CAN TWO-SPOTTED MITE BE CONTROLLED BY PREDATORY MITE RELEASES IN IRRIGATED MAIZE CROPS?

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Abstract

Two-spotted mite (TSM), Tetranychus urticae (Koch), an important pest of maize, has been the subject of a three-year research program investigating the effectiveness of predatory mites to prevent major outbreaks. Two species of predatory mite, Phytoseiulus persimilis Ahias-Henriot and Galendromus (Typhlodromus) occidentalis (Nesbitt), have successfully controlled TSM in a number of horticultural field crops in Australia. P. persimilis has provided effective control of TSM in maize in North America. Glasshouse pot trials demonstrated that both predators survived on TSM infested cv Hycorn 345 maize plants and reduced the pest populations. Overseas studies have shown that the timing and number of predators released is critical to the predator's success in maize crops. In field trials at Breeza (Liverpool Plains) predatory mites were released at two different rates (25,000 and 50,000 / ha) and at different times (different growth stages and early and late plantings) prior to the annual exponential increase of TSM, which occurs at flowering. Two-spotted mite populations were reduced by 31% and 35% by P. persimilis and G. occidentalis respectively but this level of control did not improve the percentage of grits >6.7mm or total yield. In 2004 0.25 ha single plot field trials were carried out at Darlington Point and Hillston (MIA) NSW. While economically effective biological control was not established the trials did provide direction that supports conducting further research.

Introduction

Two-spotted mite (TSM), Tetranychus urticae (Koch) is an important pest of maize but the severity of infestation varies considerably between seasons and growing districts. In the southern areas of NSW, such as in the Murrumbidgee Irrigation Area (MIA), and Northern Victoria, TSM populations reach very high levels in most seasons. In northern NSW, specifically on the Liverpool Plains, it’s usually a problem only once every three or four years (on average) whereas in Queensland it is only an occasional problem. There are many factors, including temperature, humidity, light intensity, day-length, cultivar, plant growth stage and nutritional status of the plant and slow population development rates of natural enemies, that individually or combined, influence TSM population growth and their pest status (Margolies and Kennedy 1984, Brandenburg and Kennedy 1987, Bounfour and Tanigoshi 2001). As with all insects, the key factors driving the pest status of TSM are temperature and availability of suitable host plants. In cool climates TSM survives by entering into a non-feeding non-reproductive diapause, however in mild winter temperatures TSM remains active and, given its host range that includes numerous weed species, there are always alternative hosts available. Two-spotted mite can survive for short periods at temperatures as low as -15°C (Brandenburg and Kennedy 1987) so under Australian conditions low temperature is rarely a limiting factor.

As the summer approaches and the over-wintering hosts begin to dry down TSM is stimulated to disperse by crawling to neighbouring plants or by launching itself into the wind as aerial plankton. Studies have shown that cultivation significantly reduces TSM over-wintering on leaf litter and soil and that new season infestations arrive as aerial plankton (Wilson 1995). Two-spotted mite is highly adapted to exploit crop hosts with ideal conditions for development being hot (13 to 35°C) and dry, low in-crop humidity and a water stressed host. As temperatures increase TSM fecundity increases from 1.7 eggs / female / day at 15°C to 7.1 eggs / female / day at 30°C. On average a female TSM lives for 22 days at 15°C and 17 days at 30°C producing about 38 and 121 eggs respectively (Bounfour and Tanigoshi 2001). At this rate populations grow exponentially and reach damaging levels rapidly. Two-spotted mite feed on the cell contents of the leaf. This reduces photosynthesis and in turn plant growth, cob development and yield. In a miticide spray vs. no spray trial TSM was responsible for a 13% reduction in yield (Archer and Bynum 1993).
Damage caused after the kernels have reached the dent stage did not affect cob development or yield (Archer and Bynum 1993).

Control

Controlling TSM in maize is difficult. The only products currently registered for TSM control in maize (in Australia) are petroleum spray oils, however growers rarely use them because targeting the underside of the leaves where the mite occurs is difficult and not considered cost effective.

Biological control of TSM based on predatory mites, *Phytoseiulus persimilis* Ahias-Henriot and *Galendromus (Typhlodromus) occidentalis* (Nesbitt), has been successful in a number of crops, including apples, stonefruit, strawberries, ornamental and cut flowers and vegetables. Available from commercial insectaries, each species has attributes that indicate it has potential as a control agent for TSM in maize in Australia (Broadley and Thomas 1995). *Phytoseiulus persimilis* can consume 20 young or 7 adult TSM / day and at 25°C reproduce at twice the rate of TSM. It is suited to moderate temperatures, high humidity and crops with heavy foliage. The recommended release rate in field crops is 10,000 / 1000-2000 m². *Galendromus occidentalis* is suited to hot dry conditions. Adult *G. occidentalis* can consume 5-15 TSM / day and, reaching maturity 7-8 days compared with TSM’s 14-17 days, reproduces at the rate of 2-3 eggs / day for 24 days. *Galendromus occidentalis* is best suited to temperatures of 27-32°C but can tolerate 40+°C (Broadley and Thomas 1995). Some releases of *P. persimilis* in maize have been carried out by commercial insectaries and are reported to have provided control, however efficacy and yield benefits have not been assessed (Robyn Coy - personal communication 2003, Coy 2000).

In the US, research has shown that releasing *P. persimilis* in maize prior to tasselling (TSM increases rapidly from tasselling onwards) at the rate of 5 per plant reduced TSM populations by 65-91%, i.e., below the economic threshold (Pickett and Gilstrap 1986). The release threshold was determined to be 0.1 TSM / plant (Pickett and Gilstrap 1986). The economic threshold figure was not provided. Pickett and Gilstrap (1987) demonstrated that aircraft could evenly and effectively distribute predatory mites. Following aerial distribution *P. persimilis* was recorded on 55-75% of plants.

The aim of this project was to investigate the potential of two commercially available predatory mites, *P. persimilis* and *G. occidentalis*, to control TSM in irrigated maize crops under Australian conditions.

Methods

2002 - 2003

A small pot trial with 18 maize (cv Hycorn 345) plants infested with TSM was established under glasshouse conditions of 28°C (±3°C). Predatory mites *P. persimilis* and *G. occidentalis* were released at the rate of 5 predators / plant on 6 plants for each of the two species. Two-spotted mite and predatory mite populations were compared with the remaining 6 infested plants as a control. *Phytoseiulus persimilis* Ahias-Henriot was supplied by the Beneficial Bug Co. Richmond NSW, *Galendromus (Typhlodromus) occidentalis* (Nesbitt) by Biological Services, Loxton SA. Surveys of TSM and its natural enemies were carried out on 24-25 February 2003 at nine locations in the MIA and three locations in the Spring Ridge area of the Liverpool Plains. Predatory mites were to be released in the Spring Ridge area when monitoring showed the TSM population had reached 1 / plant providing this occurred prior to tasselling.

2003 – 2004

A block of maize, cv Hycorn 345 (donated by Pacific Seed Ltd) was planted 15 October 2003 (early planting) at the Liverpool Plains Field Station (LPFS), Breeza. The block was divided into a 36 plots (6 x 6), each plot was made up of 7.5 x 1.8 m raised beds 20 m in length. Plots were separated by approximately 1 m of bare earth. Two rows of maize were planted in each bed at the rate of 14 seeds / 2.1 m. Urea was applied to all plots. All plots were flood irrigated at approximately 8-day intervals.
Five treatments and an untreated control were each allotted to six plots (replicates), total of 36 plots. Each treatment was allotted to each row of plots such that no treatment was replicated in an adjacent plot. To ensure a pest population, TSM was released on the 16 January 2004 at the rate of one infested bean leaf (ca. 110 TSM / leaf) / 10 m of row, (equivalent to 2.2 / plant) into all plots except those allotted as untreated controls. Predatory mites were released on 18 February 2004 at the rate of 780 and 1560 mites / plot, the equivalent of 25,000 and 50,000 mites / ha respectively. The treatments, *P. persimillis* 25,000 / ha, *P. persimillis* 50,000 / ha, *G. occidentalis* 25,000 / ha, *G. occidentalis* 50,000 / ha were compared to plots with TSM only and the untreated control. A second block of cv Hycorn 345 was planted on the 18 November 2003 (late planting) and replicated the early planting, except that plots made of 8 x 1.8 m beds. Predatory mite numbers were increased to account for the additional 0.5 row. Mite populations were monitored fortnightly by recording the number and species of mite on 20 leaves. Twenty cobs were harvested from each plot and the kernels graded and weighed.

2004 -2005

A single block of maize, cv Hycorn 345, was planted on the 25 October 2004 at the LPFS, Breeza. The block was divided into a 30 plots (6 x 5), each plot was made up of 8 x 1.8 m raised beds 20 m in length. Plots were separated by 4 m of bare earth. Seeding and management was as for the 2003-04 season. Two-spotted mite was released on 18 November 2004 in all plots when plants were 0.45-0.5 cm high to ensure a pest presence. The treatments were, *P. persimillis* 50,000 / ha, *G. occidentalis* 50,000 / ha, and *P. persimillis* plus *G. occidentalis* 25,000 each spp. / ha and plots sprayed with 2% petroleum oil (Sun-spray Ultra-Fine, Amtrade Melbourne). Oil sprays were applied on 5, 24, and 31 January and 15 February 2005. Predatory mites were released on the 2 December 2004 when plants were 0.7 m high. These treatments were compared with an untreated control plots. Mite populations were monitored fortnightly by recording the number and species of mite on 20 leaves. Thirty cobs were harvested from each plot and the kernels graded and weighed.

Two field trials were carried in the MIA; one at Darlington Point, the other at Hillston. Each trial had two treatments, *P. persimillis* 30,000 / ha and *G. occidentalis* 30,000 / ha and these were compared with an untreated control. Predatory mites were released on 24 November 2004. Plants were approximately 1.2 m and 0.25 m tall at the Darlington Point and Hillston sites respectively. Each plot was approximately 1 ha. Monitoring was conducted fortnightly with 50 leaves / plot checked for the presence of TSM and predators. Twenty cobs were harvested from each plot and the kernels graded and weighed.

REML Variance Components Analysis and Repeated Measures Analysis of Variance were applied to the data to determine differences between treatments the effects on yield and kernel size.

**Results and discussion**

2002 – 2003

The glasshouse pot trial demonstrated that *P. persimillis* and *G. occidentalis* were both able to survive on maize and feed on and suppress TSM. There was no significant difference between predators with TSM suppressed by up to 70%. The high level of TSM infestation and the release rate of 5 predators / plant exceeded the proposed field release threshold and the predator release rate of 50,000 / ha by 7 times, (i.e. the equivalent of 350,000 per ha) and was not considered indicative of what was likely to occur in the field.

In the MIA, crop surveys found that TSM infestation varied considerably across a district and its distribution was not uniform across a crop (Figures 1a, b, c). Natural enemies present were mainly *Stethorus* spp and the larvae of other coccinelids (ladybirds). The survey also showed that TSM infestation was low in crops or areas of crop where natural enemies were highest, indicating some level of control. The data show that natural enemies (principally *Stethorus*) did not increase in response to increased TSM. Two-spotted mite was not found in any of the crops monitored on the Liverpool Plains during 2002-2003 and predatory mites were not released.
2003 – 2004

Following 2002-2003 in which TSM was undetectable in crops monitored at Spring Ridge (Liverpool Plains), 2003–2004 crops incurred extremely high infestations. Growers reported 2003-2004 as one of the worst years for TSM on record with yields down by as much as 15%. The data showed that, even though the predatory mites were established in the crop they could not control a severe TSM infestation.

Analysis of the data from both the early and late planted crops found that there was no significant difference between treatments in the level of TSM infestation. Monitoring on the 17 March 2004 found 80% of leaves in all treatments were infested with TSM (Figure 2). It also showed that the number of leaves occupied by *P. persimillis* was similar in all treatments including the control plots. The number of leaves occupied by *G. occidentalis* was more varied, ranging from 12% to 42%. It had also spread to other treatments including the control plots. The spread of predators to other treatments, despite the 1 m gap of bare earth, demonstrates their mobility and potential to spread out from the point of release.
There was no significant difference between treatments in the total yield or the proportion of kernels that were graded as greater than 6.7 mm, which attract a premium from some food processors, i.e., cornflake manufacturers.

2004 – 2005

Two-spotted mite populations at the LPFS remained extremely low until mid-January. On the 5 January the mean number of TSM / leaf across all treatments was 0.012, however this had risen to 15 / leaf by 24 January. The number increased to 57 and 98 TSM / leaf by 7 and 21 February 2005 respectively. This rapid increase coincided with increasing temperatures and flowering. Analysis of the data showed a significant difference between treatments in the level of TSM infestation (Figure 3).

The results show that predatory mites, *Phytoseiulus persimilis* and *Galendromus occidentalis*, augmenting naturally occurring predators, provided significantly better control than the untreated controls (Figure 3). These predatory mite treatments provided the same level of control as those treated with four applications of petroleum spray oil (Figure 3). Two-spotted mite populations were reduced by 31, 35, 21, and 33% in the *P. persimilis*, *G. occidentalis*, *P. persimilis* and *G. occidentalis* and oil treatments respectively.

*Phytoseiulus persimilis* and *G. occidentalis* provided better control of TSM individually than when the two species were released together at the 0.5 rate of 25,000 / ha each. It is possible that in mixed releases *P. persimilis* and *G. occidentalis* prey on each other or one preys on the other and their numbers are reduced.
There was no significant difference between treatments in the total yield or the proportion of kernels that were graded as greater than 6.7 mm. There are two possible reasons why no significant difference was found in the yield data: 1. TSM numbers were not high enough to cause significant yield loss; 2. infestation occurred too late, i.e., after denting when no further growth takes place; or 3. a 36% reduction of TSM infestation was not sufficient to produce detectable yield differences.

Based on leaf occupation rate, monitoring of the Darlington Point and Hillston trial sites showed that the TSM populations increase rapidly in the late December - early January period, however predators were present in only low numbers and did not reach the same occupation rate as TSM until mid February (Figures 4a, b, c). Following initial release no predators were observed at Hillston where plants were approximately 25 cm tall at the time of predatory mite release and were exposed to the extremes of temperature and wind. Monitoring leaf occupation does not show the number of pests or predators present on a leaf and therefore no indication of population size. Data analysis found there was no significant difference between treatments in the total yield or the proportion of kernels that were graded as greater than 6.7 mm. Local personnel, i.e., those carrying out the monitoring, reported that TSM infestation / leaf was exceptionally high during 2004-05 and predator numbers were very low.
Conclusion

This project demonstrated that TSM populations can be suppressed in irrigated maize by augmenting naturally occurring predators with releases of *P. persimilis* and *G. occidentalis* at the rate of 50,000 / ha. However full and effective control of two-spotted mite, defined as a reduction in the population to the point where significant damage to plants is prevented and yield is increased, was not achieved.

Predatory mites were released at different times and at different stages of crop growth. Establishment was most successful in tall crops (>0.7 m) when canopy closure was complete and offered the predators protection from direct sunlight and the extremes of heat. At the time of predator release, the crop at Hillston was short and open to the direct effects heat and wind (e.g. desiccation), although these cannot be positively identified as causing the predator’s failure to establish. This project supports the findings of overseas research, showing that plant size, timing of predator release and prey numbers are the key factors. Further research is required to determine the optimum for each parameter. When predators are established, pest pressure and rate of increase (i.e. the predator / prey relationship) will determine success.

There are real benefits to be had from effective biological control of TSM. As a control technique biological control has none of the health or environmental risks associated with a conventional pesticide strategy and will, when successfully implemented, maintain the maize industry’s low chemical residue status. This could be important in maintaining access to pesticide residue sensitive export markets.

This project has helped identify some of the problems associated with using predatory mites to control TSM in irrigated maize. The fact that TSM infestations were suppressed is promising and further research is recommended.

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