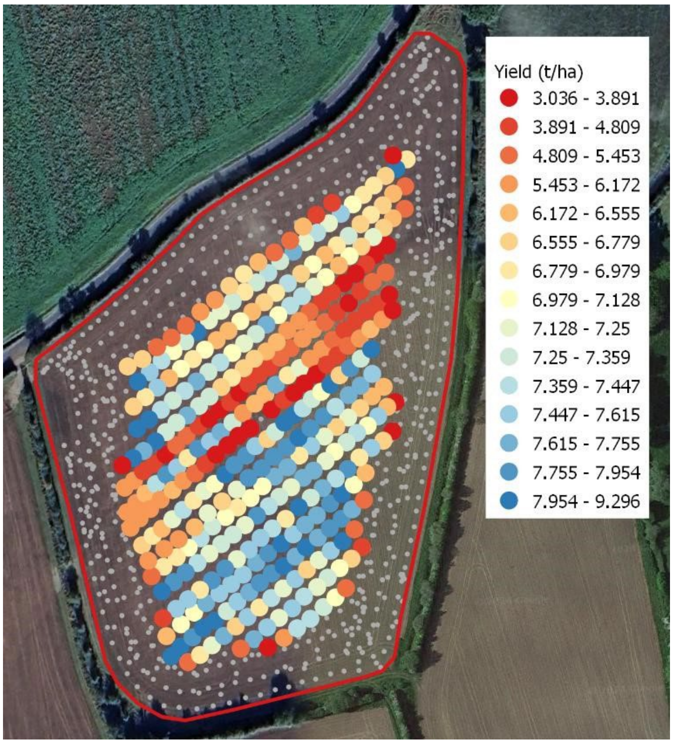
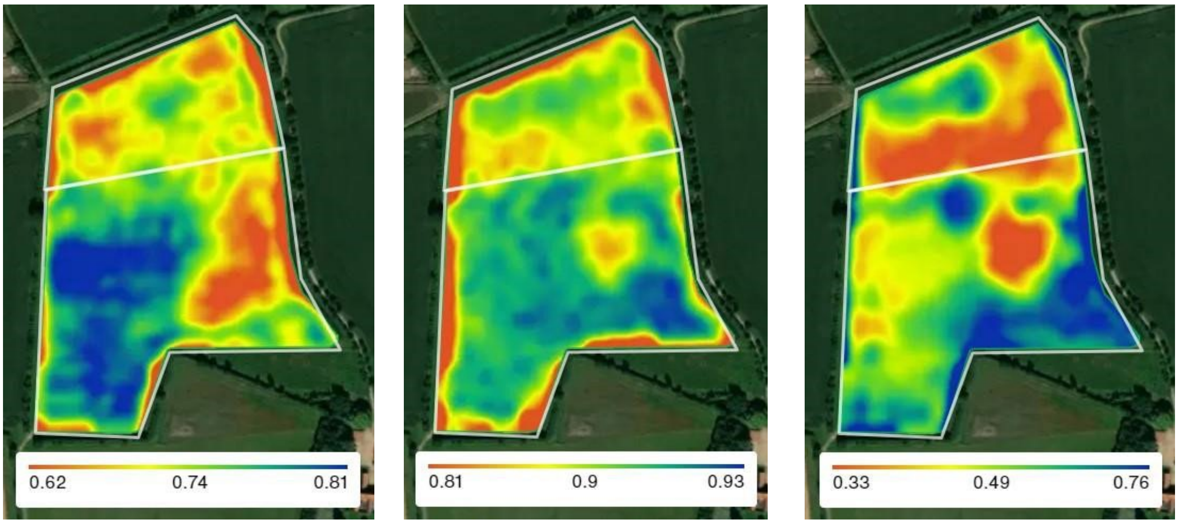


Figure 13. Cleaned yield map for Chapel Bell (cv. Grouse). The impact of the previous works to install a pipeline across the field on yield is visible

**Variety effect (additional field at the Morley Agricultural Foundation)**

Supplementary to the field trials described above, an additional field (Cranstone) was split and drilled by the Morley Foundation with both varieties (Figure 15). While there were no assessments in this field, analysis of the yield data was possible, enabling comparison between the two varieties. As this field was located within 500m of both Chappel Bell and Dead Horse, it is assumed that the risk of BYDV was comparable, and so the yield data provides an estimate of varietal performance in a low BYDV pressure season (Figure 15).

Unfortunately, the variety split was confounded with underlying variation, as shown by NDVI imagery from the previous season (Figure 14). Consequently, it is not possible to be certain whether any yield difference is connected to the difference in varieties or to underlying soil differences.




07/02/2023 10/06/2023 07/07/2023

Figure 14. DataFarming NDVI imagery of Cranstone field from harvest year 2023, before the variety split was imposed, with white lines showing where the variety split was later located

Yield data from this field was analysed using the Agronomics software. The analysis showed a modelled yield difference of 0.07 t/ha between the varieties, with Grouse yielding lower, after discounting the effects of underlying variation. The difference in means was larger, at 0.31 t/ha, but this is probably a soil effect.

This difference in yield is expected, reflecting the lower yield potential of Grouse in low BYDV pressure years. The difference in yield is consistent with yield potential details in variety descriptions. During high BYDV pressure seasons, the performance of Grouse would be expected to be unaffected, while in the absence of any further interventions the Extase/Dawsum area may have yielded lower.


Figure 15. Yield map for Cranstone. The field was split by variety (denoted by the back line running east to west) with the north drilled with Grouse and the south drilled with Extase/ Dawsum. The map shown here is the yield data after it has been cleaned for use in ADAS agronomics analysis

**Key take home messages for 2023/2024 season**

Overall, in the autumn/winter of 2023 the aphid populations were low at the trial sites, and rainfall and soil moisture were high. Both BYDV DSS and observations suggested a low risk of BYDV. Given the low risk of BYDV, and soil conditions making the risk of damage to soil and crop high, no insecticide applications were made to any treatments in either variety.

Use of the DSS supported the decision not to apply any insecticides during the vulnerable period for spread of BYDV. Given the poor soil conditions, this gave the farmer greater confidence to prioritise soil health over BYDV management. The results of tissue analysis and yield demonstrate that this approach was justified.

The yield variation within and between fields observed during the 2023/24 season was most likely due to poor establishment and the variation between fields. Given the low aphid pressure and low risk from BYDV in this season, the advantage of selecting a “resistant” variety may be less evident. The potential benefits of selecting varieties which are resistant/tolerant of BYDV are likely to be greatest in years of high pressure. This yield penalty may be offset in fields under SFI action IPM4; no use of insecticide on arable crops and permanent crops which carries a value of £45 per hectare per year.

## 3.6 Action points for farmers and agronomists

- Use of BYDV DSS improve management decisions.
- BYDV DSS provide guidance on when to scout crops for aphid activity. Treatment is only justified where the risk of spread of BYDV in the crop is high.

  Where compatible with your IPM Plan, “resistant” varieties may offer additional protection against high levels of BYDV, particularly for early drilled crops.

**Next steps**

A similar study will be done in the 2024/25 cropping season, comparing use of the TSum and ACroBAT models, with the aim of eliminating insecticide applications. Assessments will look at across the whole field in order to account for in-field variations as much as practically possible and aid in understanding the direct impact of BYDV patches on yield.

**Links to further information/references**

- https://ahdb.org.uk/knowledge-library/barley-yellow-dwarf-virus-bydvhttps://ahdb.org.uk/knowledge-library/barley-yellow-dwarf-virus-bydv-management-in-cerealsmanagement-in-cereals
- https://ahdb.org.uk/news/what-is-the-value-of-bydv-resistancehttps://ahdb.org.uk/news/what-is-the-value-of-bydv-resistance-tolerance-in-cerealstolerance-in-cereals https://ahdb.org.uk/pests
- https://www.agrii.co.uk/your-crops/cereals/winter-wheat/rgt-grousehttps://www.agrii.co.uk/your-crops/cereals/winter-wheat/rgt-grouse-bydv/bydv/ https://ragt.uk/bydv-resistant-wheat-putting-trust-in-new-technology/
- https://www.kws.com/gb/en/products/wheat/variety-overview/kwshttps://www.kws.com/gb/en/products/wheat/variety-overview/kws-dawsum/dawsum/
- https://tmaf.co.uk/ https://insectsurvey.com/

  https://www.platform.ipmdecisions.net/
- https://www.gov.uk/government/collections/sustainable-farmingincentive-guidance
- https://planthealthportal.defra.gov.uk/pests-and-diseases/uk-planthealth-risk-register/downloadExternalPra.cfm?id=4098 https://ipmworks.net/

# 4 Nitrogen Use Efficiency (work package 3)

Trial leader: David Clarke, NIAB

Start date: October 2023

End date: October 2024

## 4.1 Headlines

1. The use of a foliar-applied polymer urea product aimed to replace 40 kg N/ha of soil-applied N at the final N timing recorded no improvement in yield or grain N over untreated (no final N dose) in 2024.
2. A small (0.5 t/ha) yield increase from soil applied N (38 kg N ha) was recorded over untreated but with poor grain N uptake efficiency (29%), despite above average soil moisture after application.
3. The use of satellite-based N uptake maps should be used when situating on-farm N trials.

## 4.2 What was the challenge/demand for the work?

Farms are looking to optimise nitrogen (N) use efficiency to balance crop yield and grain quality with environmental and economic sustainability. Nitrogen fertilizers contribute significantly to agricultural carbon emissions, while low nitrogen use efficiency can lead to losses to the environment, making it critical to explore strategies that minimise N input without compromising productivity.

Since 2022, Morley, like other farms nationally, has been experimenting with foliar-applied polymer urea products, driven by rising fertilizer prices and increasing environmental concerns. These products are marketed as high-efficiency solutions capable of reducing soil-applied N inputs, potentially lowering emissions associated with conventional fertilizer use. However, monitoring on farm at Morley through the Morley SAMS project has shown that grain protein levels have been considerably below the recommended optimal of 11% for feed wheat yields since 2022 suggesting crop N demand may not be being met. This study assessed the effectiveness of a third dose of soil-applied N alongside a foliar-applied polymer urea product (MZ28). Satellite-based N uptake maps were used to enhance trial precision, and the design of replicated on-farm. Such trials should be conducted on farms seeking to test novel N management strategies.

## 4.3 How did the project address this?

The project addressed the challenges by implementing a robust three-replicate split tramline trial to evaluate the efficiency of the polymer urea product. All winter wheat fields on the farm followed a conventional nitrogen application regime of 150 kg N/ha, split into two doses: 55 kg N/ha in mid-March and 95 kg N/ha in mid-April. To identify a suitable trial location for the third application in early May, the Yara at-farm nitrogen uptake map derived from Sentinel-2 satellite imagery was used (Figure 1). This map helped identify areas with consistent nitrogen uptake, minimizing the effects of underlying spatial variation. Ravens Grove field was chosen, as the southern end displayed uniform N uptake up to this stage.

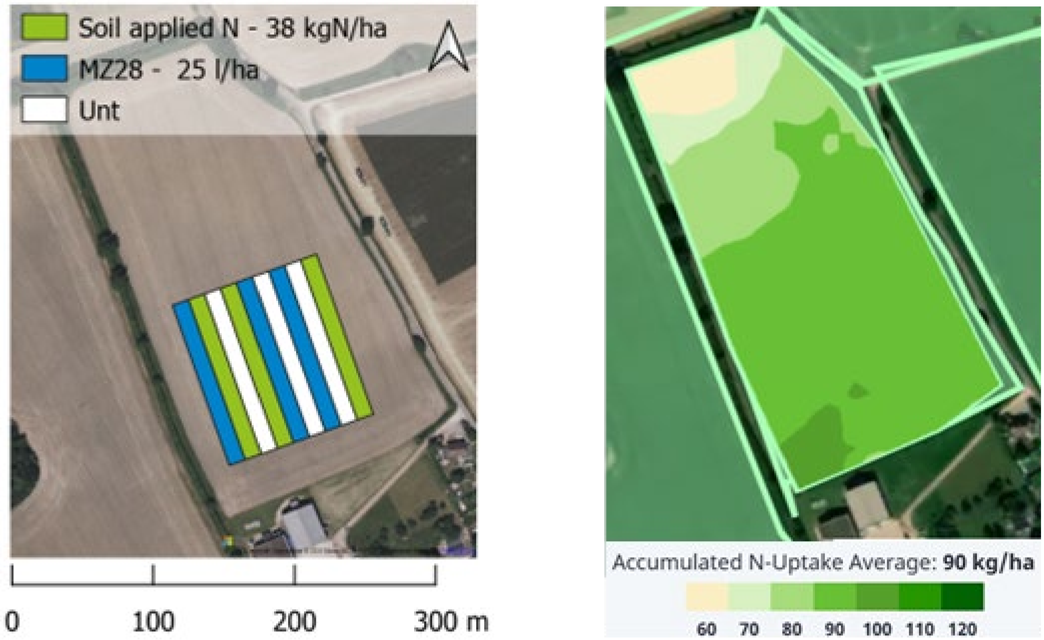



*Figure 1 Left: Treatment plan, right: Yara Atfarm N uptake map (05/05/2024) showing approx. 90 kg N ha uptake across trial area prior to final N application*

To further validate the trial location, a handheld N sensor (YARA N-Tester BT) was used to quantify nitrogen uptake prior to the application. This assessment indicated that, with an expected yield of 10 t/ha, a third dose of 40 kg N/ha would likely elicit a yield response, confirming the site's suitability for additional nitrogen applications.

Within this identified area, a randomized and replicated tramline trial was established. Each plot measured 12 meters wide (half a tramline) by approximately 150 meters long, with three replicates (Figure 1). The treatments included: a control with no further nitrogen dose (untreated), 38 kg N/ha of soil-applied nitrogen (Farm standard prior to 2022), and 25 l/ha of MZ28, advertised as a substitute for 36 kg N/ha of soil-applied nitrogen. This experimental design ensured that the trial could accurately assess the effectiveness of the polymer urea product in comparison to conventional nitrogen applications.

### 4.4 Results (to date)

Soil mineral nitrogen at drilling was 49 kg N/ha (0–90 cm) in the autumn, reducing to 21 kg N/ha in the spring before the first N application. Adequate soil moisture is crucial for crops to effectively utilise soil-applied nitrogen. Data from the CEH COSMOS weather station at Morley (2014–2023) show that soil moisture typically declines to a seasonal minimum about four weeks after the average date of the third nitrogen application (May 5$^{th}$) (Figure 2). This declining soil moisture can lead to lower uptake efficiency. Using the Sirius Crop Model (Rothamsted Research), which is well-validated for Morley (Clarke et al., 2024), the NUE of the final N dose is estimated at 48%, compared to 83% for the second dose across 29 years of simulated data. Typically, only delivering small yield benefits of approximately 0.1 t/ha from the final 40 kg N/ha. These inefficiencies have led to exploration of alternative N sources for the final split.

The treatments were applied on 8$^{th}$of May 2024. The soil moisture data for Morley showed that 2024 was a wetter than average spring and early summer with topsoil moisture remaining well above the 10-year average until the middle of June (Figure 2).

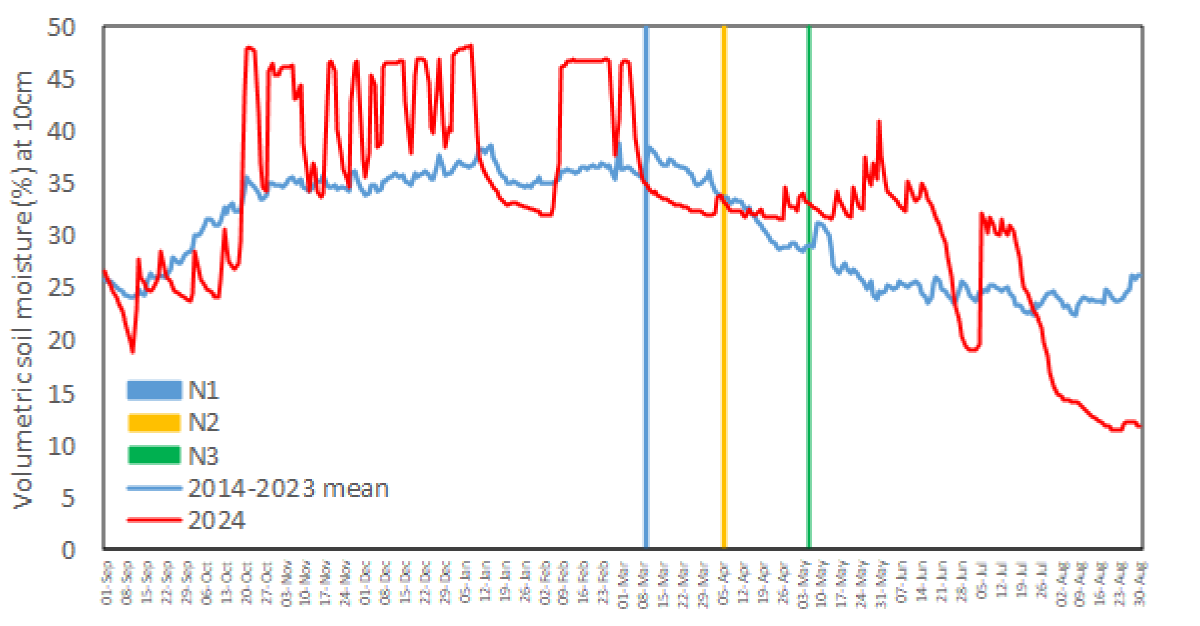



Figure 2. 2014-2023 mean soil moisture by date measured on the CEH COSMOS weather station at Morley (blue line) and the 2024 season soil moisture (red line). The columns represent the mean N split timings at Morley (N1=blue, N2=yellow and N3=green)

There was a notable septoria infection in the crop around this time (Figure 3) likely exasperated by these conditions. For foliar products to be at their most effective is logical that green leaf area must be maximised, and such pressures could limit their efficiency, however it should be recognised this is a limitation of such products.

Yield for each crop was measured using a commercial combine harvester, with the middle 7.3 meters of the 12-meter tramline harvested. The combine grain tank was emptied into a bin and weighed using a trailer weigh cell. Additionally, the mean yield from each treatment cut was extracted from the combine's yield map. Grain samples from each plot were collected and analysed for protein content to assess the impact of the treatments on yield and grain quality. The treatment trends both the weighed yield and yields extracted from the combine yield maps matched, with the Untreated and MZ28 yielding between 0.3 and 0.5 t ha bellow the treatment receiving 38 kg N ha of soil applied N (Table 1). Grain proteins where between 0.6% and 0.5% higher in the 38 kg N ha plots compared to MZ28 and Unt respectively. Using the combine yield map data which had a moisture content reading associate with each plot to allow for conversion to 85% DM, grain N uptake was calculated compared to Unt. Of the 38 kgN, 11 kg N ha was taken up in the grain through increased yields and grain protein content (Grain N = grain protein/5.7). This was calculated at an uptake efficiency of 29%, in line with the simulated results that suggest NUE of the final N split at Morley can be low. However, the increased yields improved margins by £16 ha, however this is excluding cost of application (approximately £6). The MZ28 had a negative margin over Unt due to no discernible yield increase and associated product costs.

Table1. Yield, grain protein, grain N uptake and margin comparisons

| Trt | Weighed yield (t ha) | Combine yield (t ha) | Protein (%) | Grain N uptake over Unt (percent uptake) | Margin over Unt (£/ha) |
|---|---|---|---|---|---|
| Unt | 9.9 | 9.2 | 8.6 | - | - |
| 38 kg N | 10.2 | 9.5 | 9.1 | 11 kg N ha (29%) | £16.00 |
| MZ28 | 9.7 | 9.1 | 8.5 | -3 kg N ha (0%) | £-56.50 |

Figure 3. Left; crop canopy prior to treatment application (8/5/2024), middle; septoria infection at anthesis and right; combine swath down centre of 12m plot

**Next steps**

This experiment will be repeated in 2025 to improve the data set and test the product across different growing seasons.

## 4.5 Action points for farmers and agronomists

- Test new N products in well-designed tramline trials before applying broadacre applications
- For N trials use available spatial data including soil scans (such as soil electrical conductivity), yield maps, and in season satellite derived biomass and N uptake maps to ensure trials are set up in areas with minimal initial spatial variation
- Always test against a control to ensure the current management is more effective than doing nothing
- Repeat for at least 3 seasons to ensure a range of weather and growing conditions. If soil types vary largely consider multiple trials across the farm

## Links to further information/references

Clarke, D.E., Stockdale, E.A., Hannam, J.A., Marchant, B.P. and Hallett, S.H., 2024. Spatial-temporal variability in nitrogen use efficiency: Insights from a long-term experiment and crop simulation modeling to support site specific nitrogen management. *European Journal of Agronomy*, *158*, p.127224. https://doi.org/10.1016/j.eja.2024.127224