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Report to: Horticultural Development Council

Project No: FV/85

RUNNER BEANS: CONTROL OF TWO-SPOTTED SPIDER MITE

ADAS Project Leader: B Emmett (Leeds)

ADAS Experiment Leader: R Umpelby
ADAS Worcester
Whittington Road
WORCESTER
WR5 2LQ

Tel: (0905) 763355

Period of Investigation: April 1991 to April 1992

May 1992

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No. of pages in report: 11

No. of copies of report: 8

This is ADAS Copy No.:

Report authorised by:

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S W Perkins
ADAS Cambrige
Brooklands Avenue
Cambridge
CB2 2BL

Tel: 0223 462762

SUMMARY

An experiment on the control of over-wintering two-spotted spider mite in bamboo canes reused each year to support the crop was unsuccessful due to predation. Dicofol plus tetradifon (Childion) as a spray gave good control of two-spotted spider mite in the crop. The predator, Phytoseiulus persimilis, prevented any widespread damage by the two-spotted spider mite when introduced in May, June or July at 2 or 5 per plant. Phytoseiulus spread readily throughout the crop once established.

INTRODUCTION

The two-spotted spider mite, Tetranychus urticae (Koch), was previously known as the glasshouse red spider mite and is still commonly referred to as red spider mite. The name, red spider mite, however can be used for other species of mites, particularly the fruit tree red spider mite, and as such should not be used when dealing with a single species of mite.

The two-spotted spider mite is a polyphagous species and, apart from feeding on a wide range of native wild plants, it is a serious pest of many cultivated crops. It can be regarded as a pest on most dicotyledons grown under glass, or other protection (with the possible exception of lettuce). On outdoor crops it is a regular pest on most soft fruits and occasionally can be the main mite species on top fruit orchards in exceptional seasons. Other crops in the open which have been regularly attacked in the past include hops, courgettes and french beans whilst in hot dry years it has been seen and causing significant damage on crops as diverse as potatoes and leeks.

In the 1970s a few growers of runner beans began to record damage every year, but usually at a low and relatively insignificant level. However in about 1983 some more serious infestations were seen and a few growers have since recorded damage regularly. In the hot dry summer of 1989 a large number of runner bean crops in the West Midlands were seriously affected, some being devastated later in the season. In 1990 the problem was seen over a much wider area of the country. The two-spotted spider mite breeds both sexually and asexually throughout the summer on crops in the open and may complete 7 generations, with each female laying up to 100 eggs. From the late summer/early autumn an increasing number of female mites develop into the winter form where they gradually turn to an orange/red colour and eventually stop feeding and then seek shelter for the winter. In non-crop situations these over-wintering females will seek shelter in hollow dead plant stems, in curled up dead leaves or even in dry crevices in soil or stone. Although very tolerant of low temperatures a combination of low temperature and wetness causes very high mortality of the over-wintering female mites. There is no other over-wintering stage of the two-spotted spider mite.

The mites cannot fly and dispersal is passive, either by carriage on passing animals (or humans), by transfer of infested plant material or by a type of ballooning where mites suspended on silk are carried on air currents. Therefore regular infestations only occur on perennial crops or on crops grown in or with permanent structures which offer a good over-wintering shelter (eg glasshouses or crops with permanent supports such as raspberry and hop). The problem on runner beans is perpetuated in the removable and reusable support system - the bamboo cane. As the bamboo canes are hollow and after several seasons are prone to splitting these offer an ideal over-wintering site for the mites. Where these canes are reused for runner beans the next year during May or early June the over-wintered mites simply move onto the new seasons crop.

Control of the over-wintering mites in the canes is therefore one of the possible ways of controlling the main mite infestation. Chemical control in the crop is another method which could be used, although at the time the work was done (and currently) there are no pesticides approved on runner beans which are likely to give any measure of control of the two-spotted spider mite. This mite on other crops is resistant to a very wide range of both broad spectrum pesticides and specific acaricides. Another problem with applying pesticides to runner beans is the reliance on pollination for successful cropping and therefore any pesticide used must not only be safe to pollinating insects but must not repel them.

A very promising alternative means of control has been developed recently on other crops affected by this mite, the predatory mite Phytoseiulus persimilis has been used successfully. Phytoseiulus was initially introduced for use on protected crops but is increasingly used on crops in the open, particularly strawberries. The period of the growing season and the growth habitat of runner beans would seem to be ideal for the successful use of this predator for control of the two-spotted spider mite.

Part I - Control of two-spotted spider mite in bamboo canes overwinter

MATERIALS AND METHODS

In October 1991 40 bamboo support canes (2.4 m long) were removed from a previously heavily infested runner bean plantation. The canes selected had longitudinal splits which were suitable over-wintered sites for the mites. The canes were cut into short sections (approximately 30 cm) through the 'node' and a small number were opened to confirm the presence of mites.

The numbers of mites found in the canes was considerably lower than had been expected and therefore an attempt was made to increase the number of mites by introducing them from heavily infested hardy nursery stock plants where the mites had not fully entered diapause and had not yet sought an over-wintering site. This attempt was only partially successful and the number of overwintering mites per cane section was less than 10 (when more typically over 100 could have been expected) with a high proportion of those checked not having any mites present.

The canes were then stored in the open, but protected from rain and direct sunlight. In March before treatments were due to be applied a sample of canes was checked to assess mite numbers. Mite numbers in the canes had fallen dramatically. It became apparent that this fall had been due to predation, with anthocorids being the main predator. Less than 10% of cane sections had any live mites present and where they were present numbers were generally less than 5 per cane.

A check was then made on canes from other commercial farms where mites had been a problem previously. Insufficient infestations were found and it was therefore decided to abandon the experiment.

DISCUSSION

The main reasons for the low initial diapause numbers in the canes was almost certainly late predation of the field population. Although the crop was heavily infested in late August, predation by a range of insects and mites could have continued into October at a time when mite numbers would have stopped increasing. The main naturally-occurring predators noted in commercial crops in Worcestershire in 1991 were anthocorids, midge larvae, syrphid larvae (hoverfly), lacewing larvae and ladybird larvae. All of these predators feed aphids preferentially to mites and they were present in high numbers in the crop because of unusually heavy infestations of the black bean aphid (Aphis fabae) which were widespread in 1991. When the aphid infestation reduced many of these predators started to feed on other insects or mites present in the crop. Midge larvae and anthocorids particularly are very good predators of the two-spotted spider mite and it is very likely that they were the main cause of the crash in the mite population later in the season.

Another type of predator which added to the population decline were predatory mites. Various predatory mite species are naturally occurring, particularly Typhlodromus species and Amblyseuis species and will build up naturally where spider mite populations are high. These mites were seen in runner bean crops in 1991, probably having built up in and around (ie hedgerows) infested crops in 1989-1990. These mites over-winter naturally in England and will be active in warmer spells in the winter and will feed on diapause spider mites.

Predation of diapause spider mites by anthocorids is well known and given the lower number of spider mites diapausing from runner beans in 1991/92 and the higher number of predators present in the crop it is understandable that they exerted a continuing controlling influence in the winter on the canes selected for the experiment.

Although it was not possible to do a comparative trial as planned commercial experience and previous observations in the field and at the Evesham Laboratory enables the following comments on the likely effect of cane treatment:-

1. Methyl Bromide - must be used by a licenced commercial contractor. Where used on canes in conjunction with glasshouse soil sterilisation complete mite control has been achieved.

2. Steam - providing sufficient time of exposure (wood is a good insulator) is given complete control will be achieved.

3. Formaldehyde - treatment is not effective, even where canes are completely enclosed for several weeks with formaldehyde solution.

4. Acaricides - cane treatment (drenching) with various acaricides has never proved successful. Dicofol plus tetradifon (Childion) and bifenthrin (Talstar) tried but ineffective. Diapause mites are very tolerant to chemicals and are well protected inside the canes from direct contact.

5. Oils - (eg TVO, adjuvant oils, white oil) complete drenching necessary (immersion), a very high risk of phytotoxicity to the crop due to residues in the cane being released the season after treatment. The use of oils therefore cannot be advised.

Part II a) Chemical control of two-spotted spider mite on runner beans

MATERIALS AND METHODS

The site selected for the experiment (Hallow, Worcestershire) had a serious mite problem in 1991 and canes used in 1991 were to be reused in 1992. This meant that a significant mite population was likely to be present early in 1992. In order to avoid early crop destruction, due to the use of non-approved pesticides, the start of the experiment was planned for late July thus allowing the grower to take advantage of the early season crop. By late July it was clear that the mite infestation was not increasing and the start was therefore delayed to allow a population increase. In late August it became clear that mite numbers were being limited by natural predation and therefore an application of deltamethrin (as 'Decis') was made to the whole trial area. Deltamethrin is toxic to most predators but has no effect on two-spotted spider mite. Following the application of deltamethrin harvesting ceased in the experimental area for the season.

Treatments

1. Untreated.

2. Dicofol plus tetradifon, as 'Childion' applied at 2.25 ml product per litre of water (standard rate)

3. As 2, Childion at 4.5 ml/litre (standard x 2).

4. As 2, Childion at 9.0 ml/litre (standard x 4)

Treatments were applied on 12 September 1991 using a hydraulic knapsack sprayer fitted with a nozzle giving a medium spray quality. Sprays were applied at high volume to run-off giving an approximate spray volume of 1,500 l/ha. No insecticides, acaricides or fungicides were applied in the trial area, or any of the surrounding crop, at any time during the 1991 growing season.

Design

Plots were four plants (variety Enorma) trained on a single "wigwam". Six replicates of each treatment were used and plots were arranged in a randomised block design.

Assessments

1. Pre-treatment numbers of mites and eggs on five leaves per plant, 12 September 1991.

2. Post treatment assessment, 5 leaves per plant, 24 September 1991.

3. As 3, 2 October 1991.

4. At each assessment phytotoxicity was checked on the flowers, foliage and bean pods. All mite counts were made on detached leaves, using a binocular microscope.

Samples of beans were picked on 3 October and were frozen and stored for residue analysis. Approximately one kilogramme of beans were taken from each plot and were stored separately.

RESULTS

The application of deltamethrin was successful in controlling predators in the trial area and throughout the assessment period no established predators were seen in the experiment (NB 'established predators' refers to non-winged stages).

The number of motile stages (all types) recorded on each assessment date are given in Table I below as the mean number per leaf. Table II gives equivalent results for numbers of eggs of two-spotted spider mite.

TABLE I - Numbers of motile stages of two-spotted spider mite per leaf

Treatment	Date		
	12 September (Pre-treatment)	24 September	2 October
Untreated	30.6	9.0	9.2
Childion, standard	69.5	0	0
Childion, standard x 2	84.3	1.4	0.1
Childion, standard x 4	28.6	0.1	<0.1

TABLE II - Numbers of eggs of two-spotted spider mite per leaf

Treatment	Date		
	12 September (Pre-treatment)	24 September	2 October
Untreated	20.7	6.7	5.0
Childion, standard	37.7	0	<0.1
Childion, standard x 2	69.3	2.6	1.2
Childion, standard x 4	7.1	0.1	0.1

Qualitative assessment of the effect of treatments on the leaf, flower and bean pods showed that the three rates of 'Childion' applied had no adverse effect (Phytotoicity) or beneficial effect on the plant.

DISCUSSION

There was a natural decline in the population of two-spotted spider mite in all plots in September, as shown in untreated plots. This represented a reduction of 70% in numbers overall but the reason for this was unlikely to be due to predation because after the deltamethrin application few predators were seen in the trial area.

Even allowing for this natural decline a very good level of control of mites was obtained with 'Childion' at all rates. The minimum percentage control of motile stages recorded was 94.6% when natural decline was allowed for. It should be noted that the density of foliage at the time of application was too high to allow complete spray coverage and therefore it was unlikely that complete control could have been achieved. There was no advantage in increasing the rate of product and it should be noted that the higher rates (2 and 4 times standard) were only included for the purposes of residue analysis.

The ratio of motile mites to eggs was about 1:1 which is somewhat lower than would be expected in the summer, but the effect of Childion on the eggs was similar to that on the motile stages. It is however impossible to be sure on visual examination alone whether eggs are viable so egg reduction is a less reliable means of assessing the success of a chemical treatment.

The risk of plant damage was shown to be very low with even the highest rate, four times recommended, giving no visible phytotoxcity.

b) Biological control of two-spotted spider mite on runner beans

MATERIALS AND METHODS

The predator *Phytoseiulus persimilis* was the only predator used in the experiment and is subsequently referred to as *Phytoseiulus*. *Phytoseiulus* is available commercially on 3 different media:-

1. On bean leaves.

2. In paper sachets mixed in a bran or vermiculite (only in multiples of 30 or 50).

3. In shaker bottles mixed with vermiculite - bottles approximately ½ litre capacity with 2,000 *Phytoseiulus* per bottle.

The method of introduction used in the experiment was shaker bottles, because using this method a better distribution of *Phytoseiulus* was probable (see discussion).

Site

Commercial runner bean crop at Broadheath, Worcestershire, Cultivar Enorma. Crop planted in single rows under continuous low polythene cloches, a ground mulch of clear polythene was present under the cloche. In late May the crop was 'sticked' and the sticks were linked into a 3-stick wigwam (with the polythene cloche still in position). After sticking the plants were trained through holes in the cloche and in early July, when the crop had grown to the top of canes, the polythene cloche was removed. The sticks used were bamboo canes which had been removed from an infestated 1991 crop. The canes were 2 to 3 years old and had longitudinal splits which allowed two-spotted spider mite to overwinter. A small sample of canes were checked to ensure mites were present before the experiment started.

Treatments

1.	No treatment.	
2.	Phytoseiulus at 2 per plant	24 May
3.	" " 5 " "	24 May
4.	" " 2 " "	6 June
5.	" " 5 " "	6 June
6.	" " 2 " "	20 June
7.	" " 5 " "	20 June
8.	" " 2 " "	4 July
9.	" " 5 " "	4 July

No insecticides, acaricide, or fungicides were applied in the area of the experiment.

The rates of Phytoseiulus given are estimates because in the shaker bottles of 500 ml vermiculite a population of approximately 2,000 Phytoseiulus is present. This means if the vermiculite and Phytoseiulus were perfectly mixed 0.5 ml of vermiculite should carry two Phytoseiulus and 1.25 ml should carry 5 Phytoseiulus. In the experiment the shaker bottles were agitated (rolled not shaken) regularly having been stored initially horizontally in a refrigerator and then transported to the experimental site in an insulated (cool) box. Perfect mixing was unlikely to have been achieved in the experiment and is never likely to be in commercial application of any predator (or parasite) distributed in this way. However given the correct numbers of Phytoseiulus per shaker bottle every effort was made to ensure that a mean of 2 or 5 Phytoseiulus per plant were introduced over each plot.

Layout/Design

Each treatment was replicated 3 times and individual plots were single rows each with 104 and 148 plants per row. Total plot (row) length was between 70 and 90 m. Rows were approximately 2.3 m apart and the distance between plants was approximately 0.8 m but plants were staggered, not in a straight line, up each row. Plots were adjacent to each other with one end butting onto a headland/hedgerow and the other end butting on to a central cross alley (4 m wide) in the runner bean plantation.

Assessments

Damage assessments were done on 6 June, 20 June, 4 July, 22, July, 12 August and 5 September. Counts of two-spotted spider mite (motile stages and eggs) and of Phytoseiulus were done on 20 June, 4 and 22 July, 12 August and 5 September. Up to 20 leaves per plot were assessed, damage assessments being done in the field and mite and Phytoseiulus counts in the laboratory.

RESULTS

Before the first introduction of Phytoseiulus the beans were still within the polythene cloche and only restricted leaf sampling was possible without affecting the growth. No mites were found prior to the Phytoseiulus introduction in late May.

6 June - Very low levels of leaf speckling (adult two-spotted spider mite damage) was seen overall in the experimental area. Adult mites and eggs were present at very low levels. No Phytoseiulus motiles or eggs were seen.

20 June - Plants had grown to the top of the canes, mite damage very difficult to find. Selective sampling (ie damaged leaves only) showed a mean of 2.6 mites per leaf on the worst affected plots. Phytoseiulus eggs were found in one plot where predators were introduced at 5 per plant on 6 June.

4 July - Mite numbers very low (maximum mean per treatment 0.8 per leaf) but some more damage showing (this was easier to find partly because of the removal of the polythene cloche). Mite damage seen up to 1.1 m above ground (well above cloche level). Mites seen were almost exclusively young motile stages. Damage noted on leaves where no mites were present.

Phytoseiulus was found in plots where introductions had been made on 20 June (5 per plant) and in plots where no introductions had been made!

22 July - Mite numbers had fallen overall with a maximum of 0.2 motiles per leaf and 1.0 eggs per leaf on the worst affected treatments. Phytoseiulus was present in 3 treatments (6 June at 2/plant, 20 June at 5/plant and untreated) with a mean of up to 0.17 motiles per leaf on the most heavily mite infested plots. Damage by mites was easy to find but was at a very low level, ie very light speckling on a few leaves on each plant. The damage was not often associated with live mites but there was often evidence of predation having taken place with the dried up skins of two-spotted spider mite being present.

Apart from Phytoseiulus the naturally occurring predatory midge larva Aphidoletes was seen feeding on the two-spotted spider mite. Anthocorids were also present although they were primarily associated with the low infestation of black bean aphid in the crop.

12 August - Mite numbers had increased slightly overall but this increase was accounted for by fewer but more heavily infested leaves. Mean mite numbers were slightly higher where Phytoseiulus had not been introduced until 4 July, up to 0.33 motiles per leaf and 1.43 eggs per leaf. Phytoseiulus was present in 5 of the 9 treatments, including the untreated. Plant damage was insignificant and difficult to find.

5 September - Mite numbers had fallen to the lowest of any assessment and where mites were found Phytoseiulus was also always recorded. Leaf damage was minimal and the majority of damaged leaves had no mites present, some did however have Phytoseiulus in the absence of mites.

DISCUSSION

Although Phytoseiulus was not recorded in high numbers at any time during the experiment it proved a highly mobile and effective predator of the two-spotted spider mite in runner beans. The season may have favoured Phytoseiulus somewhat but its capability for spread and the evidence of it having cleared up infestations and then moving on make the results observed very encouraging.

Late May was quite warm but in early June some significant ground and air frosts were recorded in Worcestershire and these were followed by a very cool and damp remainder of June before a warm and dry July occurred. The frosts in early June did not penetrate the polythene cloches sufficiently to cause widespread damage to the crop but the summer forms of the two-spotted spider mite are markedly suppressed by such low temperatures and their relatively low mobility probably prevented them moving lower on the plant. In contrast the highly mobile Phytoseiulus was able to survive these low temperatures by following the temperature gradient and moving towards the warmer ground and even under the plastic ground mulch.

The results showed that wherever an infestation of two-spotted spider mite developed Phytoseiulus soon moved in and gave control preventing any significant plant damage. The contact between plants, not only in the individual 'wigwams' but between the 'wigwams', makes it very easy for the predator to move along rows. The spread between rows, as demonstrated by the presence of Phytoseiulus in isolated rows where it was not introduced, 40 days after its introduction to the plantation was probably helped by the frequent 'hand-work' necessary in the crop. A similar spread was seen on the same farm where 10 adjacent rows had not had a Phytoseiulus introduction; Phytoseiulus was found in all these rows within 40 days of introduction to the rest of the plantation.

The most significant result of the experiment was the way Phytoseiulus moved into areas where two-spotted spider mite was present and prevented significant plant damage occurring. The lack of application of any pesticide during the period of activity of the two-spotted spider mite and Phytoseiulus is probably a significant factor.

Although Phytoseiulus proved very successful in 1991 it should be noted that in a season with very high June temperatures following introduction, the viability of Phytoseiulus under polythene cloches may be substantially reduced. Fecundity and survival of Phytoseiulus at over 30°C are substantially reduced. For this reason, except in situations of very high early activity of two-spotted spider mite very early introductions of Phytoseiulus should not be made. Early June is probably the ideal time for introduction on protected crops as the risk of frost is low, and for open grown crops mid June would probably be ideal.

The rate of application of Phytoseiulus did not seem to affect the level of control. Two Phytoseiulus per plant equates to approximately 30,000 per hectare and this should in most situations prove an adequate and economic rate of introduction to give good control. The ease of spread demonstrated in the experiment seems to indicate that the method of introduction may not be as critical as originally thought. The main consideration would certainly be an even distribution with the maximum chance of ensuring rapid spread.

CONCLUSIONS

1. The predator Phytoseiulus can be extremely successful in controlling the two-spotted spider mite in runner beans.

2. 'Childion' is likely to give good control of two-spotted spider mite in the crop if it is approved and applied correctly.

3. Methods of reducing the carry-over of two-spotted spider mite in the bamboo support canes should be encouraged.

RECOMMENDATIONS

The success with the predator *Phytoseiulus* seen in this experiment and in commercial observations (not reported) means it is probably not worth persuing the use of acaricides in the crop. Therefore the residue analysis should be held over until a further seasons commercial experience with *Phytoseiulus* has been gained. Growers should be encouraged to use "clean" canes for support and not to use those from areas infested with two-spotted spider mite late in the previous season.

ACKNOWLEDGEMENT

The help of Mr D Lloyd and his staff is gratefully acknowledged in the providing and running of sites for this work.