May 2025

Interim Report

Reducing the impact of cabbage stem flea beetle (CSFB) on oilseed rape in the UK

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This interim report summarises key results from project 21120185 (2020–2024). It was published to support AHDB's invitation to tender for new research to develop a comprehensive management programme for cabbage stem flea beetle in oilseed rape (submission deadline 11 June 2025). AHDB will publish the final project report for 21120185 later in 2025.

1. Summary

This project investigated research gaps on cabbage stem flea beetle (CSFB) biology and non-chemical control in winter oilseed rape (OSR). It aimed to determine the factors that influence the developmental stages of CSFB and how larvae and adults differ in their impact on OSR (work package 1). It also built on previous findings from another AHDB project to determine the effectiveness of integrated pest management (IPM) approaches to controlling CSFB in the field (work package 2).

2. Understanding CSFB biology and its interaction with IPM (WP 1)

Significant research gaps have been identified in our understanding of CSFB biology that can limit the effectiveness of control of the pest on farms. Work package 1 (W1) aimed to improve this understanding by:

- Investigating the factors governing the migration of adult CSFB
- Determining the effect of temperature and other factors on egg laying, egg development, and egg hatch
- Determining larval impacts on crop development
- Investigating preferences of adult CSFB got crop growth stages
- Determining the relationship between numbers of adult CSFB and their feeding damage
- Determining the relationship between larval scars and larval number

2.1. Investigating factors governing the migration of adult CSFB

This work investigated meteorological and agronomic factors which may influence migration patterns of CSFB. Understanding how and when CSFB migration happens is key in helping to develop early warning systems for the pest, which can be used by farmers to mitigate risk by enabling them to select a suitable sow date which could reduce crop losses.

CSFB migration was monitored, using either yellow water pan traps or yellow sticky traps, from early August until the end of October for 3 years (2020–2022) at 9–17 sites across England each year. Sites were chosen to be representative of varying environmental conditions, history of CSFB pressure and OSR production. Traps at ground level and at 1m elevation were used to assess CSFB already present within the field and migration of adult CSFB into the crop. Assessments were made weekly and daily (at most sites) at peak migration times. Based on observations in year 1, the commencement of monitoring in years 2 and 3 was moved earlier. Assessments of crop growth stage and the level of leaf loss were also made at each assessment timing.

Key results:

- Temperature and day of the year are key factors that can affect CSFB migration and flight activity
- However, there was no correlation between the number of beetles caught and OSR drill date
- This finding supports the idea that CSFB aestivation is not a reaction to environmental factors but may be a genetic trigger linked to the day of the year
- CSFB activity began 9 to 10 days after drilling, though wide variation was observed across sites and years (some sites showed CSFB activity before the crop had been drilled)
- Monitoring data shows that CSFB typically migrate within the same window (end of August to early September), with peak migration occurring within the first week of September (some slight differences were observed across sites and over years)

2.2. Determining how temperature and other factors affect egg laying, development and hatch

CSFB adults and larvae are often treated as two separate pests due to how they impact the OSR crop, but the relationship between adults that first enter the crop, and any subsequent larvae is unclear. Work was undertaken to determine the effects of temperature and other environmental factors on egg laying and development.

CSFB adults were collected from on-farm storage facilities in late July to early August over a 4-year duration (2020–2023). Adult CSFB were subsequently reared in mesh cages in a controlled environment. After approximately 1 month, males and females were separated, prior to use in experiments.

Egg laying and egg counts were monitored and recorded in egg-laying arenas. Arenas, with a single male and single female, were kept in controlled environment rooms with a light/dark cycle and 4 different temperatures (with cooler temperatures during the dark cycle). Eggs were transferred to an egg-hatching arena, 10 eggs per arena, and placed back in the same environmentally controlled chamber they were laid in. Egg hatching was recorded until all eggs had hatched or died. Factors investigated in the egg hatching arenas included effect of moisture on egg hatch, effect of temperature change on egg hatch, effect of plant root exudates and the effect of refrigeration and substrate on egg hatch.

Key results:

- Temperature impacts the length of time it takes a female beetle to lay eggs (Table 1) and can impact the development of the eggs, once laid
- On average egg laying began approximately 30 days earlier when kept at 15°C compared to 10°C
- Temperature impacted the number of eggs laid by females. Females kept at 5°C laid 81.1% fewer eggs compared to those kept at 15°C (Table 2)

- The total number of eggs laid at each temperature varied widely, with the mean number of eggs laid by each female ranging between 11 and 50
- Temperature impacted the rate of egg hatch and the time taken to hatch (Table 3)
- The rate of egg hatch varied between treatments when temperatures were cycled after set periods of time. The highest hatch rates were at the 15°C treatments (Table 4)
- In addition to temperature, moisture is key (without moisture, egg-hatch rate is reduced)
- The effect of OSR root exudates on egg hatch is not clear, as in these experiments at lower temperatures more eggs hatched in the presence of OSR root exudates, but the opposite was documented at higher temperatures
- In the experiment looking at the impact of refrigeration and substrate, more eggs hatched on a sandy substrate (39 eggs/100) than on filter paper (2 eggs/100)
- This study has identified multiple factors that affect egg laying and egg hatch in varying proportions, which suggests each factor has a role in egg viability rather than determining egg hatch

Table 1. Date of first eggs to be laid by female CSFB and last egg recorded to have been laid at 4 different temperature regimes.

Temperature treatment	Date first eggs recorded	Date last eggs recorded
5°C – constant	3 November 2020	25 June 2021
10°C – constant	19 October 2020	6 April 2021
15°C – constant	24 September 2020	5 February 2021
5/15°C – fluctuating	4 November 2020	17 February 2021

Table 2. Total number of eggs laid by females and the percentage of females that were recorded as egg laying at each temperature regime.

Temperature	Total eggs laid	% Females that laid eggs
5°C – constant	284	32%
10°C – constant	1,030	52%
15°C – constant	1,240	48%
5°C/15°C – alternating	1,048	48%

Table 3. Number of successful egg hatches and hatch rate at each temperature treatment, including start and end date of first recorded egg hatch and last recorded at each temperature treatment.

Temperature Condition	Number of eggs (total)	Number of eggs hatched	Hatch rate (%)	Incubation period range	Range length
Constant 5°C	81	0	0%	-	-
Constant 10°C	446	153	34%	17–84 days	67 days
Constant 15°C	283	214	76%	14–27 days	13 days
5°C/15°C (alternating)	408	118	29%	27–52 days	25 days

Table 4. Egg hatch rate of 100 eggs at each temperature treatment.

Temperature condition	Hatch rate (%)
Constant 10°C	7%
10°C switched to 5°C after 7 days	4%
10°C switched to 5°C after 14 days	12%
10°C switched to 5°C after 21 days	10%
Constant 15°C	46%
15°C switched to 5°C after 7 days	55%
15°C switched to 5°C after 14 days	63%

2.3. Determining larval impacts on crop development

Traditionally, CSFB larval levels in the field have been used to determine spray thresholds but the direct impact of the larvae on OSR yield is still unknown. It is important to understand any yield impacts associated with CSFB larvae to prevent unnecessary use of insecticides and inform decision for applications of plant protection products for other issues and crop nutrition products.

This work investigated the impact of larval load and timing of larval invasion on OSR growth. Pot trials of OSR (var. Duplo) were used to investigate the impact of larval abundance, timing of larval invasion and width of plant stem on tolerance to larval feeding. CSFB larvae were collected from field populations. Larvae of 3–5 mm (2^{nd} instar) were used to inoculate the pot trials. Plants were then assessed every four weeks at the ADAS site and twice monthly at the Harper Adams University (HAU) site for growth stage, height and stem width at the widest point of the stem. Destructive assessments were done to assess dry weight and internal larval feeding on mid to late flowering plants.

Two experiments investigated the effects of larval load on crop development. One experiment looked at increasing larval loads per plant (including a no larvae treatment) at a constant growth stage (GS16–18), and the other experiment looked at introducing three different larval loads (zero, medium and high) at varying growth stages (GS12, 18 and 24).

A pot trial was done to determine if stem width determines the survival of a plant after larval feeding damage. OSR plants were grown at an increasing density in pots to produce plants with different stem widths, with two larval load treatments (no larvae and 20 larvae per plant).

Key results:

- The plant growth stage at the time of infestation and the level of infestation both determine plant survival rate, with earlier growth stages and higher larval loads being most susceptible
- Choosing a drill date that ensures crops are more developed at peak migration will increase the chances of crop survival
- At the ADAS site, high levels of plant mortality were observed at higher larval loads. There was no variation in stem height, width or tunnelling damage between treatments with varying larval loads, however some tunnelling was observed in the uninoculated plants, which is likely due to natural pest invasion
- At the HAU site, plants were shorter at the first and fourth assessment timings, though no obvious correlation in treatment was observed. Stems were thinner at the first and second assessment timings with higher larval loads, but no other variation was observed at any other assessment timing. At the fifth and sixth assessment, plant growth was observed to be less developed at higher larval loads
- In the growth stage experiments, all plants inoculated with larvae at GS12 at the ADAS site died, showing that earlier stages of OSR are more susceptible to CSFB damage.
  - Plants inoculated at GS18 showed no variation in height until the final assessment, where uninoculated plants were observed to be shorter. No variation was seen in stem width
  - At GS24, uninoculated plants had the thickest stems at the first assessment. However, they had the thinnest stems at the fourth assessment.
  - There was no variation in the level of tunnelling between GS18 or GS24, however there was a trend for more tunnelling as larval load increased in both
- There was no variation in dry weight at any GS when inoculated with CSFB larvae
- At the HAU site, variation in plant height was seen in the earlier GS plants between the second and fifth assessment timing
  - Uninoculated plants were the tallest, while those inoculated with higher larval loads were the smallest
  - Variation in stem width was observed at the seventh and eighth assessment, where plants with higher larval loads had the thickest stems
- OSR sown at higher seed rates, resulting in higher plant densities in the field, were found to have thinner stems at harvest and less able to tolerate higher larval loads
  - In the final assessment, inoculated plants were shorter than uninoculated plants
  - Plant density impacted the dry weight of the plant, with lower plant density treatments having a much higher dry weight
  - No effect was observed between the number of larvae found at harvest and the thickness of the stem or number of side branches of the crop

2.4. Feeding preferences of adult CSFB at various crop growth stages

Anecdotal evidence suggests that CSFB prefers feeding on earlier growth stages of OSR, but relatively little work has been done to truly understand the feeding preferences of adult CSFB. This work investigated the feeding preferences of CSFB on OSR at various stages of plant development.

Adult CSFB were collected from on farm storage facilities in late July to early August and reared in a mesh cage. Males and females were separated prior to the experiment. For the experiments described below, the male and female CSFB were starved for 48 hours before the commencement of the experiment.

Five males and five females were placed into the center of separate feeding chambers in a controlled environment, three samples of OSR (var. Duplo) leaf at varying stages of development (cotyledons, first and second true leaves) were offered to the beetles. After 24 hours, photographs of each of the leaves were then taken and the % leaf area consumed calculated. The experiment was repeated 18 times per sex across the three treatments.

Cage experiments were done by adding 15 male and 15 female beetles to separate BugDorms, which was placed in a controlled environment and left for 24 hours. Each cage contained three potted OSR plants (var. Duplo) at GS10, GS11 and GS12. After 24 hours, leaf samples were taken from each plant, photographed and % leaf area consumed calculated. The experiment was repeated 6 times per sex across the three different treatments.

In a separate experiment, an individual beetle was then placed inside a four-armed olfactometer. Treatments included a control (wet filter paper), a cotyledon, first true leaf or second true leaf. Beetle movement within the olfactometer was recorded for 20 minutes and the footage analysed to record the length of time the beetle spent in each area of the olfactometer.

Key results:

- Percentage damage was much higher on cotyledons compared to the damage found on first or second true leaves
- However, when looking at total area consumed, leaf area loss was similar across cotyledons, first and second true leaves, which indicates that damage is more visible on cotyledons due to their smaller size
- Results of the feeding chamber experiment showed differences in the area consumed depending on the age of the leaf. Cotyledons were consumed at a higher rate compared to first or second true leaves
- Feeding damage in cage experiments showed almost twice as much leaf area was consumed by beetles at GS10 compared plants at GS11 or GS12
- No differences in feeding were observed between sexes in either the pot or the cage experiments
- CSFB showed no preference for odours from different leaf stages in the olfactometer experiment, despite research showing that they are sensitive to glucosinolates in their host plants
- Because of the strict quality controls in the experiment, many replicates were excluded, and this probably impacted the result, coupled with potentially poor volatile signals from the leaf material used

2.5. Relationship between numbers of adult CSFB and feeding damage

CSFB monitoring in the UK is traditionally done by using yellow water pan traps or yellow sticky traps and counting individuals caught. However, adult counts from trapping and observations of leaf loss in the field are relatively poorly understood. This work aimed to determine if CSFB trap counts can inform levels of pressure on farm. Data was collected from field trial sites during work done on migration activities of CSFB (WP1) and from previous ADAS projects (including unpublished work).

Key results:

- Monitoring is required over longer periods of time, rather than at single time points, to fully understand the implications of beetle numbers in the field. However, optimising the frequency of assessments should be considered for future work
- Timed counts (individual data point) and cumulative numbers (data points added over time) were assessed
- There was no correlation observed between adult count numbers (timed count and cumulative count) and leaf area loss in 2020
- However, in 2021 adult count and leaf area loss correlated well for cumulative count data
- While correlations were observed in single years, there was no correlation observed across years for either timed or cumulative count data and leaf area loss

2.6. Determining the relationship between larval scars and larval number

To determine the levels of larval pressure in OSR, crop plants must be destroyed, which is not practical on the farm. The number of larvae and the number of larval scars has been studied to see if the number of scars can accurately predict larval pressure in field. This work further investigated this relationship to determine if larval scarring can be used to accurately estimate CSFB larval pressure. Data was collected from field trial sites from trials in WP1 and WP2 and from previous ADAS projects (including unpublished work).

Key results:

- Using scar counts to estimate larval abundance in the field is a more cost-effective way for farmers to determine larval pressure. While there is not an exact match between scar counts larval numbers, they can provide an indicative estimate of infections in the crop
- There was a strong correlation between the number of scars recorded on a plant and the number of larvae collected from within
- Data showed that the higher the number of scars on the plant, the higher the number of larvae and vice versa
- Understanding larval pressure in the field may help farmers make informed decisions on crop viability in the spring, though more work is needed on the impact of larvae on yield

3. On-farm testing of promising IPM components (WP2)

Trials in work package 2 (WP2) were tailored to the intervention studied, with a range of trial types used – plot, tramline (to ensure commercial relevance), split-field and farm-scale (to ensure the beetle movement between fields was not a confounding factor). Management of the trials was also designed to reflect real-world scenarios.

3.1. In field assessments on insect activity and crop development

The following assessments were done in the field.

- Adult CSFB counts – a single yellow water pan trap was placed at ground level, in the middle of the field and positioned away from field boundaries and tramlines and monitored weekly
- Leaf loss – 50 plants were selected at random from around the yellow water pan trap and percentage leaf area loss determined using EPPO standards
- Growth stage – recorded at each assessment timing
- Larval pressure – 10 plants were randomly collected from the experiment area and assessed by either plant dissection or passive extraction methods (both CSFB and rape winter stem weevil larvae were counted)
- Plant population – emerging plants on either side of a 0.5m rod, placed between rows at 5 random locations, were counted and row spacing was measured to calculate plant density. A 0.5x0.5m quadrat was used to assess plant population in companion plant trials
- Ground invertebrate abundance – measured using pitfall traps, one trap per assessment area. After 3 days traps were collected and samples identified. Groups were assessed to species level (ground and rove beetles, spiders and CSFB) and grouped by diet and size
- Soil moisture – recordings taken at 3 random locations per assessment area. The probe took readings every minute for 5 minutes total
- Crop vigour – which was visually scored when the crop reached GS13 using a 1–9 scale, where 0 is the tallest and thickest (most vigorous) and 9 is the shortest and thinnest (least vigorous)
- Green leaf area index (GAI) – assessed at pre-stem extension and post-stem extension. Pre-stem extension assessments used 5 overhead photos to determine GAI, post-stem extension using random quadrat sampling to determine GAI
- Crop height and width – height measured from soil level to tip (nearest cm) and stem width measured to nearest 0.1 mm.
- Lower stem (0–40 cm) and upper stem (40–60 cm) – assessed for larval invasion. Each section was split open and a score was given for the level of tunnelling observed
- Growing point injury – measured based on the AHDB Recommended Lists (RL) protocol testing for varietal resistance
    - Assessments were conducted twice, once at GS57 (flower bud visible) and once between GS67–75 (flowering to early pod development)
    - Assessment areas were scored on a 1–9 scale, where 1 is 100% injury and 9 is no injury
- Small plots were harvested using small plot combining harvesters and larger scale trials were harvested using commercial farm equipment. For small plot trials yield was corrected to 9% moisture content. Larger scale field trials were harvested using the best practice guidelines

3.2. Companion crops

Trial 1

This trial was conducted at AHDB Strategic Cereal Farm West (near Leamington Spa) in 2020. Three treatments (Table 5) were investigated and replicated twice. Companion crops were drilled on the 25 August 2020, while the main cash crop (OSR var. Aurelia) was drilled on the 3 September 2020. Assessments conducted were adult CSFB numbers (using yellow water pan traps, 1 trap was located per assessment area), plant population, leaf area loss, CSFB larvae numbers, crop vigour, natural enemies). It is important to note that Strategic Farm West ended early and no yield data was collected.

Table 5. Treatment details for companion mix trial (2021 harvest).

Treatment details
OSR only
OSR + berseem clover (1.5 kg/ha, 68 seeds/m^2), buckwheat (4.23 kg/ha, 18 seeds/m^2), and fenugreek (2.6 kg/ha, 22 seeds/m^2) applied at 8.33 kg/ha (seed provided by Frontier).
OSR + berseem clover (6.25 Kg/ha) and fenugreek (6.25 Kg/ha) (seed provided by Limagrain).

Trial 2

This trial was conducted using tramline trials near Holkham, Norfolk in 2021/2022. Four treatments (Table 6) were investigated and replicated twice in a randomised design. Companion crops were drilled on the 15 August 2021, while the main cash crop (OSR var. Aurelia) was drilled on the 21 August 2021. Assessments conducted were adult CSFB numbers (using yellow water pan traps, 1 trap was located per assessment area), arthropod abundance (using pitfall traps), plant population, leaf area loss and CSFB larvae numbers.

Table 6. Treatment details for companion mix trial (2022 harvest). Including companion seed rate.

Treatment name	Companion mix
None	Monoculture with no companion crop
Buck	Buckwheat only @ 10 kg/ha
Buckwheat and Berseem clover	Buckwheat (@ 6 kg/ha) and berseem clover (@ 2 kg/ha)
Buckwheat, berseem clover and fenugreek	Buckwheat (@ 4.2 kg/ha), berseem clover (@ 1.5 kg/ha) and fenugreek (@ 2.5 kg/ha)

Key results:

- The results suggest that companion crops can effectively reduce both adult and larval numbers by potentially interfering with egg laying and larval invasion
- Leaf damage was reduced by 37% on average across all companion crop treatments, though the highest reduction was seen in the buckwheat + berseem clover mix (52% reduction)
- Adult CSFB numbers were reduced in one of the 3 tramline trials, with up to 47% reduction seen in the buckwheat only treatment
- The buckwheat only treatment also reduced the number of larvae up to 48%
- In the stacked IPM trials, damage to the crop was reduced in 3 out of 4 of the trials, and reductions in leaf area loss of up to 47% in 2 out of the 4 trials

3.3. Drill date

This trial investigated how sow date can impact both CSFB adult pressure and CSFB larval pressure, since both life stages of this pest are often treated as separate issues. Early and late-suited varieties were sown across 3 adjacent fields of OSR in Herefordshire. All fields had the same previous crop and agronomy. Three sow dates were used: 26 August, 6 September (failed trial) and 15 September. For each sow date, two varieties were selected based on the strength of their perceived autumn vigour. Assessments conducted in autumn were percentage leaf loss and plant populations at GS 10/11 and GS13, CSFB larvae numbers, plant height and stem width. Spring assessments of CSFB larval numbers, green area index, and at mid flowering a final assessment on plant height and width were made.

Key results:

- Drill date can be important in determining CSFB pressure and should be considered carefully by growers to help avoid total crop failure
- Adult CSFB damage was highest in crops drilled from late August – early September and lowest in crops drilled from mid-September onwards. However, larval pressure was highest in earlier sown crops
- Crops drilled on the 6 September experienced high larval load which resulted in total crop failure
- Lower levels of crop damage were observed at the other drill timings. Crops drilled on the 15 August appeared to avoid peak migration, while those drilled during peak migration (late August to mid-September) were more likely to be attacked
- Earlier drill dates were prone to higher levels of larval infestation. However, results also show that earlier drilled crops were generally taller and had wider stems, which may better allow the crop to tolerate CSFB feeding pressure
- Varietal differences were also observed, where one variety showed 42% more larvae than the other on the 26 August drill date. This may indicate a feeding preference between varieties. The variety, which experienced lower larval pressure, was observed to be taller and had a wider stem, as well perceived strong spring vigour
- Cultivation method has little notable effect on CSFB pressure, though it was observed that in disced plots at the 26 August drill date plants were generally shorter at mid-flower. This is likely due to reduced moisture content available, due to the cultivation method

3.4. Stubble length

Trials were conducted near Stansted Mountfitchet, Essex to determine the impact of short and long stubble on CSFB pressure and damage. A trial over two tramlines compared long and short stubble. Stubble was cut to either 20 cm or 30 cm in length (in the previous wheat crop), length was limited to what equipment was available on farm at the time of cutting. The treatments were replicated twice and the crop drilled on the 26 August 2021. Assessments conducted were adult CSFB counts, plant population and leaf area loss.

Key results:

- No consistent effect of stubble length was seen on CSFB pressure, plant populations present after sowing or leaf area loss to adult feeding
- However, one trial did show differences in variety. Some varieties had consistently more damage within long stubble and others in shorter stubble
- There was no comparison between no stubble and stubble presence, so more research is required to fully understand the impact of stubble on CSFB pressure and damage

3.5. Organic amendments

Trial 1

This trial was conducted at AHDB Strategic Farm West (near Leamington Spa) in 2020/2021. It investigated the impact of organic amendments on CSFB pressure and crop performance. Three treatments were tested: poultry manure, artificial nitrogen and no amendment. Two tramlines were placed adjacent to one another, and treatments were not replicated, due to spreader width and normalised difference vegetation index (NDVI) variation. OSR variety Aurelia was drilled on the 3 September 2020 and amendments were applied 1–5 days before drilling. All other management followed the host farmer's standard practices. Assessments made were adult CSFB counts, leaf area loss, CSFB larval numbers, plant populations and soil moisture.

Trial 2

This trial was conducted near Long Newton, County Durham in 2021/2022. Three treatments were tested: seedbed inorganic nitrogen (balanced to match the digestate nitrogen treatment), seedbed digestate and migration digestate (applied at CSFB migration). Each treatment was applied on two replicate tramlines, each in a randomised design. The crop was drilled on 23 August 2021. Management followed the host farmer's standard practices. Assessments made were adult CSFB counts, plant populations, leaf area loss, CSFB larval counts, green area index, plant height and plant width.

Key results:

- Overall, organic amendments improved crop establishment, through increased nitrogen availability, which resulted in better developed crops able to tolerate feeding damage at peak migration
- When poultry manure was applied prior to drilling, better crop establishment was seen, and lower CSFB feeding was observed at the earlier growth stages. At later growth stages, however, there was no observed effect of poultry manure on CSFB pressure
- Seedbed digestate was found to improve crop establishment by up to 51% and reduce leaf damage by adult CSFB by up to 18%, though increased larval loads were seen in the autumn (+39%) and spring (+150%). Green area index was highest in this treatment in March compared to other treatments, which may have attracted higher levels of CSFB

3.6. Straw mulch

This trial was conducted at AHDB Strategic Farm West (near Leamington Spa) in 2020/2021. The work investigated the impact of straw management on CSFB pressure and crop performance. Two treatments were applied, chopped straw left as mulch on the surface of the soil and straw that had been baled and removed from the field. OSR variety Aurelia was drilled on the 27 August 2020. All other management practices followed the host farmer's standard practice. Assessments made were adult CSFB counts, leaf area loss, plant populations and soil moisture.

Key results:

- No differences were observed between treatments and the number of adult CSFB present in water pan traps
- When baled straw was used at GS9–10, approximately 5 adults were recorded per trap, compared to the straw mulch treatment which recorded on average 3 per trap
- No differences were seen when baled or straw mulch was used at GS11–12, where approximately 5 beetles were caught per trap
- Leaf area loss was also low across all treatments (<2% at all GS).
- Baled straw seemed to increase the success of plant establishment, as slightly higher plant populations were observed

3.7. Seed rate

This trial was conducted near Eltisley, Cambridgeshire. The work investigated the effect of different seed rates on CSFB pressure and crop development. Four different seed rates were applied to OSR variety KWS Campus: 30 seeds/m^2, 60 seeds/m^2, 90 seeds/m^2 and 120 seeds/m^2. Seeds were drilled on the 24 July 2021 as tramline widths and replicated twice. An issue during drilling resulted in the abandonment of one of the replicates (60 seeds/m^2). Berseem clover was drilled as a companion crop on the same day. All other management practices followed the host farmer's standard practice. Assessments were made on plant populations, leaf area loss, CSFB larval numbers, plant height and stem width.

Key results:

- Crops sown at lower seed rates may produce larger and more robust plants that are better able to tolerate feeding damage, while crops sown at higher seed rates might increase the number of larvae per m^2 and offer limited benefit in helping to reduce the impact of CSFB feeding damage in the crop
- Increasing seed rate results in increased plant populations but can result in a higher percentage of plants lost at establishment
- In one trial, adult CSFB feeding was reduced when higher seed rates were used, with lower number of larvae per plant at GS18–19, though increases in larvae were observed in the autumn and spring assessments (+136% and 116% respectively)
- Crops drilled at lower seed rates developed much more quickly
- There was no consistent effect observed between seed rate and yield. Crops sown at lower seed rates with higher larval loads yielded similarly to crops sown at higher seed raters with lower larval loads

3.8. Plant growth regulator (PGR)

Trials were conducted in Staffordshire and Bedfordshire. The work aimed to determine the impact of autumn and spring applications of plant growth regulator (PGR) on CSFB pressure and crop development. The Staffordshire trial site investigated rate variations of spring PGR applications, while the Bedfordshire site investigated timing of application for spring and autumn PGR applications. Treatments were applied on two replicated tramline trials at assessments made at three locations. The PGR applied at both locations was Caryx (BASF). Assessments of leaf area loss and plant population were made at establishment. Over winter, the number of larvae per plant, plant height, green area index, number of leaves and stem width were assessed. At mid-flowering assessments were made on total plant height, green area index, stem diameter at 20 cm, 50 cm and 100 cm above ground level and yield analysis.

Key results:

- CSFB tunnelling has been associated with reduced stem strength and increased lodging risks
- Canopy management may help mitigate the risk of lodging, but the effectiveness of any PGR application may vary depending on the CSFB pressure, environmental conditions and other agronomic factors at the time of application
- PGR application showed no effect on CSFB larval numbers at either site
- PGR application reduced plant height at one site and reduced green area index at the other (Staffordshire) site
- Spring PGR or nitrogen applications showed no effect on yield, plant height at mid-flowering or stem width
- Dry spring weather may have limited nitrogen uptake and canopy development

3.9. Cultivation intensity

Three tramline trials were planned to investigate the impact of different cultivation intensities, however in 2020/2021 the trial failed. In 2021/2022 the trial established well and data on plant populations, arthropod abundance and CSFB larval counts were collected.

Key results:

- Incomplete data from this series of trials restricts what conclusions can be drawn
- High intensity cultivation resulted in increased plant numbers, likely due to the seedbed being better suited for crop establishment.
- In the drill date/no discing treatment, plants were found to be taller at mid-flower and had improved yield
- Plots that had minimal cultivation had the highest levels of CSFB in pitfall traps, but it is important to note that pitfall traps are not optimal for monitoring CSFB in the field and are more suited to monitoring ground dwelling arthropods.

3.10. Varietal choice

This work aimed to investigate the impact of varietal choice on CSFB feeding pressure, larval load and determine any potential tolerance of varieties to CSFB. Commercially relevant OSR varieties were tested. Trials were conducted across multiple sites over a three-year period. Fourteen core varieties were tested over the duration of this experiment, with one additional variety tested during 2021–22. Assessments made at each site were of plant establishment, leaf area loss, autumn vigour and CSFB larval numbers. Physiological characteristics were also measured in the aim of understanding how variation in crop development might impact a varieties ability to tolerate CSFB feeding.

Key results:

- Due to low larval pressure, results should be treated with caution
- Patterns observed across all sites and years show that more vigorous and taller varieties tended to attract the most larvae but still yielded well, which suggests that these varieties are better able to tolerate CSFB feeding
- Varieties that were less vigorous tended to be more susceptible to feeding from adults and were also often lower yielding
- Trials had mixed success due to variable establishment, high resource demands for CSFB assessments and inconsistent sampling across sites
- Responses varied by site and year for assessments on plant population, leaf area loss, larval pressure and yield
- Physiological traits, such as height, vigour and flowering time, also varied across site and years, likely due to the environmental conditions at the time
- Level of infestation between varieties varied, though the one which had the highest number of larvae, as displayed the leaf area lost to adult beetles, consistently yielded highly and had perceived strong autumn vigour

3.11. Stacked IPM trials

In the final years of the project, several trials investigated the impact of 'stacked' IPM approaches, which are more reflective of how IPM would be conducted in real-world scenarios.

Trial 1 (seed rate, companion cropping and rolling)

This trial was conducted near Kneesall, Nottinghamshire. Four treatments (Table 7) were randomly applied as tramline widths in two replicate blocks. It is important to note that where the trial was situated, half of the field was cultivated and half was not. This was outside of the trial design parameters but aligned with the blocking structure. Assessments were made on plant populations, leaf area loss, CSFB larval numbers, plant height and stem width.

Table 7. Treatment details for IPM strategy stacking trial (2023 harvest).

Treatment name	Treatment details
Single roll	Single rolled + 50 seeds/m²
Double roll	Double rolled + 50 seeds/m²
Double roll + high seed rate	Double rolled + 80 seeds/m²
Double roll + high seed rate + companion	Double rolled + 80 seeds/m² + companion crop @ 8 kg/ha

Trial 2 (seed rate and companion crops)

This trial was conducted near Letton Green, Norfolk. Three treatments (Table 8) were investigated and replicated twice on farm. Companion crops were broadcast on 6 August 2022 by Crop Angel, followed by drilling of OSR variety Aspire on 16 August 2022. A fourth treatment was planned (low seed rate + companion crop + sheep grazing) but failed due to poor establishment. Assessments were made on adult CSFB counts, plant populations, leaf area loss and CSFB larval counts.

Table 8. Treatment details for seed rate and companion crop stacked IPM trial.

Treatment name	Treatment details
High seed rate	70 seeds/ m²
Low seed rate	50 seeds/ m²
Low seed rate + companion plants	50 seeds/ m² + companion mix (berseem clover + buckwheat @ 8Kg/ha)

Trial 3 (drilling method, varietal autumn vigour and companion cropping)

This trial was conducted near Walpole Highway, Norfolk in 2022 – 2023. The drilling method was investigated to determine the impact on CSFB pressure and two treatments identified (direct drill or by a Väderstad drill). The Väderstad combines light cultivation and drilling in one pass, while direct drilling leaves the soil undisturbed. Two oilseed rape varieties were tested, Aspire and Attica. The addition of companion crops was also tested to determine if they can deter CSFB from finding the crop and as a habitat for natural enemies. A treatment summary is in Table 9.

Table 9. Treatment details for stacked IPM, drilling method and vigour (2023 harvest)

Name	OSR seed rate	Components
Väderstad - Aspire	70	Väderstad drill (light cultivation and removes stubble) + Aspire seed (poor autumn vigour)
Direct drill - Aspire	70	Direct drill (retains stubble) + Aspire seed (poor autumn vigour)
Direct drill - Attica	50	Direct drill (retains stubble) + Attica seed (good autumn vigour)
Direct drill – Attica + companion	50	Direct drill (retains stubble) + Attica seed (good autumn vigour) + companion plants (berseem clover + buckwheat @ 8 kg/ha)

Trial 4 (companion crops, flower strips and trap crops)

This trial was conducted at RSPB Hope Farm, Cambridgeshire. In 2022, the trial failed due to poor establishment but was re-established in 2023/24. Treatments compared in-field flower strips, companion plants and trap crop strips on CSFB feeding pressure. Flower strips on the farm had been established prior to the trial from a previous project, companion plants and trap crops were specifically added for this trial. The four treatments (Table 10) were replicated twice. Assessments included plant population counts, leaf area loss, CSFB larval counts, plant height and stem width.

Table 10. Treatment details for stacking IPM, additional 2024 harvest trial.

Treatment details
Control – OSR monoculture – not next to trap or flower strip
Next to flower strip
Next to flower strip + companion crop
Next to flower strip + companion crop + trap strip

Key results:

- Generally, CSFB pressure was low and drought conditions were experienced across all sites at the time of drilling and establishment
- Environmental conditions will likely have impacted how well interventions performed, as well as influencing the overall level of CSFB pressure
- Trial 1 showed a reduction in CSFB pressure when stacking double rolling, higher seed rates and companion crops. There was variation in leaf area loss between the single roll, double roll and double roll + companion crop treatments at GS15–16. There was no effect in any of the treatments on the number of larvae per plant, plant height or the number of leaves in the autumn
- Trials 2, 3 and 4 showed little evidence of the benefit of stacking the IPM interventions.
    - In trial 2, more adult CSFB were caught at the first assessment timing compared to the second, the lowest numbers of adults were caught in the low seed rate + companion crop treatment
    - Leaf area loss between treatments varied, with the lowest levels of loss seen in the low seed rate + companion crop mix
    - In trial 3, leaf area loss was higher at the first assessment for plots drilled directly with *var*. Attica compared to seed drilled with the Väderstad
    - It was also noted that Attica had a thicker canopy than Aspire (though leaf loss was generally low across treatments)
- In trial 3, there was no variation in CSFB numbers across assessments, but fewer adults were observed in the treatment with companion crops. Similar observations were seen in trial 4, with lower levels of CSFB (both adults and larvae) observed in the companion crop + trap crop + flower margin trial
- However, due to the limiting factors, more work is required in this area
- Each of the interventions have been shown to have some level of control for CSFB
- Stacking interventions is likely to increase the reliability of IPM measures in the field

4. Conclusion

Environmental conditions impact CSFB biology and the success of IPM in the field. Temperature and moisture impact egg viability but do not trigger egg hatch. Although temperature is a key factor, genetic triggers (potentially linked to the day of the year) are likely to have the greatest influence on adult migration. These results show that peak migration occurs at similar timings each year (end of August to mid-September). Therefore, using stacked IPM practices to improve crop resilience during this period can help farmers to mitigate the risk of crop failure and yield reduction.

AHDB will publish the final report for this project later in 2025.