

Project title: Control of two-spotted spider mite (*Tetranychus urticae*) on protected cherry using the predatory mite *Amblyseius andersoni*

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[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

Headline

- *Amblyseius andersoni* introductions made at a rate of one Gemini sachet per 5 cherry trees under protection disperse evenly across the trees giving the potential to control pest mites.

Background and expected deliverables

Growing cherries under protection brings benefits of consistency of supply by reducing fruit splitting from frosting and rain. However, the increased temperature and humidity under tunnels also causes problems including pests and diseases which thrive in these conditions.

Pest mites on cherry include two spotted spider mite (TSSM, *Tetranychus urticae*) and the European fruit tree red spider mite (*Panonychus ulmi*). Due to the warm, dry conditions in protected cherry there has, in recent years, been a build-up in *T. urticae* close to harvest causing bronzing of the leaves and webbing. This was particularly problematic in 2013 when warmer dryer weather conditions promoted the population growth of *T. urticae* on cherry trees in tunnels. There was concern by agronomists that this may affect the subsequent years' bud growth. Products approved on cherry for spider mite control are either damaging to natural enemies, have short persistence or have harvest intervals which are too long.

Since 2012 the occurrence of the invasive pest, spotted wing drosophila (*Drosophila Suzuki* – SWD), which causes damage to developing fruits, there has been an increased range and number of applications of crop protection products to cherries. It was hypothesised that these products may have detrimental effects on naturally occurring predatory mites in cherry trees, resulting in the proliferation of spider mites in the crop.

Many species of predatory mites occur naturally and/or are available commercially. Naturally occurring predators offer some control of spider mites, but there can be a lag between the population build-up of the pest and the predator, resulting in spider mites overwhelming the trees before the predator can gain control.

Amblyseius andersoni is a generalist predator and will feed on many mite species including *Panonychus ulmi* and *Tetranychus urticae*. *A. andersoni* is a common predatory mite species on cherry trees, but it is not always present in sufficient numbers to control spider mite infestations. Commercial trials have shown promising results using *A. andersoni* Gemini sachets to control spider mites in outdoor apple trees.

The aim of this project was to test the efficacy of *Amblyseius andersoni* as a preventive and curative control agent of spider mites in protected cherry.

Summary of the project and main conclusions

In 2014 it was demonstrated, in replicated plot trials, that *A. andersoni* deployed in Gemini sachets on every fifth cherry tree, in two protected orchards, dispersed evenly on cherry leaves resulting in uniform numbers of predatory mites on each tree. Unfortunately, in that year, phytophagous mite populations never developed sufficiently in the untreated plots and hence we could not assess the effects of *A. andersoni* on the pest mites.

In 2015 it was demonstrated that a very low diversity of Acari (mites) was present on the cherry leaves in the study orchard; populations were almost completely dominated by *A. andersoni* even after a spray of lambda-cyhalothrin (Hallmark) before the trial began. This indicated that there may be at least some tolerance to this product in this orchard. *T. urticae* introduced on infested leaves did not establish in the cherry trees, even in the control plots which did not receive Gemini sachets. It is believed that this may be because the numbers of *A. andersoni* in this orchard were already at sufficient levels to control the pest. The experiment indicated that one *A. andersoni* per four leaves could be sufficient to control *T. urticae* in the absence of predatory mite damaging product sprays.

In 2016 we carried out a similar field trial to the previous year in a protected cherry orchard at NIAB EMR to test the efficacy of *A. andersoni* Gemini sachets to control or prevent *T. urticae* population build-up. The cherry trees had either, 1) Gemini sachets added and then *T. urticae* (preventative), or 2) *T. urticae* and then Gemini sachets (curative). These were compared to 3) an untreated control, where only *T. urticae* was introduced to the trees. In this whole trial *T. urticae* infested potted trees were tied to trees in the orchard. The plots were assessed on three occasions by collecting 40 leaves per plot and using ethanol extraction of the mites before counting under a microscope.

As with 2015, there was a low diversity of Acari (mites), even after two sprays of lambda-cyhalothrin and two sprays of chlorpyrifos in this strategic orchard (NB: chlorpyrifos applications are not approved in commercial cherry orchards). The numbers of predatory mites per leaf were higher than the previous year suggesting that *A. andersoni* could be tolerant to the products applied in this orchard. Although *T. urticae* managed to establish in significant numbers by the first assessment, by the final assessment *T. urticae* populations had reduced in all plots. It was likely that the naturally occurring *A. andersoni* in this orchard halted the population build-up of *T. urticae*.

Financial benefits

The economic damage caused by *T. urticae* feeding on cherry has not been estimated, but it led to economic losses in 2013 when some fruit was discarded. Supermarkets demand consistency of supply from year to year and many, e.g. Sainsbury's, are aiming to sell double the volume of UK fruit by 2020. Reliable control of *T. urticae* from early in the season would help to reduce the risk of damaged fruit nearer to harvest.

Action points for growers

- Assess cherry leaves for the presence of predatory mites early in the season – before flower.
- If naturally occurring predatory mites are low or absent in cherry orchards, Gemini sachets can be deployed as soon as the protective covers are placed over the crop.
- Releases of *A. andersoni* in Gemini sachets can be made at one sachet per 5 trees to supplement naturally occurring predatory mites for spider mite control in cherry orchards before spray programmes begin for *D. suzukii* control.
- Potentially, sprays applied for *D. suzukii* management could interfere with spider mite control, so supplementing with early, well-timed, predatory mite releases may prevent spider mite establishment before *D. suzukii* becomes a problem in the crop.

SCIENCE SECTION

Introduction

Growing cherries under protection brings benefits of consistency of supply by reducing fruit splitting from frosting and rain. However, the increased temperature and humidity under tunnels also causes problems from pests and diseases which thrive in these conditions.

Pest mites on cherry include two spotted spider mite (TSSM, *Tetranychus urticae*), and the European fruit tree red spider mite (*Panonychus ulmi*). *T. mcdanieli* was recorded in Europe 1981, but is probably currently of minor importance compared to the two former species. Due to the warmer conditions in protected cherry there has, in recent years, been a build-up in *T. urticae* close to harvest. *T. urticae* is a widespread species that feeds on several crops including walnut, strawberry, blackcurrant, gooseberry, raspberry, apple, cherry, pear, and plum (Alford 2005). It reduces the photosynthetic ability of the leaves (Wise et al. 1999) by feeding on the leaves of cherry trees causing stippling, bronzing and in severe cases cause webbing and eventually early defoliation (Fig. 1). This was particularly problematic in 2013 when warmer dryer weather conditions promoted the population growth of *T. urticae* on cherry trees in tunnels and there is concern by agronomists that this may affect the subsequent years' bud growth. In one orchard in 2013 the fruits were shrivelled as a result of spider mite attack and had to be destroyed. *T. urticae* overwinters as a diapausing (red) adult female, probably in the cracks and crevices of the trees and the post and wire structure. This allows reproduction and population growth to begin early in the spring of the following season.

The infestation builds up close to harvest when there are no reliable options of plant protection products. Pesticide controls need to ensure full coverage and it is especially important to target the underside of leaves. Very few insecticides effective against plant feeding mites were approved for use on cherry. Clofentezine (Apollo 50) has a harvest interval of 56 days and only one application can be made in a season. Pyrethrins are damaging to natural enemies in the crop, have a short persistence and have little efficacy against spider mites which are widely resistant. Mitochondrial electron transport inhibitor products (e.g. tebufenpyrad (Masai) and fenpyroximate (Sequel)) are probably effective at controlling *T. urticae* but have not been approved for use on protected cherry. In 2015 spirodiclofen (Envidor) had an emergency approval for use in protected cherry for spider mite and is considered non-toxic to *Amblyseius andersoni* (Raudonis 2006).



Figure 1. Photographs of spider mite webbing and characteristic feeding damage on protected cherry leaves in 2013

More recently spinosad and cyantraniliprole have been approved for use on cherry to reduce damage by *Drosophila suzukii*. Spinosad is toxic to predatory mites and has a persistence of up to 2 weeks (Fountain and Medd 2015). A few studies on vines, apples (Müther-Paul 2010a,b in Radtke & Koper 2013) and coffee plants (Reis et al. 2014) have shown either no significant reduction in predatory mite populations in the field or only low toxic effects in laboratory tests using cyantraniliprole.

Many species of predatory mites occur naturally and/or are available commercially. *Typhlodromus* sp. and *Neoseiulus fallacis* (not commercially available and the latter not present in the UK; <http://www.lea.esalq.usp.br/phytoseiidae/>) offer some control of spider mites, but there is often a lag between the population build-up of the pest and the predator, resulting in spider mites overwhelming the trees before the predator can gain control. In addition one of the most common predator species, *T. pyri*, is not common on cherry, probably because the leaves are smooth and hairless and the mite is unable to survive on these surfaces.

The two most promising commercially available predatory mites for outdoor use for control of spider mites on cherry trees are *Phytoseiulus persimilis* and *A. andersoni*.

Phytoseiulus persimilis is used against *T. urticae* in apple orchards in Israel at a release rate of half a million / acre (maintained populations) until the spider mite was under control – below economic threshold. *P. persimilis* could disperse at least 90 m within 45 days of the original release site (Steinberg and Cohen 1992). *P. persimilis* is a spider mite specialist

and may have good potential for curative control, but its reliance on spider mites makes it difficult to sustain on trees when the pest is not present, and because *P. persimilis* will only attack *T. urticae* other pest mites may persist and increase. In addition *P. persimilis* does not overwinter in cold winters in the UK.

A. andersoni is a generalist predator and will feed on many mite species including *P. ulmi* and also pollen grains. It is been reported that *A. andersoni* populations increase after pollen peaks in conditions of prey scarcity (Lindquis et al. 2001). Commercial trials have shown promising results using *A. andersoni* Gemini sachets to control spider mites in outdoor apple trees.

Objective

The aim of this project was to test the efficacy of introductions of a commercial sachet formulation of *Amblyseius andersoni* as a preventative or curative control agent of spider mite in protected cherry.

Materials and methods

Site: A strategic planting of cv. Penny and Sweetheart in rows 10 and 12 from the south side (tree spacing was 2 m), on plot 'Rookery Field RF 181' at NIAB EMR, managed by Graham Caspell, Farm Manager. The Penny trees in the experiments were protected with anti-bird netting and were tunnelled (100 m) under polythene protection. Each plot was 3 m long and closed on three sides with the polythene. There were three trees per plot and the centre tree was marked with red and white tape (Fig. 2). There was a guard of 4 trees between each plot.



Figure 2. Photograph showing one plot with the polythene to the ground on three sides of the three cherry trees (cv. Penny)

To eliminate naturally occurring predatory mites in the strategic orchard before we began the experiments four insecticide sprays were applied; 2 sprays of Dursban (chlorpyrifos) before budburst and 2 sprays of Hallmark (lambda-cyhalothrin) post budburst (NB: these applications were applied as part of the experiment and are not approved on commercial cherry).

Artificial infestation: In 2015 trees were infested with *T. urticae* infested cherry leaves paper clipped to leaves in the canopy in the experimental trees. However the *T. urticae* failed to establish. For this trial, one whole, heavily infested, potted tree per plot was tied inside the canopy of the experimental trees to allow *T. urticae* to move onto the leaves of the orchard

trees. Infested cherry trees were initially maintained in a glasshouse at NIAB EMR and had leaf stippling damage, webbing and many adult and eggs of *T. urticae*. Branches from both trees were tied together with tape to increase the leaf surface contact (Fig. 3). The average number of *T. urticae* on one leaf pre infester tree for each plot was estimated before deployment. No significant differences in the number (mean of 38) of *T. urticae* per leaf for the plots were found.

Treatments: *A. andersoni* was introduced in Gemini sachets (supplied by Richard GreatRex, Bioline AgroSciences) prior to (preventative) or post (curative) *T. urticae* inoculation (Table 1, Fig. 4). These treatments were compared to an untreated control where no *A. andersoni* were introduced. The trees in each plot had branches touching (18 plots), but the branches between the plots (because of the polythene covering) were not touching.

Table 1. Timetable of inoculations, treatments and assessments, TSSM = *T. urticae*

	Preventative Red	Curative Blue	Control Green	Assessments
31 May	-	-	-	Pre assess
2 June	Add Gemini sachet	Introduce TSSM	Introduce TSSM	-
9 Jun	Introduce TSSM	Add Gemini sachet	-	-
20 Jun	-	-	-	1 st assessment
28 Jun	-	-	-	2 nd assessment
18 Jul	-	-	-	3 rd assessment

Assessments: A full pre assessment was done on 31 May (Table 1). Forty leaves were sampled from the full canopy of the middle tree in each plot. Leaf samples from one plot were pooled into one large container (20 cm high x 11 cm diameter) of 70% ethanol. Mites were extracted using the ethanol washing method in Harris et al. (submitted). After the treatments were applied 3 subsequent assessments were done (Table 1). A record was made of the numbers of prey and predatory mites under a dissecting microscope. Samples of extracted mites were mounted onto slides with Hoyer's medium and then identification confirmed using taxonomic keys.

Statistical analysis: The trial was a randomised replicated experiment in two rows with 1 tree per plot (tunnel) and 6 replicates. Data was analysed using repeated measures ANOVA in Genstat 13.1. Square root transformation was done for one of the dependant variables.



Figure 3. a) *T. urticae* infested potted cherry tree at the beginning of the trial (2 June) and b) End of the trial (18 July)

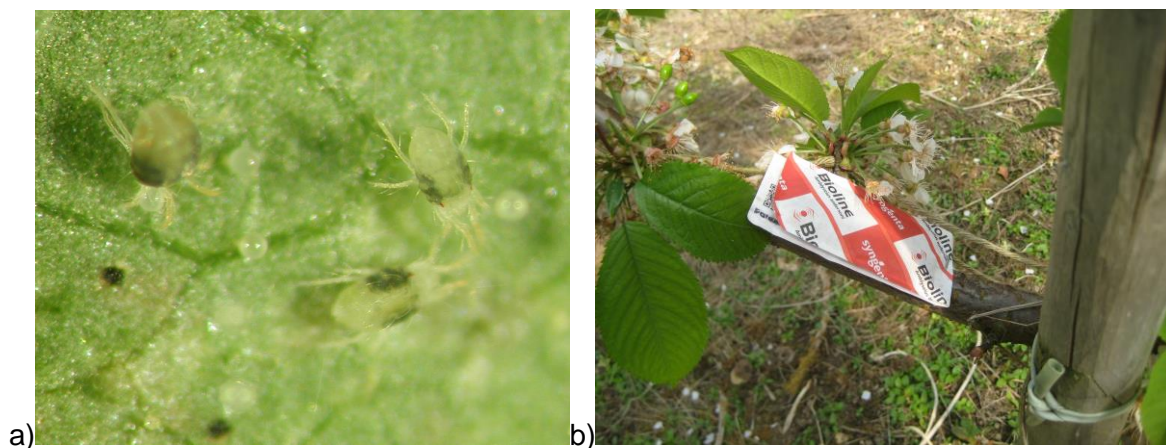


Figure 4. a) *T. urticae* motiles and eggs on a leaf and b) Gemini sachet in a cherry tree

Results

At the pre-assessment, 0.33 *A. andersoni* per leaf were present on cherry leaves. Numbers did not differ significantly between the allocated treatment plots. Regardless of the spray programme, which aimed to reduce the populations of *A. andersoni*, the number of predatory mites was similar to the previous year (0.24 *A. andersoni* per leaf).

Gemini sachets added to the curative and preventative treatment plots did not significantly increase the numbers of immature or adult *A. andersoni* on the cherry leaves compared to the untreated control plots (Fig. 5).

T. urticae established in significant numbers on the cherry trees at the first assessment, however, no significant differences between treatments were found (Table 2). At the second assessment a statistically greater number of *T. urticae* was found in the preventative plots, 19 days after the trees were inoculated with the pest (ANOVA Square root transformation $P = 0.001$, s.e.d = 0.719, l.s.d. = 2.264). However, because there was no difference between the untreated and the curative plots, this indicated that there were sufficient *A. andersoni* on the trees to control *T. urticae* without supplementing with Gemini sachets.

At the final assessment, 39 days after *T. urticae* introduction, numbers of *T. urticae* did not differ significantly from the untreated control (less than one *T. urticae* in 40 leaves). This suggested that it took approximately 3 weeks for *A. andersoni* to gain control of *T. urticae*.

There was a significant increase in *A. andersoni* on the cherry leaves over all plots over time (ANOVA Square root transformation $P < .001$, s.e.d = 5.29, l.s.d. = 10.55, Fig. 6).

Table 2. Mean numbers of *A. andersoni* and *T. urticae* (TSSM) on 40 leaves for each assessment date. Values with different letters in a column were significantly different ($p<0.05$). All plots were pre assessed on 31 May

Treatment/Date	2-Jun	9-Jun	20-Jun		28-Jun		18-Jul	
			<i>A. andersoni</i>	TSSM	<i>A. andersoni</i>	TSSM	<i>A. andersoni</i>	TSSM
Preventative	Add Gemini sachet	Introduce TSSM	28	35	60	42 b	68	0.2
Curative	Introduce TSSM	Add Gemini sachet	27	32	43	2 a	48	0.5
Control	Introduce TSSM	-	27	37	48	3 a	60	0.3

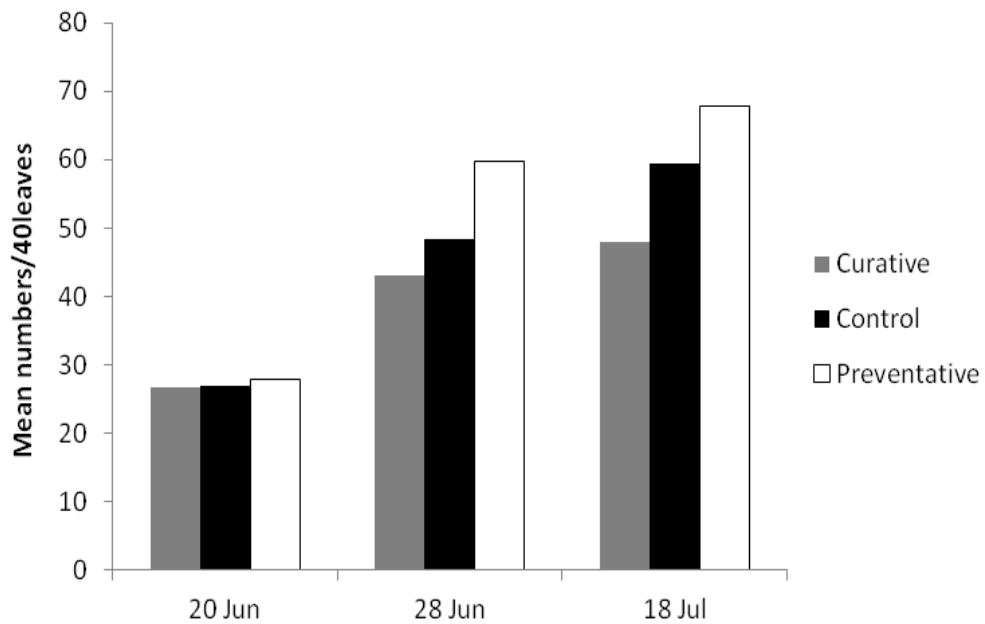


Figure 5. Mean numbers of *A. andersoni* on 40 leaves on the assessment dates

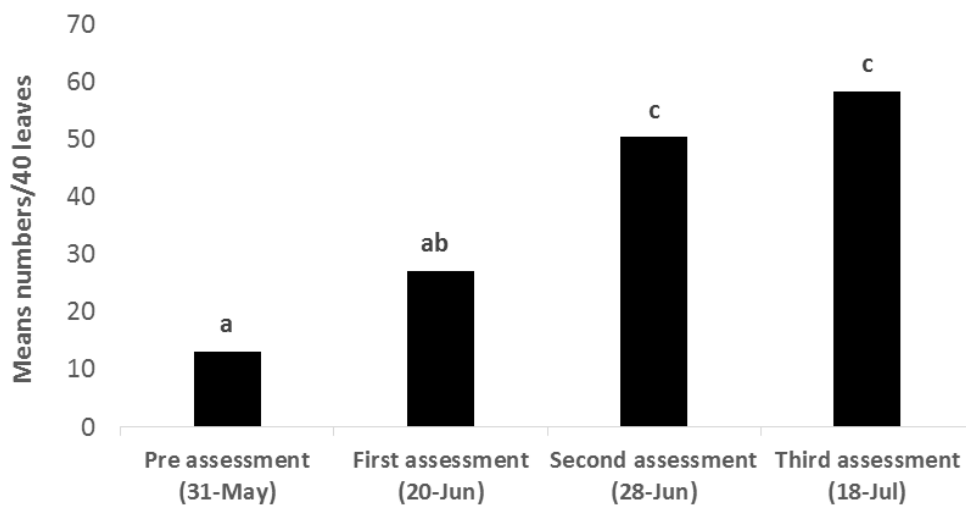


Figure 6. Mean numbers of *A. andersoni* on all plots over the trial

Discussion & Conclusions

There was a very low diversity of mites on the cherry leaves in the 2016 trial; populations were almost completely dominated by *A. andersoni*. In addition 4 applications of broad spectrum insecticides before the trial began did not deplete the numbers of *A. andersoni* compared to the previous year.

In 2015, our studies indicated that one *A. andersoni* per 4 leaves could, potentially, be sufficient to control a low to moderate *T. urticae* population in the absence of predatory mite damaging insecticide sprays. In 2016 one *A. andersoni* per 3 leaves did not initially control *T. urticae*, but numbers of *A. andersoni* increased over time resulting in a reduction of *T. urticae* after ~3-4 weeks. Because of the resident populations of *A. andersoni* in the trees it was not possible to determine if the additional *A. andersoni* introduced into the trees in Gemini sachets, both before and after *T. urticae* inoculation, impacted on *T. urticae* populations.

Numbers of *T. urticae* were high at the second assessment in the preventative treatment, but ratios of *T. urticae* to *A. andersoni* reached 1:1.5 resulting in a decline in the pest population in the following sample, taken 3 weeks later.

To date, sprays targeted against SWD do not seem to be increasing the incidence of *T. urticae*. This indicates that *A. andersoni* appears to be at least tolerant to current commercial sprays against pests and diseases.

Knowledge and Technology Transfer

26 Mar 2015 Control of spider mite (*Tetranychus urticae*) on protected cherry using the predatory mite *Ambyseius andersoni* TF 219. HDC Tree Fruit Day. PRESENTATION Michelle Fountain, Adrian Harris, Roshan Ullah

28 Feb 2017 Alvaro Delgado EMRA/AHDB Tree Fruit Day: PRESENTATION Control of spider mite on protected cherry (TF 219)

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