Grower Summary

SF/TF 145a

Development and implementation of season long control strategies for *Drosophila suzukii* in soft and tree fruit

Annual report 2021

Project title:	Development and implementation of season long control strategies for *Drosophila suzukii* in soft and tree fruit
Project number:	SF145a
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Report:	Annual report, Year 4, March 2021
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Key collaborators	Berry Gardens Growers and Angus Soft Fruits
Location of project:	NIAB EMR
Industry Representative:	Marion Regan, Hugh Lowe Farms
Date project commenced:	01 April 2017
Date project completed (or expected completion date):	31 March 2021

DISCLAIMER

[The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.]

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

Introduction

Native to eastern and south-eastern Asia (Walsh et al. 2011), the Asiatic vinegar fly *Drosophila suzukii* Matsumura (Spotted Wing Drosophila, *D. suzukii*) recently invaded the UK, immediately becoming a key pest of stone and soft fruit crops. Numbers have increased from year to year, causing severe fruit damage and increases in production costs. The invasion of *D. suzukii* across Europe has strongly disrupted existing and developing integrated pest management IPM control strategies, as currently crops are being protected against the pest with programmes of multiple sprays of plant protection products (PPPs) including broad spectrum products. This causes a deterioration of beneficial arthropod populations disrupting their ecological contribution in keeping pests below economic threshold values. In the EU there has also been an ongoing review and phase-out of chemical PPPs since the 1980s (pan-europe.info. 2008), including a recent restriction on neonicotinoid applications (eur-lex.europa.eu. 2013). Along with this there is a continuing trend to reduce the risks and impacts of chemical PPP use and to promote the use of non-chemical alternatives (eur-lex.europa.eu. 2009). Internationally, the need for insecticide-based management programmes to control *D. suzukii* close to harvest has become problematic too, because of inconsistencies among export markets regarding maximum residue limits (MRLs) that are allowed for different insecticides on imported fruit (Haviland et al. 2012). Moreover, there is now evidence for *D. suzukii* resistance to spinosad which is commonly used to control this pest, further presenting a need for the development of alternative management strategies (Gress et al. 2018).

In Europe and America, research projects on *D. suzukii* have ended (projects IPMDROS, DROSKII and DROPSA). The aim of these projects was to create new knowledge and understanding of the damage and losses on fruit crops resulting from *D. suzukii* activity, by studying its biology and evaluating control methods. This project builds on progress internationally and on the AHDB project SF145 but focuses on practical development and elaboration of new control technologies that can be used by UK growers within the short to medium term.

The specific objectives within this AHDB funded project were:

1. Continue to monitor *D. suzukii* in England and Scotland with additional habitat evaluation in Scotland

2. Develop and optimise a push/pull system using repellents and attract and kill strategies

3. Further develop, optimise and test bait sprays

4. Investigate prolonging spray intervals for maximum effect but minimal applications

5. Integrate exclusion netting with other successful controls

6. Integrate approaches for season long control

7. Identification and quantification of D. suzukii parasitism in the UK

8. Identification of Drosophila suzukii tolerance to plant protection products

This Grower summary reports on the results of each of these objectives in turn.

Financial benefits of this research

Gaining control of spotted wing drosophila does not just require additional crop protection sprays, it also requires good crop management and hygiene, which incurs additional labour costs.

Growers producing susceptible crops incur additional labour to monitor for the presence of the pest using monitoring traps and flotation testing for the presence of SWD larvae in the fruit. They incur additional labour costs to remove old and damaged fruit from the plantation floor (to stop attracting SWD into the crop). They also incur additional labour costs to pick and remove late ripening fruits, which continue to develop several weeks after the main harvest has been picked.

Some growers employ narrow mesh netting to prevent SWD ingress into the crop to reduce population numbers in and around the developing fruits. This incurs expenditure for the netting and additional labour to erect it.

Typical additional costs incurred for all of this, coupled to the additional sprays required to control the pest are listed in the table below.

	SWD cost per hectare
Strawberries	£4,344
Raspberries	£6,557
Blackberries	£11,074

The continuing programme of research in this and other SWD projects, aim to develop novel and sustainable control methods, which will become available for growers to adopt in the short to medium term to reduce reliance on the use of conventional spray control and reduce the typical costs being incurred in the crops listed above.

Objective 1. Continue to monitor *D. suzukii* in England and Scotland

Task 1.1. National Monitoring in England and Scotland (Yrs. 1-4; NIAB, JHI, NRI)

Task 1.2. Modelling of the 17-year National Monitoring dataset (JHI)

Headlines

- *D. suzukii* numbers at NIAB EMR in 2020, overall, were similar to the catch numbers of 2017 and 2018, but 2020's trend most closely relates to 2019's profile.
- As with previous years at NIAB EMR, unprecedented peaks in trap catches occurred in conjunction with uncharacteristic peaks in temperature.
- In Scotland 2020 total trap catches for the year were lower than 2019.
- Predictive models using monitoring trap catches have been successful in predicting key SWD events including first spring female peak with 93.3% accuracy.

Background and expected deliverables

Since the first detection of *D. suzukii* in the UK in 2012, populations of the pest have continued to rise in most regions of England. In contrast, populations in Scotland, in which the pest was first detected in 2014, have been slow to increase. To monitor the pest, modified Biobest traps using the Cha Landolt bait system were deployed in a range of commercial and wild crops in 2013 at 14 sites across the UK.

In 2017 and 2018, in collaboration with Berry Gardens, the main fruit growing regions of England were monitored by deploying 57 traps across nine farms (Kent, Surrey, Herefordshire, Staffordshire, Northamptonshire, Yorkshire and Norfolk) and 40 traps on four farms in Scotland.

In 2019, monitoring in England was reduced to maintaining 10 traps in England at NIAB EMR and three traps in Scotland at JHI including one wild area at each site. Monitoring data is summarized monthly from both institutes and reported to the project team at project meetings. It is disseminated to growers and other stakeholders at regular intervals. Although there has been a reduction in the number of monitoring traps, NIAB EMR and JHI have still been able to provide the AHDB with updates on pest dynamics which in turn are used to alert growers to key SWD population events.

Since 2018, NIAB EMR has been hosting one of the 12 m high Rothamsted suction traps and has been given access to historic trap catches from other locations. In 2018 *D. suzukii* was identified between August and November at NIAB EMR, which is consistent with previous years. Adults were detected at 12 m from the ground during the main flight/dispersal period which coincides with the emergence of the winter-form adults, a depletion in egg laying resources (fruit) and defoliation of trees (reduced refugia). Suction trap catches from 2019 and 2020 will be analyzed in summer 2021. Rothamsted have also agreed to share the Scottish suction trap catches from 2014, 2017 and 2019. Access to these samples has been delayed by COVID-19 restrictions.

Summary of the project and main conclusions

At NIAB EMR, a cooler spring in 2020 resulted in lower trap catches compared to 2019. In addition to 2019, 2020 also saw an unprecedented activity peak in June, which coincided with above average temperatures during this time. In September 2020, the largest peak trap catch occurred (since monitoring began in 2013), a 20% increase from 2019.

In Scotland, average peak trap catches have varied between years, and are typically 10-40-fold lower than numbers collected at NIAB EMR. The pattern of abundance is similar between years and to NIAB EMR's trend, with insects appearing in traps in August-September, increasing to a peak in October-November, then decreasing to low values December-January. Winter/spring catches are low with very few insects trapped. Highest peak catches were obtained in 2014 (c. 20 per trap). There is an indication that trap catches at the JHI site might be increasing in 2019 and 2020 compared with earlier years. However, this may be a local finding.

For both sites, there continues to be a general year-on-year increase in annual mean trap catches, except for the year 2020 where a decrease of ~200 SWD per trap was seen at NIAB EMR and ~14 SWD per trap at JHI.

Predictive models have been developed using historic trap catch data coupled with environmental information. The models have been successful in predicting first spring female peak (93.3% accuracy), SWD presence / absence (90.2% accuracy), first summer peak (83.1% accuracy) and female fecundity (76.1% accuracy). Modelling can also predict female activity based on male activity (83-87% accuracy) and time required to reach a % value of SWD population size (72-99% accuracy). These weather-dependent predictive tools could be further improved with the addition of more SWD data, in particular fecundity.

Action points for growers

- Continue to monitor adult SWD in hedgerow and cropping areas.
- Be aware of AHDB communications with alerts to key SWD monitoring events.
- Monitor for fruit damage throughout the cropping season to inform control measures.

Objective 2. Develop and optimise a push-pull system using repellents, and attract and kill strategies

Task 2.1. Analyses of fermentation products from yeasts attractive to D. suzukii (Rory Jones and NRI)

Headline

- Yeast species of ecological relevance to D. suzukii can be separated from one another by the relative amounts of volatile chemicals which they produce.

Background and expected deliverables

Yeast species are known to play vital roles in the ecology of *D. suzukii* in terms of nutrition and insect behaviour. Rory Jones of University of Lincoln has been undertaking an AHDB PhD Studentship (CP171) to investigate the attractiveness of a range of exotic yeast species to SWD. NRI scientists are assisting him in collection and analysis of volatiles produced by yeast species with the aim of finding new attractants for *D. suzukii*.

Summary of the project and main conclusions

Volatiles were collected from four exotic yeast species associated with *D. suzukii* and a commercial yeast species. Collections were analysed by gas chromatography coupled to mass spectrometry and over 34 compounds were detected and identified. Results of Principle Component Analyses (PCA) indicated that the five yeast species could be separated according to amounts of the different volatiles produced. However, these differences could not be correlated with differences in behaviour of *D. suzukii* in an activity bioassay.

More work would be required to test whether differences in yeast volatile profiles may render some yeast species more attractive than others to *D. suzukii* in the field. This information could be used to reduce movement of *D. suzukii* into crops and increase catches in precision monitoring traps.

Action points for growers

- Currently there are no action points for growers.

Task 2.2. Investigating the potential of precision monitoring to reduce fruit damage in the neighbouring crop by reducing numbers of overwintering **Drosophila suzukii (*NIAB EMR*)**

Headlines

- In woodlands (and neighbouring crops) where trapping 'precision monitoring' has been applied to control the wild source of *D. suzukii,* fewer *D. suzukii* have been recorded compared to untreated (control) equivalents.
- Preliminary findings show traps positioned on the woodland perimeter caught significantly more male *D. suzukii* than within the main woodland.
- Summer habitat assessments show more *D. suzukii* were caught in traps surrounded by vegetation favoured by the pest.

Background and expected deliverables

Alongside commercially grown fruit, *D. suzukii* utilises wild fruits and habitats where it can find food and a shelter year-round (Grassi et al, 2011). Such habitats provide a source of *D. suzukii* at the beginning (winter form) and throughout the crop growing season (summer form), which migrate into crops. This is supported by the UK *D. suzukii* national monitoring survey (Objective 1), which shows high activity peaks of *D. suzukii* in woodlands during late autumn/early-winter when there is reduced availability of commercial and wild fruit. A trial was established in 2019 to investigate whether the deployment of precision monitoring traps in wild habitats has the potential to reduce *D. suzukii* numbers and minimise the impact in crops in the early spring.

Summary of the project and main conclusions

In September 2019, a grid of 64 precision monitoring traps spaced at eight metre intervals were deployed in isolated pockets of woodlands on six soft fruit farms in South East England. These were compared to a second woodland on each farm with no traps (untreated control).

A RIGA monitoring trap was positioned in the centre of each woodland and respective neighbouring crop and checked fortnightly to monitor numbers of *D. suzukii.* So far, this data shows fewer *D. suzukii* were caught in RIGA monitoring traps in woodlands treated with precision monitoring (and neighbouring crops) than untreated (control) equivalents.

To determine if precision monitoring can prevent or reduce *D. suzukii* numbers invading the neighbouring crop, in spring, summer and autumn 2020, sentinel traps containing raspberries were deployed in the woodlands and respective neighbouring crops to attract females to lay eggs. Subsequent numbers of adult *D. suzukii* emerging from these raspberries were compared. To date, low numbers of *D. suzukii* have emerged from all sentinel fruit deployments. This is likely the result of competition from other Drosophila spp. egg laying in the same fruit. Sentinel fruit deployments in spring 2021 will need a method to allow *D. suzukii* egg laying exclusively. Ripening fruit instead of ripe fruit is being considered.

The trial is also investigating findings that some precision monitoring traps catch more *D. suzukii* than others. This information should help growers decide where best to position precision monitoring to optimise *D. suzukii* control. Catches of *D. suzukii* in traps were investigated in relation to surrounding host vegetation, temperature, humidity, light level and trap position.

To date, findings show significant positive correlations between *D. suzukii* catches in traps and vegetation that is favoured by the pest, during summer. There was also a positive correlation in autumn, though not significant. Statistical analysis of the winter assessment is underway. Further investigation of the influence of specific host vegetation on trap catches is recommended.

Our investigation also found traps positioned on the woodland perimeter catch more *D. suzukii* than those on the woodland interior spring, summer, and autumn.

Assessment of microclimate conditions at traps has so far revealed negative correlations between numbers of male *D. suzukii* caught in traps and temperature, but only in summer. So far, we've found no significant correlations with humidity or light intensity.

This trial will continue into 2021, to see if long-term placement of these traps can suppress local *D. suzukii* populations over time.

Action points for growers

- Monitor for *D. suzukii* in and around soft fruit crops year-round to predict potential incursions.

Task 2.3. Development of a push-pull system for control of Drosophila suzukii (Christina Conroy and NRI)

Headline

- Two repellent compounds have been demonstrated to reduce egg-laying by *D. suzukii* in strawberries at over 6 m from the source.

Background and expected deliverables

Push–pull is a strategy for controlling agricultural pests, typically using a repellent plant to ‘push’ the pest out of the target crop towards an attractant acting as the ‘pull’. In previous work, several compounds were found to repel *D. suzukii* in small-scale trapping experiments. NRI are working with CTP student, Christina Conroy, to develop a push-pull approach for control of *D. suzukii* using synthetic repellents and attractants. From electrophysiological studies, bioassays, and field experiments three compounds were shown to be repellent to *D. suzukii*. These were taken forward into field trials to test their efficacy in preventing egg laying on strawberries.

Summary of the project and main conclusions

The three candidate repellents were formulated in polyethylene sachets. In trials on strawberries in experimental polytunnels, two repellents significantly reduced egg-laying by *D. suzukii* at distances over 6 m. These should be taken forward into larger-scale field trials.

Action points for growers

- Currently there are no action points for growers.

Objective 3. Develop bait sprays for control of *D. suzukii*

Task 3.4A Determine the effect of baits in combination with reduced dose insecticides on D. suzukii control in raspberry (Microbiotech, NIAB EMR)

Headlines

- Weekly alternating dilute applications of Tracer and Exirel combined with Combi-protec or molasses baits, were as effective in controlling *D. suzukii* as full field rates (i.e. a reduction in insecticide application of 96% with the same *D. suzukii* control effect)
- Residues of spinosad and cyantraniliprole were at least x11 higher in fruit samples taken from plots sprayed with the full field rates of insecticides than from plots sprayed with the dilute rates with baits

Background and expected deliverables

D. suzukii phagostimulatory baits could improve the efficacy of plant protection products or minimise the dose of product required. The use of baits is expected to improve *D. suzukii* control efficacy of products with the potential to reduce application rates and improve efficacy of a wider range of product types, leading to reduced risk of chemical residues and resistance. In a series of laboratory assays we tested commercially available and novel baits for attractiveness to *D. suzukii*, toxicity when combined with a low dose of product, and finally, ability to prevent egg laying.

In 2018, the baits were; fermented strawberry juice (FSJ), a suspension of the yeast *Hanseniaspora uvarum*, a combination of the two and Combi-protec, a proprietary mixture of protein, yeast and sugars. Experiments were done in the laboratory in jar microcosm bioassays. Chronophysiology assays (activity counts) using the activity of *D. suzukii*, in the presence of different baits, was the more useful screening method of attractant baits than the large arena test. Without plant protection products, the baits did not affect *D. suzukii* mortality. For Tracer (spinosad), Exirel (cyantraniliprole) and Hallmark (lambda-cyhalothrin), the baits caused higher mortality of *D. suzukii* summer morphs, under summer conditions, compared with using the products in water. The efficacy of products, in terms of increased mortality and reduced egg laying, was greater with *H. uvarum*, FSJ + *H. uvarum* and Combi-protec treatments than with the FSJ only bait. In addition, *H. uvarum* and FSJ baits increased the mortality of *D. suzukii* winter morphs held under winter conditions when used with spinosad or cyantraniliprole but not with lambda-cyhalothrin. When used with cyantraniliprole, *H. uvarum* reduced the egg laying of winter morphs that were transferred to summer conditions after three days of exposure to treatments under winter conditions.

In 2019, baits were tested in mini tunnels containing strawberry plants in grow bags. Bands of Benevia (cyantraniliprole) combined with either *H. uvarum* or Combi-protec were applied as 30 ml per hectare in 40 L, twice during the experiment to the crown of the strawberry plants. This was compared to a water control (untreated) and a positive control (Benevia at maximum field rate). Male and female *D. suzukii* were released into the tunnels on several occasions to inoculate the fruit. Both baits, in combination with Benevia, significantly reduced *D. suzukii* in fruit compared to the water control. There was no significant difference between the positive control, Benevia at full field rate (750 ml in 500L/ha) and the two baits combined with Benevia (30 ml in 40L/ha). The cost of Benevia applied in the bait treatments amounted to £77.50/ha, a reduction from the full rate of £112.5/ha. Application time was reduced by 75% in the bait combined with Benevia treatments compared to Benevia alone.

Summary of the project and main conclusions

The aims of the work in 2020 were to compare the *D. suzukii* control efficacy of weekly applications of dilute rates of Tracer and Exirel when used with and without Combi-protec or molasses, against full field application rates of the same products in raspberries under semi-field conditions.

Weekly alternating dilute applications of Tracer at 8 ml in 40L per ha and Exirel at 36 ml in 40L per ha, combined with Combi-protec or molasses baits, were as effective in controlling *D. suzukii* numbers as full field rates of the same products applied at 200 or 900 ml in 500L per ha (i.e. a reduction in product application of 96% with the same *D. suzukii* control effect). The products used at the full field rates or dilute rates with bait sprays remained as effective in controlling *D. suzukii* numbers in the two weeks after they were applied as they were during the four weeks when they were being applied. Control of *D. suzukii* was equally good with the molasses spray treatment as with the Combi-protec or full field rate spray treatments but at only 21% or 17% of the product costs. The application time for the bait sprays was 10% of the full field rate application of product sprays.

Residues of spinosad and cyantraniliprole were at least x11 higher in fruit samples taken from plots sprayed with the full field rates of products than from plots sprayed with the dilute rates with baits. Residues in fruit from the dilute insecticide rates + bait spray plots were not detectable or lower in samples taken from the bottom of plants than in samples from the top and middle of plants. None of the product or product + bait treatments caused phytotoxicity symptoms and there was no mould growth on the bait spray droplets. The spray coverage of the low rate sprays was approximately 8-times lower than the full rate spray. Despite the larger droplet sizes used for the low rate applications, there was no evidence of any extremely large deposits that could breach MRLs.

Action points for growers

- Growers should discuss the use of approved adjuvants in combination with plant protection products with their agronomy provider and adhere to approvals.

Objective 5. Integrating exclusion netting with other successful controls

A decision was made to defer this until a later year as a new Waitrose CTP PhD student will be working on this in collaboration with Berry World, the University of Reading and NIAB EMR, with 10 replicate tunnels of meshed versus unmeshed raspberry crops in 2020.

Objective 6. Develop, design and communicate a year-round strategy for *D. suzukii* control in UK crops

Headline

- One peer reviewed publication and 15 oral presentations were disseminated in 2020.

Background and expected deliverables

In collaboration with the AHDB communications team, we are producing recommendations for year-round control of *D. suzukii* that targets all life stages and habitats to reduce year on year populations, damage to fruit and the use of plant protection products used for control. Results have been disseminated – over 14 presentations and courses were delivered in 2017, 10 in 2018. In 2019, five peer reviewed manuscripts were published and 16 industry/scientific communications/presentations were given.

Summary of the project and main conclusions

In 2020, one peer reviewed manuscript was published and 15 oral presentations given at both national and international events. This does not include all the one-to-one discussions on *D. suzukii* control with individual agronomists and growers.

NIAB EMR monitoring data was regularly communicated to the AHDB and SWD Working Group, for dissemination to growers.

Action points for growers

- Keep abreast of the latest *D. suzukii* control strategies and research through AHDB communications.

Objective 7. Identification and quantification of *D. suzukii* parasitism in the UK

Task 7.1. Screening Scottish habitats for the presence of Drosophila suzukii parasitoids (JHI)

Headline

- In Scotland, using sentinel *Drosophila melanogaster* larvae and pupae, potential *D. suzukii* parasitoid activity has been identified.

Background and expected deliverables

A Worshipful Company of Fruiterers funded project linked to SF 145 aimed to identify species of parasitic wasps parasitizing *D. suzukii* in South East England. Field surveys also aimed to identify *Trichopria drosophilae*, and to investigate potential interactions of *D. suzukii* with native UK parasitoid species that may contribute to *D. suzukii* control. Field surveys were conducted across several fruit growing and wild sites in the South East of England in two consecutive years (2017 and 2018). Five species of hymenopteran parasitoids were collected using *D. suzukii* larvae/pupae sentinel traps. Two species of larval parasitoids and three pupal parasitoids were recorded in 2018. All five species are generalist parasitoids of *Drosophila.* Habitat surveys highlighted how landscape diversity could influence parasitoid presence.

In 2019, parasitoid surveys were conducted in Scotland using *D. melanogaster* baited traps from the end of July (2019). The numbers of parasitoids emerging from baited traps in 2019 indicated that parasitoid populations were already established prior to the deployment of traps. Parasitoids in 2019 were identified as the larval parasitoid *Asobara tabida*. Parasitoids were trapped in highest numbers in July-September in 2019.

Summary of the project and main conclusions

In Scotland in 2020, parasitoid surveys were conducted using *D. melanogaster* baited traps deployed at the end of May. The numbers of parasitoids emerging from baited traps in 2019 indicated that populations were already established prior to the deployment of traps in July, and so traps were deployed earlier in 2020. Parasitoids were trapped in highest numbers in August and October in 2020, compared to July-September in 2019, and the numbers were up to four-fold higher in 2020 compared with 2019. In 2020 *Asobara tabida* was confirmed as the species detected in the baited traps. There was regional variation in total catch size but no clear link between parasitoid presence/abundance and the suitability of the surrounding vegetation for their SWD hosts.

Action points for growers

- Currently there are no action points for growers

Task 7.2. Investigating the proportion of Drosophila suzukii pupae in sentinel traps parasitized by UK parasitoids (NIAB EMR)

Headlines

- In England, we were able to calculate the rate (%) by which some of the native parasitoids, previously identified in our surveys, parasitize *D. suzukii* in the field.
- Our survey also recorded the parasitoid *Trichopria modesta* for the first time since the survey began in 2017.
- To date, the survey has recorded six native parasitoids associated with *D. suzukii* in England.
- *Trichopria drosophilae,* remains unidentified in the UK and hence cannot be released as a biocontrol agent.

Background and expected deliverables

In 2017 and 2018, a Worshipful Company of Fruiterers funded project linked to SF 145, aimed to identify species of Hymenoptera parasitizing *D. suzukii* in South East England that may contribute to *D. suzukii* control. Field surveys were conducted across several fruit growing and wild sites, also aiming to identify *Trichopria drosophilae*; a pupal parasitoid commercially available in Europe for use in biological control.

Five species of hymenopteran parasitoids were collected using *D. suzukii* larvae/pupae sentinel traps. This included two species of larval parasitoids (*Asobara tabida* and *Leptopilina heterotoma*) and three pupal parasitoids (*Spalangia erythromera*, *Pachycrepoideus vindemmiae* and *Trichopria prema*) all of which are generalist parasitoids of *Drosophila.*

The presence and abundance of these parasitoid species varied greatly among the sites and across the season. At sites where parasitoids were active, small numbers were recovered in May, but the main period of activity was from June to October, with no parasitoids present from November onwards.

Habitat surveys also highlighted how landscape diversity could influence parasitoid presence.

Laboratory tests were performed to calculate the rate by which collected parasitoids parasitize *D. suzukii*. Results showed two pupal parasitoids produced most offspring per parent on cultures of *D. suzukii.* However, the rate of *D. suzukii* parasitism by these species and potential others could not be calculated accurately in UK populations in the field.

The objectives of the survey in 2020 were to:

- Calculate *D. suzukii* parasitism rate under field conditions.
- Determine if parasitism rates change throughout the year.

- Continue to search for the pupal parasitoid *T. drosophilae*, to confirm its presence in the UK.

Summary of the project and main conclusions

To determine the percentage of parasitism in the field, in 2020 two types of sentinel traps containing fruit (control and treated) were infested with equal numbers of *D. suzukii* and deployed in areas with known parasitoid populations, as identified in 2018. A control trap was designed to enable normal *D. suzukii* development, using a lid which prevented parasitoid entry, whilst a treatment trap was designed to enable parasitoids to enter and lay eggs in developing *D. suzukii*. Equal numbers of these traps were deployed on five occasions between July and September, then collected and incubated for 6 weeks. During incubation, adult *D. suzukii* and parasitoids emerging within traps were identified and counted. Mean percent parasitism was calculated as number of parasitoids emerging in treatment traps as a percent of number of *D. suzukii* emerging in control traps.

The most common species recorded in 2020 was the pupal parasitoid *Spalangia erythromera,* with a mean parasitism rate of 1.1% (range 0 to 6%), which peaked in August. *S. erythromera* has been recorded in consistent numbers at the same two sites every survey year. It has also shown promise for *D. suzukii* biocontrol; being active from May to October and completing development to adulthood in lab cultures of *D. suzukii* with mean offspring per parent 0.2. It also does not hyperparasitize.

Surprisingly the pupal parasitoid *P. vindemmiae* was not recorded in 2020, despite it being the most common parasitoid recorded in sentinel traps at the same sites 2017 and 2018. In laboratory tests, this species recorded the highest mean offspring per parent 3.6.

The survey also identified *T. modesta* for the first time since surveys began in 2017, bringing the total number of native parasitoid species recorded in sentinel traps containing *D. suzukii* up to six.

Larval parasitoids *L. heterotoma*, *A. tabida*, *T. prema,* and *T modesta* are less successful at parasitising *D. suzukii*.

To date, *T. drosophilae* has not been identified during these surveys.

Action points for growers

- Ensure that spray drift does not contact hedgerows and woodlands to preserve parasitic wasps of *D. suzukii*; and a range of other generalist predators.
- Continue with crop hygiene and insect exclusion mesh measures to reduce the need for plant protection products.

Task 7.3. Investigating UK waste fruits as a potential source of parasitoids to control Drosophila suzukii in neighbouring crops (NIAB EMR)

Headline

- Due to the low recovery of parasitoids, waste fruit is not worth pursuing as a source of parasitoids.

Background and expected deliverables

Improved hygiene practices are known to help reduce *D. suzukii* pressure in commercial crops. This includes removing waste and unmarketable fruit which may be the result of larval feeding damage. It is possible that the waste fruit collected at UK soft fruit farm is a potential source of parasitoids which could be used for biological control of *Drosophila suzukii.* If managed effectively, waste fruit could be used to provide a source of parasitoids to control *D. suzukii* without releasing *D. suzukii* into the crop.

Summary of the project and main conclusions

Waste fruit was collected from sites known to have *D. suzukii* parasitoids, which were identified during the 2018 surveys (see Obj 7.2). Fruit was collected during the period that parasitoids were known to be active; July-September. These samples were collected on a minimum of two occasions and maintained for six weeks. Most parasitoids have been previously recorded to emerge within one to five weeks post collection.

D. suzukii emerged from all waste fruit collections, but numbers varied between collections. The highest number that emerged (per kg of waste fruit) was from raspberry collected on 17 July and the lowest from cherry collected on 6 July (total = 351.5 and 0.1 respectively). The raspberry collection from which the highest number of *D. suzukii* emerged (17 July) was also the only waste fruit collection from which a parasitoid emerged (0.2 parasitoid kg^{-1}). The parasitoid was identified to be in the Braconidae family.

Other *Drosophila* spp. emerged from all waste fruit collections, but these numbers also varied between collections. The highest number emerged (per kg of waste fruit) was from strawberry collected on 9 September and the lowest from cherry collected on 21 July (total = 353.3 and 0.1 respectively). Other Drosophila species that emerged included: *Drosophila melanogaster, Drosophila simulans* and *Drosophila subobscura*. The species of parasitoids that have been identified in the UK to date are generalist parasitoids and so in cases where *D. suzukii* emergence was low, parasitoids could have emerged from the other species of *Drosophila.*

Where there was low insect emergence from waste fruit, the use of chemical plant protection product (PPP) application and crop hygiene could have potentially been the cause. PPPs are known to affect parasitoids regardless of species (Schlesener et al., 2019) and crop hygiene measures reduce the opportunity for *D. suzukii* egg laying and subsequent parasitism.

This pilot study demonstrated that waste fruit is unlikely to be a significant source of parasitoids, although the one collection with parasitoid emergence was collected in July, which is the time of year when highest numbers of parasitoids emerged during the 2018 wild habitat survey.

Action points for growers

- Currently there are no action points for growers.

Objective 8. *Drosophila suzukii* tolerance to plant protection products

Task 8.1. Investigating the susceptibility of D. suzukii *to approved plant protection products (NIAB EMR)*

Headline

- Early season strains of SWD collected in 2020 appear to be more sensitive to spinosad and lambda-cyhalothrin than late season strains collected in 2019.

Background and expected deliverables

Since its arrival in the UK in 2012, use of Plant Protection Products (PPP) has played a vital role in supressing *D. suzukii* numbers in vulnerable fruit crops. In 2018, an increased tolerance to spinosad (Tracer) was detected in organic raspberries in California by Gress and Zalom (2018). Flies from spinosad treated areas required 4.3-7.7 times higher dose of spinosad for control than those from untreated areas.

In 2019, laboratory trials were established to identify a baseline level of susceptibility in wild populations of *D. suzukii.* Three wild populations were collected from soft and stone fruit farms in the South-East of England and mass reared in the laboratory. They were established from crops with a known insecticidal input and included two commercial crops and one with minimal inputs. These were compared an unsprayed laboratory strain, which has been in culture since 2013 and is expected to have a very low tolerance to PPP. There were varying levels of susceptibility to three PPPs tested between the three wild populations; lambda-cyhalothrin (Hallmark), cyantraniliprole (Exirel) and spinosad (Tracer). Although there was no detection of resistance in the populations we tested, there was an increased level of tolerance in some of the populations to one or more of the products tested.

Summary of the project and main conclusions

In 2020 early season strains were collected from fruit at the end of July. Due to the logistical operations being affected by the pandemic, the early season wild strains took several months to build-up enough flies to execute the bioassays. When looking at the survival probability of the wild strains between years, there was a significant difference between 2019 and 2020 with lower survival in 2020 from all three strains when treated with spinosad and for WS1 when treated with lambda-cyhalothrin. If resistance had been developing in the field populations, we would expect 2020 to have higher survival than 2019. It may be that due to these early season populations being collected early in the growing season they have not been as exposed to control products as those collected towards the end of the season, like the 2019 strains.

Action points for growers

- Growers should consult their agronomist for up-to-date approvals prior to using spray applications for control.
- Where possible, growers should rotate between different product modes of action to prevent build-up of resistance.
- If growers suspect resistance has occurred on their farms, please alert researchers at NIAB EMR.