Final Report to HDC - Part of Contract

Project BOF 25

Bulb Scale Mite - Origins of Infestation of Narcissus

Project Leader

M J Lole ADAS Cambridge

Location of Project

HRI Kirton, CSL Slough, ADAS Cambridge and Black Hole Drove, Spalding

Project Co-ordinator

Mr Brian Taylor, O A Taylor Ltd, Holbeach, Lincs

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Key Words

Narcissus
Bulb Scale Mite (Steneotarsonemus laticeps)

Application

The objective of this project was to study Bulb Scale Mite with the purpose of discovering why it was still a serious bulb pest, particularly of forced bulbs, despite routine biennial hot-water treatment of stocks.

A field study of an infested narcissus crop did not confirm bulb scale mite spreading from the site to any extent. Similarly, a study of bulb scale mite in the post-harvest phase of narcissus growing did not show it to be spreading in store. Finally, an experiment investigating the effects of different durations of hot water treatment on survival of bulb scale mite was completed.

Despite the above work we still do not know how bulb scale mite spreads from stock to stock and whether it manages to survive hot-water treatment.

In the absence of new information growers are advised to continue with routine hot-water treatments, to practise good hygiene procedures and to drench bulbs for forcing on housing if the mite is known to be present.

Summary

Three pieces of work are reported.

In the first, the emergence of bulb scale mites from the bulbs of an infested crop onto the foliage, and subsequent dispersal, was monitored for one growing season. The aim was to discover if and when the mites could be vulnerable to chemical control measures aimed at reducing the numbers present in the crop and at minimising dispersal. Most mites were found as the foliage emerged from the ground in the early spring. Numbers then declined very rapidly until from two weeks later and until the end of July, the mites were only occasionally found and then in small numbers.

In the second, detailed assessments were made of bulb scale mite numbers on the fabric and contents of a bulb-growing farm with a history of bulb scale mite problems. This was done to confirm the assertion common in the literature, that bulb scale mites spread largely during the storage phase of bulb growing. Bulb scale mites were only found within individual bulbs of a stock that was known to have been infested in 1992. They were not found on the outside of these same bulbs, nor on the boxes used to store them, the machinery used to handle them or on the fabric of the buildings where they were kept. At least 4 different types of other mites were encountered during the survey.

The third piece of work consisted of an experiment to clarify the criteria of hot-water treatment temperature and duration of exposure that are necessary for the control of bulb scale mites in narcissus. This was considered valuable because the literature described at least 5 different sets of criteria, ranging from 30 minutes exposure to 40°C to 4 hours exposure to 43.3°C, and a definitive answer would be of benefit in order to optimise treatment. A range of exposure times, in half hour increments from 0 hours to 4 hours, at a temperature of 44.4°C was used. Unfortunately, for a reason not understood, all of the mites died during the period of incubation included in the experiment, enabling no conclusions to be drawn about temperature/time criteria.

Experimental Work

Introduction

The bulb scale mite (Steneotarsonemus laticeps) has been recorded causing economic damage to forced narcissus since at least the 1920's, and in England there have been even earlier records than this (unconfirmed). It remains a sporadic pest today, particularly of forced crops.

In 1991 bulb scale mite was responsible for the greatest number of potentially exportable stocks of narcissus that were failed due to pest attack. This prompted questions from the industry about the biology of the pest, its origins in field crops, its means of dispersal and control measures. A brief review of the literature showed that some of these questions were unanswered, and as a result the HDC sponsored this work on bulb scale mite in which ADAS, HRI and CSL collaborated.

As originally designed the work was divided into three parts. These were

1. A literature review (CSL)

2. The development of a methods of in-vitro study of bulb scale mite with particular reference to the relationship between temperature and development. (CSL).

3. A study of field dispersal of bulb scale mite, to allow the design of a chemical control programme which would minimise the spread of the mite.

Part 1. has been completed and reported separately to HDC. Part 2. is making progress and is also being reported separately. The purpose of this document is to report the findings of part 3 of the work.

Since the original proposals the work making up part 3. of the report has been modified, after consultation with the HDC. The work on field dispersal was completed, but the result indicated that development of an effective chemical control system aimed at minimising spread was unlikely to be feasible. The money set-aside for this work was therefore used to fund an investigation of the spread of bulb scale mite during the dry bulb handling and storage phase of narcissus culture and for an investigation of the temperature and time parameters necessary for the control of bulb scale mite in the bulbs by subjecting them to hot water treatment. In the latter case the literature is surprisingly at odds. Various recommendations are as follows: 30 minutes at 40°C (Blattny 1933); 1 hour at 43.3°C (Hodson, 1934); 1½ hours at 43.4°C (Doucette 1936); 3 hours at 44.4°C or 4 hours at 43.3°C (Winfield 1958). It could be important to establish the true nature of the criteria necessary for the successful control of BSM so that optimal treatments can be given to the bulbs.

Materials and Methods

i) Field dispersal of bulb scale mite

Two tonnes of a stock of narcissus, cv Texas, that was known to be infested with bulb scale mite (BSM) were purchased in September 1991. The bulbs were planted at HRI Kirton in a square block measuring approx 50m along each side. Planting was done by machine into ridges, in the normal way. An investigation showed that at least 90% of the bulbs were infested with BSM at planting.

Two methods of monitoring BSM dispersal were used through the growing season. These were 1) foliage sampling and 2) water trapping.

Foliage sampling was carried out on a weekly basis. This was done as a routine on the same day each week, rather than any attempt being made to co-ordinate sampling with any particular weather conditions. On each occasion the foliage of 25 bulbs was removed by cutting it off as near to the bulb as possible without allowing more than a minimum of soil contamination. This foliage was then thoroughly washed with tapwater, the rinsings passed through an Endecotts Test Sieve of aperture 53µ. The contents of the sieve were then washed into a 200ml conical flask using saturated magnesium sulphate solution. The flask was then topped up to half full and gently agitated to disperse its contents. It was then placed back on the 53µ sieve and topped up with magnesium sulphate solution until a gentle overflow occurred. This was repeated several times. The contents of the sieve, trapped from the overflow, were then finally washed off into a glass tube with water, and the contents of the tube were then poured into a Doncaster dish and the BSM adults and eggs were counted.

Three water traps, consisting of 200 mm diameter plastic dishes approx 50 mm deep, half-filled with water and with a drop of liquid detergent added, were placed along each side of the trial at a height approximately equal to the height of the ridges in which the bulbs were growing. These were emptied on the same occasions that the foliage samples were taken. The contents were collected on a 53µ sieve and examined for BSM in a Doncaster dish.

Brief trials were also made with a 'spore trap'. This consists of an electric-powered fan which draws an air sample across a slowly-rotating drum that is faced with sticky tape. A vane keeps the device pointing into the wind. Wind-borne particles impinging on the drum stick to the tape. This is removed at intervals and can be examined under a microscope. Problems with contamination of the tape by wind-blown soil particles and debris, which made the tape impossible to examine satisfactorily, caused abandonment of this method of sampling at an early stage.

2) In-store dispersal of bulb scale mite

Two visits were made to the bulb storage and processing facility of a farm near Spalding in Lincolnshire that grows narcissus for sale as bulbs and also forces them for flowers.

The farm had had a recent history of bulb scale mite problems in its own stock of narcissus cv Carlton.

The bulb handling facilities were contained in 2 buildings and there was also some outside storage for bulbs in boxes and trays. The buildings consisted of a cold store where bulbs for forcing were given the pre-forcing cool treatments that encourage early flowering, and a larger barn that contained the bulb cleaning and grading machinery.

At each visit dust samples were taken from different places on the holding. This was done by using a 12 mm soft-bristle brush of the paintbrush type to carefully sweep dust into a petri dish which had had a grid engraved upon its base. The contents of the dish were examined under a binocular microscope using 400 x magnification, the engraved grid being an aid for this process.

On each occasion that the premises were visited two operators were involved. A total of 55 samples of dust were examined.

The first visit was on 29.7.93 a day of light rain. This was chosen as it was believed that high humidity might encourage BSM to leave the bulb environment. Samples were taken from the fabric of the cold store facility, from the boxes that contained the recently-harvested bulbs and from the surface of the bulbs themselves, including the stock of Carlton known (and confirmed) to be infested. The cleaning and grading facility was not sampled as it had not been in use since harvest 1992.

The second visit was on 18.8.93, when the infested Carlton stock was being cleaned and graded. Samples were taken from the cleaning and grading machinery, the boxes containing the bulbs, the bulbs themselves and from the boxes after the bulbs had been emptied. As at the previous visit the presence of live bulb scale mites was confirmed in the stock of Carlton.

3) Parameters for successful hot-water treatment (HWT)

This experiment was done on the stock of narcissus cv Texas that was used for the field monitoring of bulb scale mite dispersal at HRI Kirton in 1992. Actual treatments were carried out at HRI Kirton in their HWT tank on 19th August 1993.

The normal treatment temperature, 44.4°C, used for HWT of narcissus was used in this experiment. This was chosen because a) it is a standard temperature used in the industry and b) it is the hottest that narcissus bulbs will stand for an exposure of 3-4 hours without either being specially acclimatised beforehand or suffering reduced growth and increased malformation of flowers and leaves. The variable in the experiment was the duration of the HWT.

The presence of live bulb scale mites in the bulbs used in the experiment was first confirmed. 25kg of bulbs were then placed in each of 8 nylon nets which were then tied at the neck. The 8 sets of bulbs were then loaded into an open-sided wooden box, normally used for the hot water treatment of bulbs in bulk. This was then hoisted into the HWT tank containing water at 44.4°C and the lid was replaced. Formaldehyde and an anti-foaming agent were included in the tank, as is normal practice in the bulb industry. Adding relatively cool bulbs to a warm tank lowers the latter's temperature somewhat, so that only when the temperature had returned to the target level did timing of the duration of the dip begin. After 30 minutes duration the box containing the nets of bulbs was briefly lifted from the tank, one of the nets of bulbs was removed and the box was then replaced on the tank. After the net of bulbs that was removed had been allowed to drain for about 1 minute it was opened and a subsample of approx 50 bulbs was placed in a new 250 gauge plastic bag which was tightly sealed to prevent the ingress or egress of bulb scale mites. The cycle of removing the box, extracting a net, replacing the box and taking a subsample of bulbs was repeated every 30 minutes until 4 hours had elapsed since the start of the experiment. A subsample of untreated bulbs was also taken, bringing the total number of samples to 9 - one untreated, the others exposed to HWT for 0.5, 1, 1.5, 2, 2.5, 3, 3.5 and 4 hours respectively.

The nine samples were then transferred to ADAS Cambridge and placed in an incubator maintaining 22-25°C, for 4 weeks. During this time the bags were kept well sealed to prevent cross-contamination of the bulbs. The purpose of incubation was to allow any viable eggs to hatch. Although it is relatively easy to see if motile stages of bulb scale mite are dead by manipulating them with a needle this is not the case for the eggs, which do not change appearance for some time after death. Egg hatch has been reported as occurring between 8 and 16 days after egg laying, so that the period allowed for incubation was sufficient to encourage viable eggs to have hatched. Obviously, the presence of live, freshly hatched larvae after incubation would indicate that eggs had survived the hot water treatment.

After the incubation period bulbs were removed from their bags, sectioned and the areas showing evidence of bulb scale mite damage were examined for live mites under 400 x magnification using a binocular microscope.

Results

1) Field monitoring

The most successful method of detecting bulb scale mites was the foliage sampling, but even this method detected mites on relatively few occasions. See graph 1 for details.

Water traps only detected BSM twice, and on each occasion only a single individual was found. In addition, the first time a mite was detected (14.7.92) some weeds were overhanging the water trap, and on the second occasion (19.8.92) the narcissus foliage had actually been flailed off immediately before the traps were emptied.

2) In-store monitoring

On both monitoring occasions bulb scale mites were detectable inside the bulb tissues of the growers stock of cv Carlton. However, on neither occasion was any BSM detected outside the bulb-not on the store fabric, machinery, boxes nor on the external surface of the bulbs themselves.

The sampling and examination system used did detect at least 4 different families of mites. These were Tydeidae (Prostigmata), Cheyletidae (Prostigmata), Eriophyidae (Prostigmata) and Rhizoglyphus spp (Astigmata). Rhizoglyphus and Cheyletidae are relatively large mites but Tydeidae and Eriophyidae are both of similar size to bulb scale mite. The implication is that the methods of detection used should have been able to detect BSM if it had been present in the areas sampled.

3) Hot water treatment

Subsamples of bulbs from each of the treatments were examined after they had been in the incubator for 4 weeks. Although inactive (dead?) mites and apparently healthy eggs were present in all of the samples, no live mites were confirmed present in any of the bulbs. Unfortunately however this also included the untreated bulbs kept as controls, where all the mites had also apparently died.

Discussion

1) Field monitoring

By far the largest number of mites were present on the foliage of the bulbs as they emerged in early February. From March onwards until July the number of mites found was small and the findings were sporadic.

The reason for the large numbers present in February is probably linked with the growth of the bulbs themselves. After harvest in the summer the bulbs tend to lose some moisture. This causes the inter-scale spaces within the bulb to enlarge, which in turn allows the mites access to a larger feeding area. After replanting, the bulbs undergo a period of dormancy during which the bulb scale mites feed and reproduce. As there is plenty of food and space available to them at this time numbers increase rapidly. However, after the dormant period is complete the bulbs start to re-grow. The root system picks up water from the soil and this causes the bulb to swell, which leads to compression of the inter-scale spaces. At this time, many of the bulb scale mites present are crushed to death whilst the remainder are forced up into the neck region of the bulbs. They are then carried up on the foliage as this emerges. It was at this point that they were detected in relatively large numbers by the foliage sampling technique.

There was no evidence that the presence of large numbers of mites on the foliage of the plants in the sample was attributable to a dispersal mechanism. It seems to be a response to a change in the structure of the host plant. It is however difficult to account for the rather sudden decline in the number of mites on the foliage. This cannot be accounted for by a "dilution factor". Although the amount of foliage on each plant increased as the plants grew, on each occasion it was the foliage of 25 plants that was sampled rather than a fixed weight of foliage. It seems that mites were lost from the foliage by natural wastage (dehydration, predators?) rather than dispersal.

Mites were found on such few occasions on the foliage that it was not possible to propose a link between weather conditions and the appearance of mites.

2) In-store monitoring

It is common in the literature to refer to contamination of clean stocks by mites moving from nearby infested ones. We failed to confirm this in our monitoring exercises. It is possible that we chose inappropriate times for the two visits although on the first occasion it was humid, which should have suited the mites, and on the second infested bulbs were being handled. It is also possible that the method used was inadequate for the detection of BSM, but the fact that other species of mites of a similar size to BSM were detected on several occasions tends not to support this theory.

3) Temperature/Time Criteria for HWT

This experiment cannot be considered a success as even the mites in the untreated sample of bulbs failed to survive four weeks in an incubator set at 22-25°C. For this reason the failure of the mites in the treated bulbs to survive has no significance.

The reason for the death of the mites in the untreated bulbs is not clear. It is unlikely to be related to the temperatures in the incubator as these were well below those that are common in hot-water treatment. There is a possibility that storing the bulbs in tightly closed plastic bags may have been responsible for the mites' failure to survive. The bags were closely tied to avoid the risk of cross-contamination of the different treatments by survivor mites wandering from other treatments. In retrospect, it seems that the bulbs, respiring inside the bags, may have altered the ratio of oxygen to carbon dioxide thus producing the fatal effect on the BSM.

It should be possible to devise a different bulb storage system that would prevent cross-contamination whilst allowing gaseous exchange to take place. However, by the time that the experimental assessments were completed for the above experiment it was too late in the season for further work to be feasible.

Conclusions

Most of the conclusions that can be drawn from these pieces of work are unexpected.

From the field monitoring it appears that bulb scale mites only leave the shelter of growing bulbs in significant numbers when they are forced to by conditions within the bulb. In this work they were only found in large numbers on the foliage in the 10 days after emergence of the bulbs in the field. They were found subsequently to this on relatively few occasions spread over 6 months and then in only small numbers. Originally it was hoped that this work would discover mites emerging from the bulbs in order to disperse, and that this dispersal phase would provide an opportunity to apply some chemical control measures. This latter option does not now appear to be feasible. If chemicals are ever to be applied to growing bulbs for control of BSM then the best time may be at foliar emergence in the spring, since this is when most mites seem to be exposed further field studies are required. However, it also seem likely that some mites deep within the bulbs will always manage to escape treatment so the concept of chemical control does not appear to be a particularly useful one.

From the in-store monitoring we were unable to confirm that BSM spreads between bulb stocks in the storage period (harvest to replanting). We found other mites, including bulb mites, during our inspections but no BSM except within some bulbs. This lack of apparent dispersal at this time contradicts with the literature and popular supposition, but if it is true then it means that measures aimed at limiting spread in store are unlikely to have much effect on the distribution of mites between stocks. Good store hygiene is still however important for other reasons.

The final work did not enable us to draw any conclusions about the temperature/time criteria for successful hot-water treatment for the control of BSM in narcissus. In the absence of further information it seems logical to adopt the most extreme of the recommendations enshrined in the literature, namely 3 hours at 44.4°C or 4 hours at 43.3°C. The former is the standard regime practised for stem nematode control.

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