Grower Summary

SF 145a

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

Annual 2019

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AHDB Horticulture,
AHDB
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel – 0247 669 2051

AHDB Horticulture is a Division of the Agriculture and Horticulture Development Board.

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Project number:	SF145a
Project leader:	Michelle Fountain, NIAB EMR, New Road, East Malling, Kent ME19 6BJ
Report:	Annual report, Year 2, March 2019
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Key staff:	Glen Powell, Adam Walker, Francesco Maria Rogai, Rosa Blanco Fernandez, Gabriele Antoniella, Alastair Gibbons, Molly Perry-Clark, Chris Coyne, Phil Brain (NIAB EMR); David Hall, Dudley Farman (NRI); Dr Ralph Noble, Andreja Dobrovin-Pennington (Microbiotech), Alison Dolan, Gaynor Malloch (JHI)
Key collaborators	Berry Gardens Growers and Angus Soft Fruits
Location of project:	NIAB EMR
Industry Representative:	Marion Regan, Hugh Lowe Farms
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GROWER SUMMARY

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

Headline

- A number of novel techniques are being developed to manage and control SWD in soft and stone fruit crops

Background and expected deliverables

The Asiatic vinegar fly *Drosophila suzukii* Matsumura (Spotted Wing Drosophila - SWD) first appeared in the UK in 2012 and has increased in numbers ever since. It has become a key pest of soft and stone fruits, causing significant damage and an increase in production costs. Growers are forced to implement a number of additional cultural and management practices to monitor for the pest, maintain crop hygiene and exclude it from developing fruit. Additional crop protection sprays are also necessary to achieve complete control and these can disrupt IPM programmes deployed for other insect pests.

Concerted European and North American research projects on SWD are coming to an end (projects IPMDROS, DROSKII and DROPSA). The aim of these projects was to develop new knowledge and understanding of the damage and losses on fruit crops resulting from SWD activity, studying its biology and evaluating control methods. This AHDB funded project builds on international progress and a previous AHDB project (SF145), but focuses on the practical development and elaboration of new control technologies that can be used by UK growers within the short to medium term.

SWD is native to eastern and south-eastern Asia (Walsh et al. 2011) and is a potential target for push-pull control strategies. Growers are still highly reliant on plant protection products to gain complete control. However the number of approved products continues to decline and consumer pressure to reduce their use is increasing. More reliance is placed on those approved products that remain and this can result in the development of pest resistance to these products.

This project therefore aims to develop novel management and control techniques which will reduce our reliance on the remaining approved products.

Specific objectives are to;

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

Summary of the project and main conclusions

Objective 1. Continued National Monitoring of the populations of *D. suzukii* in Scotland and England

Since SWD was first detected in the UK in 2012, populations have continued to rise in most regions of England and there are more frequent reports of the pest being detected nationally and in Ireland. In contrast to the general UK trend, populations in Scotland have been low since the pest was first detected in 2014. In the West Midlands and East Anglia the numbers have been reasonably low, but fruit damage in these regions is increasingly being reported.

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

Monitoring traps were deployed in pairs, one in the centre and one at the edge of each crop. Pairs of traps were also deployed in a wooded area on each farm. The modified Biobest trap design and Cha-Landolt bait was used.

Activity-density of adult SWD in the monitoring traps was lower in the spring (Mar-May) of 2018 compared to 2017 and is typical of findings in a cold spring. The overall tally for SWD in 2018 was therefore lower than 2017. Trap catches in the late autumn vary each year and are largely dependent upon temperature. SWD adults were again detected (Rothamsted Research) at 12 m from the ground during the main flight/dispersal period from September to November. This timing coincides with the emergence of the winter-form adults, a depletion in egg laying resources (fruit) and defoliation of trees (reduced refugia). Despite higher than average temperatures recorded in Scotland during the summer months of 2018 the number/activity levels of SWD remained low.

Data from all four Scottish monitoring sites showed similar trends to those in England, suggesting that the national monitoring data set is representative of the SWD density/activity in Scotland. The density/activity was lower in 2018 than in 2017. The lack of potential egg laying sites detected at the site may have partially contributed to the reduction in the overall catch.

Data has been collated throughout the reporting period and regularly sent to the AHDB.

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

Potential repellents to deter *D. suzukii* laying eggs in fruits or discouraging adults entering the cropping area were investigated in the previous project (SF 145). These were further investigated in 2017 either alone or as a blend. Repellent methods are likely to be more effective in combination with other methods such as 'Attract and Kill' (A&K) technology to form a 'Push-Pull' strategy; pushing away from the crop and pulling towards an attractant which would contain a distracting or fatal component. To this end, we further optimised the NIAB EMR / NRI prototype device including the design and the attractant formulation and compared this to a commercial trap currently undergoing approval. The control component in the prototype is enclosed within the inner surface of the device to minimise human exposure and environmental contamination including adverse effects on beneficial insects. Unlike 'mass traps', the A&K device is open ended and does not become saturated with dead flies which reduces the high labour costs which can be associated with A&K.

Repellents

In 2017, two repellent experiments were done in an unsprayed cherry orchard at NIAB EMR. All six treatments used synthetic semio-chemical compounds which were coded. Repellents were dispensed from polyethylene sachets or rubber septa. Twenty sachets/septa were suspended evenly throughout each cherry tree (plot) on 12 May and again on 13 July. Sentinel fruits were then deployed within the tree canopy and incubated for two weeks in a laboratory to test for the presence of *D. suzukii*. There were five replicates of each treatment in a randomised block design. Sentinel fruit were deployed on 15 and 22 May for the first experiment and 14 and 21 July for the second experiment.

Only one SWD emerged from sentinel strawberries in a blend treatment in the first experiment suggesting that a blend may be more effective than single components. However, SWD was aggregated in only two blocks in the first experiment removing the possibility of detecting a significant effect. SWD was present throughout the cherry orchard by July but numbers were too high and plots probably too small to detect repellent effects.

In 2018, it was decided to use the blend of potential repellent compounds as part of a push pull strategy. Repellent sachets were placed in 25 x 25 m plots and surrounded with a commercial, coded, trap, the aim being to push SWD out of the crop and towards the traps to remove adult flies from the cropping area.

The trial was repeated at four commercial strawberry plantations in Kent and a randomised block design was used. Each block was sub-divided into four plots which had one of four treatments 1) **Push** - a central square of polyethylene sachets containing the repellent every 2 m, 2) **Pull** - sixteen coded traps positioned around the plot perimeter 3) **Push-Pull** - repellents and traps 4) **Control** – no repellents or traps.

Despite repeated attempts to adjust the methodology to gain information, the trial was unsuccessful. Following statistical analysis, push, pull, or push-pull appeared to have no significant effect on SWD.

In 2019, a more focused semi-field study will be done to determine the repellent activity of the blend. Some new potential repellents will be assessed as part of the Berry Gardens CTP PhD studentship. Once this finer detailed study is complete, and if successful, we may follow this with re-testing on commercial crops.

Attract and kill device

Work has been developing an A&K Falcon Tube at NIAB EMR. In 2017, we compared the device and attractant to a commercial standard. Laboratory cultured SWD were introduced with the prototypes and mortality assessed 24 hours later. The lures used in the prototype were separate half size sachets of ethanol/ acetoin, acetic acid and methionol (provided by NRI) and referred to as mini Cha-Landolt. Experimental prototypes, with the exception of the untreated controls, were coated on the inside with Decis formulation (deltamethrin) or a field formulation of spinosad (Tracer). The colour, position and number of holes in the prototype were manipulated in the replicated trial.

The prototype Falcon tube devices, with Decis as killing agent, were as effective as the commercial trap in controlling SWD. The devices give up to 30% kill of SWD within 24 hours in these semi-field cage trials. The devices with eight holes on the red sections were more effective than devices with four holes on the clear part of the trap. However, increasing the number of holes on the device from eight to sixteen did not increase the efficacy.

In 2018, with a similar experimental set up we tested the Falcon tube device in comparison to two other commercial standards; one with insecticide coating and one without. The Falcon tubes had 8 x 0.5 cm holes on the red part and 1 x 0.6 cm hole in the bottom, painted red in the middle and base clear. This experiment was done with and without fresh strawberries in the cage to determine whether the presence of fruit affected the kill of *D. suzukii*.

In a second trial we only introduced either mated or unmated female SWD to determine whether the traps were more likely to kill unmated rather than mated female flies.

The prototype Falcon tube A&K device gave up to 25% kill of SWD within 24 hours in these semi-field cage trials in the absence of fruit. Compared to the same trial in 2017, the efficacy of the device declined by 5%. The Falcon tube A&K device was confirmed to be as effective as the commercial trap in causing mortality of SWD. With no insecticide coating, neither the commercial trap (B) nor the Falcon tube was effective in controlling SWD. Importantly, in the presence of ripe fruit, the efficacy of both the Falcon tube device and the commercial trap (A), with Decis, decreased substantially killing up to only 15% of flies within 24 hours. This suggests that these trap/devices should be deployed in early spring when there is no competition with ripening fruit and SWD populations are at their lowest. A&K devices should be used within an IPM context and be deployed in large numbers around the outside of crop perimeters and combined with insect meshing to prevent migration into the crop. There was no difference in effectiveness of the devices at controlling mated or unmated females. Our study confirmed that mated females are motivated to spend more time on fruit than away from fruit.

Work in 2019 will focus on using the devices in wild habitat in order to reduce populations in the spring adjacent to cropping areas.

Improving the Cha-landolt bait

In a third piece of work we aimed to improve and miniaturise the standard Cha-Landolt bait which is composed of the fermenting volatiles: ethanol, acetic acid, acetoin and methionol into a dry formulation, removing the need for a liquid killing agent.

All tested formulations were compared to the standard Cha-Landolt lure; ethanol and acetic acid were dispensed from the drowning solution (300 ml) and/or the commercial Biobest “Dros’Attract” solution (300 ml). Dry formulations were dispensed in polyethylene sachets. Release of the four components of the Cha-Landolt blend from polyethylene sachets provides a practical “dry” alternative to the conventional liquid bait, as required for development of devices for control of SWD by attract-and-kill and, particularly, lure-and-infect approaches.

In 2017, the standard sachet lure developed originally released ethanol and acetic acid at 1% and 10%, respectively, of the rates from the liquid Cha-Landolt lure and requires changing every six weeks rather than weekly.

The attractiveness of the standard sachet lure was not affected by increasing the release rates of ethanol or acetic acid, or by reducing the release rate of ethanol to one quarter. However, the attractiveness of the standard sachet lure can be increased by increasing the release rate of acetoin by four times to approximately 32 mg/d. Further increase in the release rate of acetoin did not increase catches significantly.

In most experiments removing the methionol did not affect catches of SWD, but in other experiments catches were reduced. In some experiments catches with the optimised sachet lure were at least as great as those with the liquid Cha-Landolt and Dros'Attract lures, but in others they were significantly lower.

A MiniLure was developed for use in the Falcon tube attract-and-kill devices and shown to be effective under semi-field conditions. This should have a lifetime of at least 6 weeks and probably longer in the confines of the Falcon tube. Although release rates of ethanol, acetic acid and methionol are probably adequate, there was scope to increase attractiveness by increasing the release rate of acetoin from the MiniLure nearer to the optimum level.

In 2018, the aims were to further reduce the size of the mini-lure, evaluate commercial versions of the mini-lures developed by Russell IPM for use in attract-and-kill devices and optimise the attractiveness of the mini-lure relative to those of Cha-Landolt and commercial wine/vinegar mixture standards.

Using repeated field trapping tests, it was confirmed that catches with the sachet lure could be at least doubled by increasing the release rate of acetoin, making it similar in attractiveness to the Cha-Landolt mixture currently used in the UK SWD National Monitoring Survey. Methionol was found to be unnecessary in either the sachet lures or the Cha-Landolt. This is an important result as methionol is the most expensive component and the most unpleasant and hazardous. In addition, it should also be noted that we have never detected methionol in any of the commercial wine/vinegar lures.

The greater attractiveness of lures with attractants in the drowning solution over "dry" lures is probably due to large differences in release rate rather than some specific effect of having attractants in the drowning solution. In this year's experiments, the Cha-Landolt lure was less attractive than the current Biobest Dro'Attract, even though previous work had shown them to be comparable in attractiveness.

The Russell IPM lures need further improvement, at least in part due to low release rates of ethanol and acetoin.

In 2019 we will aim to determine the volatile attractants in the yeast ferments of attractive yeast species from a recent CTP PhD on attractive yeast strains.

Objective 3. Develop bait sprays for control of SWD in vitro

SWD phagostimulatory baits could improve the efficacy of control products or minimise the dose of sprays required. The use of baits is expected to improve SWD control efficacy of products, potentially reducing application rates. They could also improve the efficacy of a wider range of product types, leading to reduced risk of residues and resistance. In a series of laboratory assays we tested commercially available and novel baits for attractiveness to SWD. We also assessed toxicity when combined with a low dose of product, and finally, their ability to prevent egg laying.

The baits tested included 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 SWD in the presence of different baits, was a more useful screening method of attractant baits than the large arena test.

Without control products, the baits did not affect SWD mortality. For spinosad, cyantraniliprole and lambda-cyhalothrin, the baits caused higher mortality of SWD summer morphs, under summer conditions, compared with using the products in water. The efficacy of products, in terms of increased mortality and reduced oviposition, was greater with *H. uvarum*, FSJ + *H. uvarum* and Combi-protec treatments than with FSJ only bait. In addition, *H. uvarum* and FSJ baits increased the mortality of SWD 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 oviposition of winter morphs that were transferred to summer conditions after three days of exposure to treatments under winter conditions.

Phytotoxicity on cherry and strawberry leaves in the field was observed in treatments including cyantraniliprole, both with and without baits, but was not seen in any other product and/or bait combinations.

Phagostimulant baits improved the product control of SWD summer and winter morphs by increasing mortality and reducing oviposition. The relative phagostimulant effect of the baits did not fully correspond with their olfactory attractiveness to SWD determined using the chronophysiology equipment.

With control product treatments, SWD mortality was lower using raspberry leaves than using blackberry, blueberry, cherry or strawberry leaves but the effect of leaf type on SWD mortality was small (up to 12% difference) compared with the effects of baits and control products (up to 90% difference).

This work will now progress to semi-field testing in tunnels at NIAB EMR in 2019. Baits will be tested with strawberry plants containing SWD.

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

The aim of the studies in this objective were to determine the length of time that cherry extrafloral resources were available to SWD in a cherry orchard and to investigate the length of time that control products targeted against SWD in spray programmes were active in order to prolong the spray intervals beyond 7-10 days.

For the first aim, in 2017 we picked leaves weekly from the varieties `Penny` and `Sweetheart`. From 05 April to 14 September, five leaves from each variety were collected and introduced, individually, onto the floor of a culture cage of SWD. The number of SWD that landed and fed, the time to find the extrafloral nectaries and the length of feeding time over a five minute period was recorded.

The first fecund SWD was found on 6 April, then a week later more than half (57%) of the female SWD in the traps were fecund; this coincided with flowering. As the season progressed the time taken to locate nectaries in the leaves tended to increase, but demonstrated that there was a food source available to SWD until after fruit harvest. There was a weak link with less feeding after a period of rain, indicating that potentially nectar and beneficial microbes could have been washed from the surface of the leaves making the extra floral nectaries less attractive to SWD.

To investigate spray intervals on cherry, two small trials were established in 2017; 1) Commercial trial with 2 replicate tunnels, 2) Semi-field trial at NIAB EMR in one tunnel. In the commercial trial, all plots were insect meshed but no untreated control was used. In the semi-field trial, no insect mesh was installed and an untreated control was included.

Either a weekly or fortnightly commercially approved spray programme was employed at the two sites. At the commercial site, 50 fruits were collected weekly. At the semi-field site, leaves were collected weekly just before the next spray was applied and a laboratory bioassay done to test the mortality of SWD that came into contact with the leaves. In the commercial trial, on fruit there were two replicates of two cherry fruit varieties (Kordia and Regina) and in the semi-field trial there were four replicates of five leaves. Fruits collected from the commercial trial were incubated to calculate emerging SWD. Monitoring traps were in place at both sites on the perimeter and inside the crop.

At the commercial site, the numbers of adult SWD captured inside the insecticide treated tunnels (peak 11) inside the mesh, was lower than in the perimeter (peak 70), outside the insect exclusion mesh. Only two female SWD were found in all of the fruits sampled throughout the growing season; one from the weekly and one from the fortnightly spray programme.

In the semi-field leaf bioassay the mortality in the untreated control plots was usually less than 10%. There was significantly more SWD mortality in the weekly and fortnight spray programmes compared to the untreated control, but no difference between the two spray programmes until the spray applications ceased. Following the cessation of sprays the effects of the products declined over time (7-28 Aug). Hence, in this study, either weekly or fortnightly applications of insecticides to cherry leaves gave significantly higher mortality (~90%) compared to untreated leaves (up to 10%) 48 hours after exposure.

We repeated the cherry spray trial in 2018, but on eight orchards across two grower sites. The findings were similar to the smaller commercial trial (two orchards) in 2017. Fortnightly spray programmes gave equal efficacy of SWD control as the grower's standard spray programme. In addition, very few fruits were damaged by SWD egg laying in both spray programmes, even though adults were clearly in the crop and around the perimeter. Where mesh was employed, there were fewer SWD adults in the crop. Hence for cherry under protection, even on mid and late season varieties, as long as insect exclusion mesh is employed and good crop hygiene measures are used, the current recommendations for the number of SWD sprays appears adequate under current SWD populations.

Also in 2018, we began to test extending the spray interval from one to two weeks in raspberry, but only on two primocane raspberry crops. At a grower site, two tunnels in each of the two crops were treated with the fortnightly spray programme and compared to the growers' standard programme.

Assessments were made weekly, again the day before spraying (if a spray was planned). More SWD were caught in monitoring traps outside the raspberry tunnels than inside the insect meshed tunnels.

More adult SWD were also caught inside the crops where the growers spray programme was applied, on three occasions, compared to the fortnightly spray programme, even though the fortnightly plots were under higher SWD immigration pressure from the surrounding habitat.

Because there were only two replicates of each treatment it was not possible to do statistical analyses on pest emergence from fruit (an indicator of egg laying) or the numbers of SWD that came into contact with raspberry leaves. However, in most weeks, fewer SWD emerged from fruit and more adults died in contact with leaves in the crop in the fortnightly applied spray programme compared to the growers' conventional programme.

As with the cherry spray trial, a fully replicated spray trial in 2019 will help to confirm the beneficial findings of the fortnightly spray programme in raspberry.

Objective 5. Integrating exclusion netting with other successful controls

A decision was made to defer this until a later year as a new CTP PhD student will be working on this in collaboration with Berry World. Initial results will be communicated in late summer 2019.

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

In collaboration with the AHDB communications team, we are producing recommendations for year round control of SWD 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 and 10 in 2018, by the team. National Monitoring data was regularly communicated to the AHDB and *D. suzukii* Working Group for dissemination to growers.

Main conclusions:

- SWD numbers continued to increase in traps in most regions of the UK.
- The components of a Push-Pull system have shown promise and will be tested in 2019.
- Advances have been made with a feeding bait which increases mortality and reduces egg laying when combined with a low dose of spray control product.
- A fortnightly spray programme was as effective as a 7-day spray programme at controlling SWD in cherry when combined with insect mesh.
- The potential for SWD to feed on the extra-floral nectaries of cherry leaves lasts until the leaves senesce in late summer.

Financial benefits

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.

Action points for growers

- Use a range of control measures to control SWD on affected fruits.
- Prevent SWD migration into the crop in the spring by using insect mesh, ideally in combination with precision monitoring around the perimeter.
- Continue to use precision monitoring throughout the winter when the traps are more attractive due to the lack of fruit.
- Protect fruits with applications of approved products. Consult your agronomist for the latest approvals.

- Spray intervals under protected cherry can be extended to 2 weeks from white fruit stage in combination with insect exclusion mesh and rigorous crop hygiene.
- Good spray coverage is essential to protect the fruit. Thorough coverage allows SWD to pick up the product and achieve further control.
- Continue to monitor adult SWD both inside and outside the mesh to ensure spray programmes are effective.
- Make regular inspections of fruits to ensure populations are not building inside the crops.
- Consult AHDB Factsheet 06/17 'Management and control of spotted wing drosophila' for full guidance on current management and control practices.