European Innovation Partnership (EIP) Wales

Improving knowledge and experience of integrated pest control of soft fruit in Wales to reduce pesticide application and wastage

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Background

Soft fruit production in Wales has begun to increase in recent years as farms diversify into new ventures. Farms that are attracted to horticulture as a potential development area are mostly traditional farms. Often younger generations see the scope and what could be achievable on their farms. These farms do have a lot of experience in growing crops and intensive management and with some technical support available to them can make useful opportunities with horticultural crops as an alternative venture. With more growers moving into growing horticultural crops in wales, they are increasingly vulnerable to damage from aphids, mites, thrips and other pests.

Integrated Pest and Disease Management (IPDM) has seen increasing prevalence across commercial horticulture as growers seek to reduce the impact of pests and diseases on production. Decreasing availability and effectiveness of conventional (chemical) controls and an increasing pressure from supermarkets and consumers to reduce pesticide usage has seen a need for growers to adopt IPDM programmes. Further pressure from a government level is in place with a UK national action plan for the use of sustainable use of pesticides, the consultation ended in February 2021 and is aiming to further regulate pesticide usage to protect human health and the environment as well as encouraging the development of IPDM.

Most of the UK soft fruit industry now implement IPDM to various degrees. The industry was forced into using biological controls to control a pest called Western Flower Thrips (WFT) that became resistant to all approved pestides. This led to high value crops being abandoned in July when they should have produced until October and represented a devastating loss to profitability and the industry overall. IPDM offered the most successful control for this pest, leading to growers encouraged to try options for other pests and diseases that were affecting them. IPDM has become more of the norm now for other species of pest as well, with growers now looking at solutions that IPDM can offer them. Biological controls also offer the principal advantage that due to it being a natural process of predation pests cannot become resistant to them unlike conventional chemistry applications.

A number of IPDM solutions require more technical expertise than the use of conventional pesticides. So a lot of the adaption of IPDM solutions have been initially taken up by the larger supermarket growers with larger teams and higher budgets. However, once demonstrated IPDM has the potential to provide methods of control for a range of crop pests, reducing wastage and increasing profitability while reducing pesticide inputs, costs of conventional pest control and enhancing biodiversity of the agri-ecosystem even at the smaller scale. IPDM is an increasingly attractive way for growers to improve the profitability and competitiveness of their businesses as a result.

The managed introduction of biological control agents (predators or parasites of pest species) can be an effective tool in controlling pests with a range of products available commercially. A range of biological control species (e.g. *Aphidius, Amblyseius, Phytoseiulus* and nematodes) are commercially available and can offer comparable if not greater pest control than chemical methods. Biological controls can be used alongside bioprotectants (biological based chemicals used as pesticides) to get greater levels of control.

Pest and disease control is a key area allied with plant nutrition and other husbandry issues. The EIP projects allow scope to bring on new farmers and also update existing ones. This IPDM project works with two farms in Wales; one new to fruit production and one very experienced practitioner. There is therefore an opportunity to share and develop new skills in tandem with the support from the project and to then go on and deliver these skills to the other industry members in Wales.

The main aim of this project is to show to growers in Wales that biological controls can achieve equal if not greater pest control compared with a conventional approach in strawberry crops which has the benefit of reducing reliance on pesticides as well as being a contingency in case any products are revoked.

Integrated pest and disease management (IPM) Programme & Application Schedule

Two sites were used to demonstrate the biological control products in 2020. Springfields (Site 1) and Scurlage (Site 2); both sites used two tunnels of tabletop grown strawberries, one to test the biological controls (known as the IPM tunnel) and one for the standard Grower programme used at that site (known as the control tunnel). The control tunnel would represent the standard code of practice used by the growers at that site and would act as a control to compare the treatments/ methods used in the IPM tunnel. Both tunnels were monitored for the nominated pests (

) for the season.

IPM programmes were created by C. Creed in conjunction with ADAS entomologists and industry experts for use in the IPM treatment tunnels to be implemented at the two sites. The biological control companies Biobest, Koppert and BASF supplied the biological control products used in the trial. The programme design focused primarily around biological controls which offered the greatest chances of success, bioprotectants would have been used in a situation where biological controls could not control the pests present. Biological controls offered the greatest chance for long term success in the crop once established.

Site 1 consisted of growers who had been using IPDM successfully in their own everbearer strawberry tunnels for a large number of years. They were already using products like *Neoseiulus cucumeris, Phytoseiulus persimilis and Aphidius colemani.* They were looking for ways that they could tweak or add to their current programmes and expand the IPDM methods used. They were picking fruit from May until November.

Site 2 consisted of growers who were comparatively newer to using IPDM in their June-bearer strawberry crops. They were looking for support in adding IPDM to their methods of crop protection. They were picking fruit from June until July.

The schedule that these biological controls were applied to is in

Table *2*, supply was initially difficult in the early part of the season due to COVID-19 making it difficult to acquire biological controls due to impacts on the supply chain and supplier workforce. The biological controls were largely in place on the anticipated start time despite this. Site 1 saw an unprecedented increase in aphid numbers at the time, due to higher than average temperatures, bringing their typical window earlier than normal. As a result the growers approached Fargro to get biological controls delivered earlier as they needed something to address the pest increase quickly.

Table 1: Summary of pest species and associated biological control description for control.

Target Pest	**Photo of pest**	**Biological control Agent**	**Description**
Two spotted (Red) Spider Mite		*Phytoseiulus persimilis*	Predatory mites released as adults and nymphs from a plastic tube.
Thrips		*Neoseiulus cucumeris* (sometimes referred to as *Amblyseius cucumeris*)	Mites in a sachet with food that feed on 1st stage larvae of some thrips species (principally for Western flower thrips).
		Orius laevigatus	Predator adults or nymphs released from a bottle (will feed on adults and larvae of most thrips species).
Aphids		Parasitoid wasps of a mix of species (*Aphidius colemani, Aphidius ervi, Aphelinus abdominalis, Praon volucre and Ephedrus cerasicola*) though sometimes just *Aphidius colemani* is used.	Parasitic wasps as mummies in a bottle that then hatch and fly amongst the crop.
		Chrysoperla carnea	Lacewing larvae, not mobile but effective predators of aphids and also Two spotted spider mite.

Vine Weevil		*Steinernema kraussei*	Nemasys® L targets larval stages of the black vine weevil in soil or container-grown crops.
Whitefly*		Encarsia formosa	Winged parasitoid wasp that parasitizes both the Greenhouse whitefly (*Trialeurodes vaporariorum*) and the Tobacco whitefly (*Bemisia tabaci*).

*This pest was spotted in the trial area at Site 1 and though not initially one of the pests proposed to be controlled was added to the monitoring scheme, ADAS approached Biobest for *Encarsia* to control the pest.

Table 2: Application schedule of biological controls used in the IPM tunnel at the two sites.

Biological control Product	**Supplier**	**Rate**	**Application Dates**
Phytoseiulus-System *(Phytoseiulus persimilis)*	Biobest	Rate: 4 mites/plant,	6/5/20, 13/5/20 & 27/5/20
ABS - System *(Neoseiulus cucumeris*)*	Biobest	Rate: 2 sachets per 2m	13/5/20 & 3/6/20
Orius-System *(Orius laevigatus)*	Biobest	Rate: 0.25 adults per plant.	3/6/20
Aphiscout *(Mix of parasitic wasps, Aphidius colemani, Aphidius ervi, Aphelinus abdominalis, Praon volucre, Ephedrus cerasicola.)*	Koppert	Rate: 1.25/m² (Curative rate)	Weeks 19, 20, 21, 22, 23.
Chrysopa *(Chrysoperla carnea)*	Koppert	2-5 per m^2	7/5/20 & 13/5/20
Nemasys L *(Steinernema kraussei)*	BASF	1 million nematode/m^2 applied as a soil drench.	Week beginning 14 September.
Encarsia-System *(Encarsia Formosa)*	Biobest	1 card per 25 linear metres	12/7/20, 28/7/20 and 11/8/20
An additional application of *Amblyline, Aphyline & Phytoline* were made in the week beginning the 13 April by an additional order from Fargro at site 1 in order to get biological controls into the crop as soon as possible due to rising aphid numbers.			

**Neoseiulus cucumeris was only applied at Site 1, Site 2 was reported by the grower to not have a problem with Western flower thrips (the primary prey of Neoseiulus cucumeris) and so was not applied there.*

Table 3: Biological control and bioprotectants products applied to the grower tunnel for pest control as well as any conventional pesticides applied at Site 1.

Date	Product	Also applied to the IPM tunnel?
8/3/20	Paraat (Conventional fungicide, Dimethomorph)	Y
26/3/20	Calypso (Conventional pesticide, Thiacloprid) & Fortress (Conventional herbicide, Quinoxyfen)	Y
1/4/20	Clayton Abba (Conventional fungicide, Abemectin)	Y
10/4/20	Flipper (Bio protectant, Fatty acids), Topas (Conventional fungicide, Penconazole) & Teldor (Conventional fungicide, Fenhexamid)	Y

15/4/20	*Phytoseiulus persimilis*	N
17/4/20	*Aphidius colemani*	N
19/4/20	AQ10 (Bioprotectant fungicide, *Ampelomyces quisqualis),* Serenade Aso (Bioprotectant fungicide, *Bacillus subtilis)*	Y
29/4/20	*Neoseiulus cucumeris* & Amylox (Bioprotecant fungicide, *Bacillus amyloliquefaciens)*	N
29/4/20	Majestik (Bioprotectant insecticide for TSSM, Maltodextrin)	Applied just to IPM tunnel.
30/4/20	*Chyrsoperla carnea*	N
6/5/20	*Phytoseiulus persimilis*	N
12/5/20	AQ10 *(Bioprotectant fungicide, Ampelomyces quisqualis)*, Serenade Aso (Bioprotectant fungicide, *Bacillus subtilis)*	Y
13/5/20	*Phytoseiulus persimilis*	N
22/5/20	Amylox (Bioprotecant fungicide, *Bacillus amyloliquefaciens), Pretect*	Y
21/5/20	*Chyrsoperla carnea*	N
27/5/20	*Neoseiulus cucumeris*	N
28/5/20	AQ10 (Bioprotectant fungicide, *Ampelomyces quisqualis)*, Serenade Aso (Bioprotectant fungicide, *Bacillus subtilis)*	Y
2/6/20	Potassium bicarbonate	Y
3/6/20	*Neoseiulus cucumeris*	N

Table 4: Biological control and bioprotectants products applied to the grower tunnel for pest control as well as any conventional pesticides applied at Site 2.

Date	Product	Also applied to the IPM tunnel?
29/1/2020	Batavia (Conventional pesticide, Thiacloprid)	Yes
11/4/2020	Amistar	
25/4/2020	Switch	
12/5/2020	Teldor	
25/5/2020	Charm	
6/6/2020	Luna sensation	
22/6/2020	Charm	
9/7/2020	Luna sensation	

Assessments & Results

Due to Covid–19, ADAS scientific staff were not allowed to visit the grower sites initially. An assessment schedule was devised for the growers to monitor the crops and send data through to ADAS consultants throughout this period. As growers are very busy the assessments were designed to minimise the impact on the growers but still enough to collect a robust data set for comparison.

Ideally assessments were to take place every two weeks but monthly was also suitable. This was successful at Site 1. Site 2 was unable to send through data sets however did send through virtual crop walks to ADAS consultant Chris Creed for crop monitoring and programme development.

Eight to ten strawberry plants per tunnel were selected, each plant had four leaves, four flowers and four strawberry fruit checked for the pests in

. After the 25th of June ADAS was able to access the sites so A. Clarke from ADAS was able to visit monthly. Assessments finished on the 25 August at Site 1 and the 15 July at Site 2, Site 2 was visited on the 4 August however the polytunnel skin had been removed and crop left to dry out so no recordings were made.

Site 1 performed an early spray of Calypso (26/3/2020 -Thiacloprid) and Flipper (10/4/20 – Fatty acids) (Table 3) to reduce initial pest numbers continuing from last season. Risk of pest pressure is higher when keeping overwintering crop as done so at this site as pests have longer to establish a foundation as well as an earlier chance to build up.

Aphid numbers at Site 1 were initially higher in the IPM programme than in the Grower programme in the early months of the season. The higher numbers are very likely to be due to the higher temperatures that occurred which boosted the aphid numbers seen early on. The growers at Site 1 were able to react faster and started treatments earlier allowing for a swifter control in the control tunnel. Numbers peaked on the 20 May at a mean of 7.5 aphids per leaf assessed compared to the 0.13 in the Grower programme. Aphid specimens delivered to the lab found that the species was the potato aphid *Macrosiphum euphorbiae.* Parasitoids were applied heavily from early May at the site in both the grower tunnel and the IPM tunnel, with lacewing applications as a curative measure in both as well. The main difference in usage was that the IPM tunnel used a species mix which is effective against a wider range of aphid species. *Aphidius colemani* which was used in the control tunnel at Site 1, though effective against the cotton aphid (*A. gossypii*) and the peach potato aphid (*Myzus persicae) is* less effective against the potato aphid. A different species of parasitoid is recommended *(Aphidius ervi)* to deal with them. It can often take time to identify aphids to species and to apply the correct parasitoid species, hence why the species mix of parasitoids is recommended. Many mummified aphids in the IPM tunnel were spotted in late May and all through June showing the parasitoid wasp were having an impact on aphid numbers. The grower added to this control by removing infected runners of particularly infested plants in April to drop the numbers. Between these actions numbers were much lower on the 4 June and barely seen at all from the 18 June.

Low levels of adult vine weevil damage was seen in the IPM tunnel during July and early August before the nematode applications were made mid-September. Overall though damage from vine weevil adults was low. The main risk to crop from vine weevil comes from the larvae which consume the roots and can cause plant death in the autumn, no plant death or damage due to vine weevil larvae was observed at any of the visits. The nematode applications should have controlled the larvae in the root zone to help avoid plant death. Unfortunately there is no physical way to monitor the larval numbers without removing the plants and checking the root zone, which is a destructive assessment and beyond the remit of this monitoring. The monitoring will continue into the next season to show how the nematodes have achieved control of the larvae as that will result in less adults.

Mean numbers of thrips peaked in June, laboratory identifications found these to be a species of thrips called the Rubus thrips (*Thrips major*). This species largely does not breed in the crop to the same level as Western Flower Thrips and so *Neioseiulus cucumeris* which feeds on larvae, would have had less of an impact on its numbers. As a result the introductions of *Orius* that feed on adults of T. major will be the controlling element of the IPM tunnel.

The observation of whitefly in the crop which were low in number and observed on other plants than those monitored led to the introduction of *Encarsia*. From the grower notes it was able to reduce the whitefly levels.

Table 5: Results from Site 1, Springfields. Aphid numbers, Two spotted spider mite (TSSM), vine weevil damage are mean per leaf assessed. Mean number of thrips and mean % thrips bronzing are per flower and per fruit respectively. Thrips bronzing is damage caused by thrips feeding that leads to a discolouration of the fruit.

DATE OF ASSESSMENT	TREATMENT	MEAN APHID NUMBERS	MEAN TSSM DMG	MEAN % VINE WEEVIL DMG	MEAN NO. THRIPS	AVERAGE OF % THRIPS BRONZING
22.4.20	IPM Programme	0.35	0.00	0.00	N/a*	N/a*
	Grower Programme	0.00	0.00	0.00	N/a*	N/a*
6.5.20	IPM Programme	4.38	0.00	0.00	0.00	0.00
	Grower Programme	0.00	0.00	0.00	0.00	0.00
20.5.20	IPM Programme	7.50	0.00	0.00	0.00	0.00
	Grower Programme	0.13	0.00	0.00	0.00	0.00
4.6.20	IPM Programme	1.01	0.00	0.00	0.94	0.00
	Grower Programme	0.00	0.00	0.00	0.45	0.00
18.6.20	IPM Programme	0.08	0.00	0.00	0.95	0.00
	Grower Programme	0.00	0.00	0.00	0.38	0.00
14.7.20	IPM Programme	0.00	0.00	0.31	0.38	0.00
	Grower Programme	0.00	0.00	0.00	0.22	0.00
4.8.20	IPM Programme	0.00	0.00	0.78	0.38	0.00
	Grower Programme	0.00	0.00	0.00	0.24	0.00
25.8.20	IPM Programme	0.00	0.00	0.00	0.09	0.16
	Grower Programme	0.00	0.00	0.00	0.03	0.00

*no thrips data from this period as there were no flowers or fruit.

Below are the yields from the two tunnels at Site 1 (**Table 6**). Yields are presented in kg, the two tunnels have a different cladding which can sometimes impact the yield but the total yields are relatively similar and equates to approximately 45 t/ha. The IPM tunnel had a cladding that reduced daytime temperature whereas the grower tunnel had a standard 5 year poly. The fact that the yields are similar is a positive sign given the difference in pest pressure and the different cladding on the external skin.

Table 6: Yields from the Grower and IPM tunnel at Site 1, the IPM tunnel is clad with Luminance and the other standard 5 season poly.

	GROWER TUNNEL	**IPM PROGRAMME**
MAY	157	130
JUNE	126	76
JULY	631	519
AUGUST	558	652
SEPTEMBER	221	168
OCTOBER	71	100
TOTAL KG	1764	1645

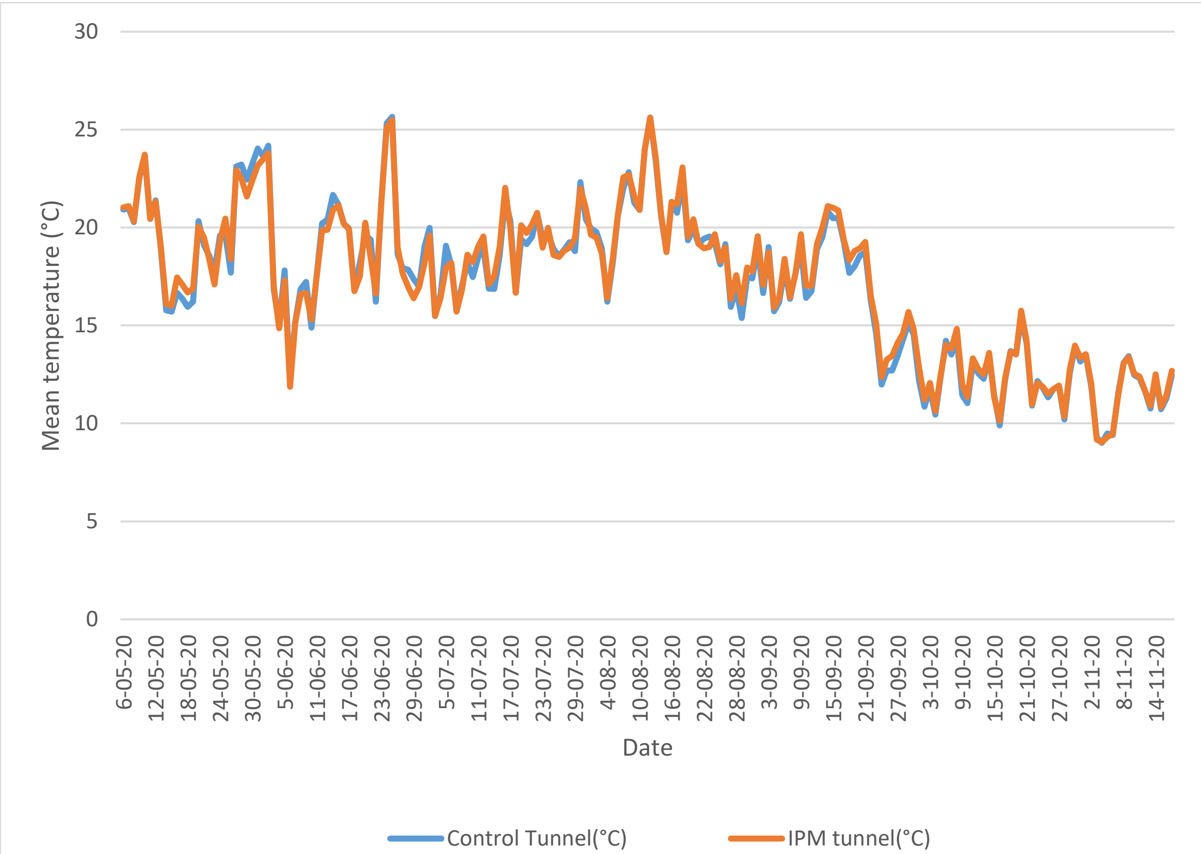

Figure 1: Mean temperature (°C) in the control and IPM tunnels at site 1.

Mean temperatures in the two tunnels were roughly consistent with each other throughout the trial period. The highest temperatures noted was on the 24 June (25.4°C) and 12 August (25.6°C). The lowest temperature was on the 4 November (9.0°C).

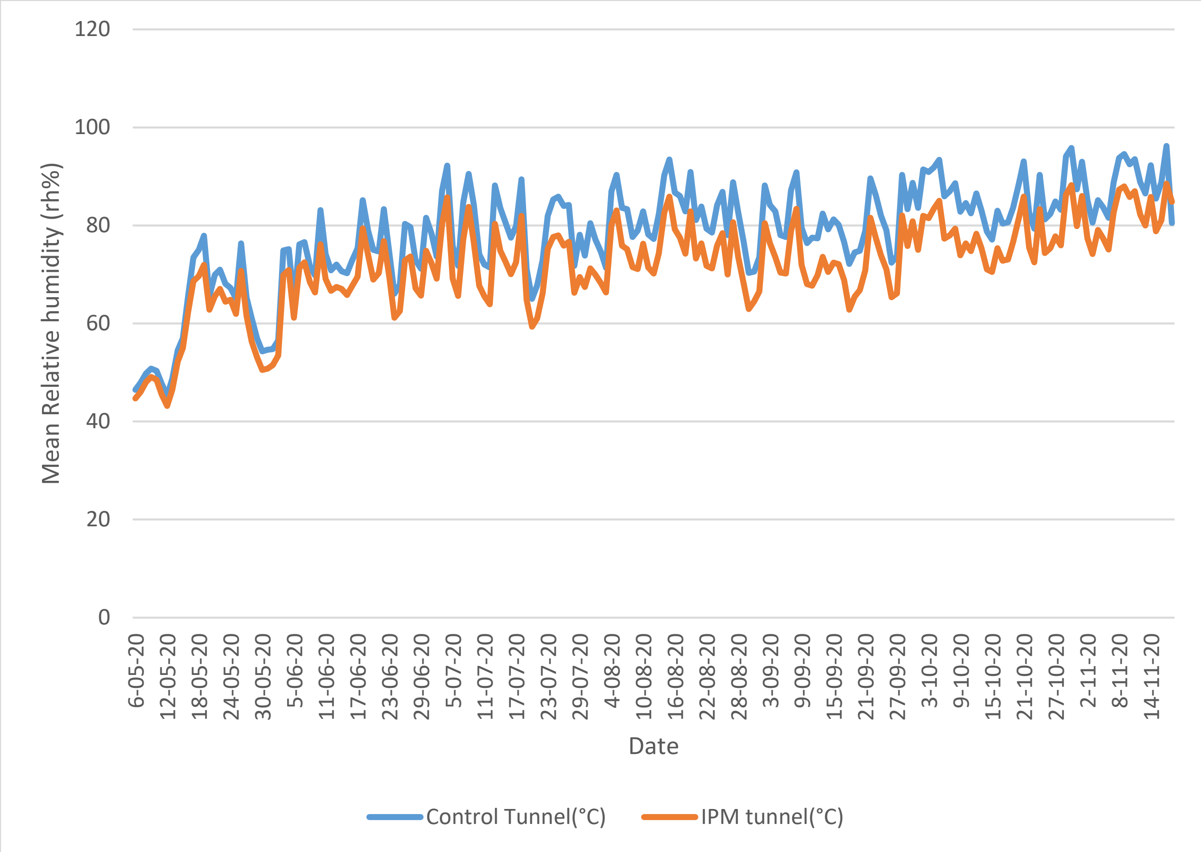

Figure 2: Mean Humidity (%rh) in the control and IPM tunnels.

Mean humidity was roughly consistent between the two tunnels with the control tunnel typically seeing slightly higher levels of humidity than the counterpart IPM tunnel. The highest level of humidity was observed on the 17 November at 96% rh in the control tunnel. The lowest observed was 43.18% rh seen in the IPM tunnel on 31 May.

At site 2, only two assessments were made, these were made as soon as Covid restrictions lifted and ended when the cropping of the June-bearers ended at the end of July, an assessment attempt was made at the start of August, but the cropping had finished. Numbers of all pests were very low in both the IPM tunnel and the grower tunnel with very small numbers of aphids observed (in the grower programme) and no two-spotted spider mite damage observed. No vine weevil damage was seen in the crop during the two assessments. Low levels of thrips were seen, their abundance was patchy however numbers were so low and so not presented (<0.4 thrips per flower) and with minimal damage to the fruit. From the comments made by the grower, videos send to C. Creed and the two visits by A. Clarke the IPM tunnel fared well compared to the grower control. Risk is lower for June-bearer crops due to their shorter cropping especially for western flower thrips, hence why no *N. cucumeris* were applied there. Unfortunately the two data loggers that were placed at site 2 were rusted through and could not be downloaded. It is possible that water got within the housings and damaged them. This has not happened in previous trials. Data loggers will be setup differently next year to avoid this being repeated.

Grower comments

Site 1

"Conventional pesticides were used until 19/4 (except Majestik on 29/4). All those, with exception of Topas, are known to have harmful effects on some predators. All spray rounds were the same in both treatments and were generally carried out early or late, avoiding high light or periods of low humidity. Old, damaged and diseased leaves, fruit and trusses were removed at each picking (3 x weekly).

No pest problems occurred except the early incidence of aphid in T3 and white-fly in late July/August in both tunnels, thought to originate in pinks in a third tunnel.

The predator programme seemed to work fine but this year (2021) we intend to use the combination of parasitic wasps for the later introductions rather than straight Chyrsoperla Carnea, and we will also monitor the crops for whitefly and introduce Encarsia sachets earlier if necessary.

Powdery mildew is quite difficult to manage. If there is a break-down of control too early that threatens the fruit we would revert to conventional fungicides towards the end of the season.

Regarding 2021, as of 3/2/21 we will not be able to apply Calypso (due to its withdrawal from the market) and are reluctant to substitute Hallmark (conventional pesticide). We would prefer to rely on Flipper and Botaniguard (both bioprotectants) early and to pile in with early introduction of aphid-predators rather than invest in another conventional pesticide. Also we must substitute Amistar (conventional fungicide) for Fortress (bioprotectants, herbicide), and include Signum or Scala (both bioprotectants) rather than latish Teldor (conventional fungicide). By September we were running out of options for mildew/botrytis control and have decided to include a third combination of bioprotectants, namely Sonata (MAPP 19161) & Botector (MAPP 19443) to alternate with those already used (subject to availability). Also we are looking at an elicitor Fytosave (18433) (which is designed to improve natural plant defence mechanisms).

I think last year amply demonstrated the usefulness of the programme. Perhaps the ADAS treatments could be more innovative this year, the only real difference last year was timing and the inclusion of Orius. Maybe look at lower cost options and definitely some input on the appropriate fungicide strategy would be welcome.

Finally we need to discuss how the trials' results will be disseminated. Considering the likely situation with Covid 19 maybe there need to be plans for some regular video recording at both sites."

Site 2

"I was very impressed with the biological controls we used last year and will definitely use the parasitic wasps and *Phytoseiulus* again in all tunnels and the wasps in the raspberries for aphids (I think it was a bad year for aphids in all crops last year but the wasps certainly kept the aphids at bay).

We used the nematodes for vine weevil in the strawberry crops kept for next year as a precaution and I was very pleased how cheap they were.

Tom and I were impressed by the biological controls and definitely had a build-up of aphids in the later tunnels, not in trial, when we forgot to order wasps.

It is important to compare the prices of biologicals against standard sprays as this would encourage more to use them. Biologicals are surprisingly good value, easy to administer and of course much more 'organic'.

In conclusion IPM seems to be very useful in our crops. It helps that we do not have everbearers and we only over winter half the strawberries, as trouble does not have an opportunity to build up.

I think it would be good to repeat this year again next year. We found the biologicals very good this year, but you never know year to year. Hopefully will be able to meet next year. If we intend to continue the trials we should sort things out well before spring starts."

Summary of Project – Year 1

It was a difficult year for a number of reasons, COVID 19 made availability of biological controls limited as they're mostly imported from Europe, leading to early delays. High temperatures early in the year also led to a spike in pests early in the season before IPDM would normally be deployed in the region. This primarily consisted of aphids at Site 1 that developed quickly in the high temperatures. Ideally if the higher temperatures could be predicted aphid protection would have started earlier in the season to match this. This is a key change to be made in the next year's trial. Parasitoid wasps are a preventative biological control and are best applied early with lacewing applied as a curative measure. The applications of biological controls combined with runner removal were able to get the aphid numbers under control and comparable with the standard grower programmes.

Low levels of vine weevil damage were seen in the IPM tunnel during July and early August at site 1 before the nematode applications were made. No vine weevil damage was observed at Site 2.

Low numbers of thrips were seen through the trial at both sites, so it appears that the preventative *Neoseiulus cucumeris* combined with *Orius* protected the tunnels well.

At Site 1 the yields from the two tunnels were similar, though not directly comparable due to different claddings it is reassuring that they have yielded very similarly despite the issues with aphids in the early season.

Site 2 had low numbers of pests overall and it appears that the pest pressure overall was low. It is likely that this is due to a combination of the Batavia spray early in the year, combined with less pests present due to the shorter growing season of the junebearers compared to the everbearers.

Overall the aim of this trial was to demonstrate that biological controls could operate comparably to standard grower programmes. Though it had a difficult start the IPDM strategy was able to control pests to a similar level as the grower programmes after there was a period of time for establishment. The grower programmes were also able to keep numbers of pests low through the season and avoided a build-up which is positive.

Next steps

- Next year's grower trials – programmes will be set up earlier to get protection in as early as reasonably possible and avoid an aphid build up like this year. Bioprotectants (such as flipper) to be used initially if needed.
- Determine whether any bioprotectants (in this instance biological fungicides) could be used for disease control as part of the project.
- Aim to cover a longer period of monitoring by combining ADAS and grower assessments.

- Incorporate monitoring for SWD (Spotted Wing Drosophilla) into the monitoring scheme.
- Carry out a cost analysis comparing the grower programmes and biological controls.
- Tweak the applications of biological controls at Site 1 to reflect what was seen this year.
- Ensure a better data coverage at Site 2, to monitor the crop on a site using more conventional methods and to refine the applications of biological controls there.
- Continuation of grower training.

Acknowledgments

We would like to give sincere thanks to our two host grower sites who have worked with us through a difficult year and carried out assessments on the crop to allow the trial to continue.

We also want to thank the companies BASF, Biobest and Koppert (actors) that donated biological controls to the growers for testing.