Effects of Insecticide Mode-of-Action on Onion Thrips Survival and Fecundity, and Onion Feeding Injury – Field Trial, 2012

Diane Alston, Entomologist
Utah State University

Onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), is an economically important pest of onions throughout onion producing regions of the world. It is the primary vector of Iris yellow spot virus, another important pest of onion worldwide. The primary control tactic for both pests is multiple applications of insecticides, as frequently as weekly during mid-summer. To reduce the likelihood of insecticide resistance in thrips populations, rotations of different classes of insecticides are recommended. However, a thorough understanding of how insecticide modes of action affect different life stages of onion thrips, including fecundity and egg viability, is not fully known. This field study was undertaken to compare the effects of insecticides with contact and ingested modes of entry, and translaminar and systemic movement in plants, on onion thrips life stages and the ability of thrips to inflict feeding injury to onion plants.

Methods

Plots and experimental design

The study was conducted in a field of 'Vaquero' onion planted on beds (3 ft spacing; 2 rows of onions per bed) at the Utah State University research farm in Kaysville, UT. Onions were seeded in late March, 2012, and irrigated twice per week (approx. 4 hr each time) with overhead sprinklers on a wheel line. Each plot was 5 ft in length and one bed wide. The experimental design was a complete randomized block with five replicates of each of five insecticide treatments. Insecticide treatments were applied with a Solo® backpack mist sprayer at a rate of 50 gal of solution per acre on June 27 and July 5 (8 day interval). The only other pesticides applied to the field were herbicides (Round-Up, Buctril, and Prowl) for weed control.

Insecticide treatments*:

1. Movento 240SC at 5 oz/acre
2. Benevia 100OD at 20.5 oz/acre
3. Mustang Max EW at 4 oz/acre
4. Radiant SC at 8 oz/acre
5. Untreated Control (no solution was applied)

*0.25% v/v methylated seed oil (MSO) was added to all insecticide treatments

Caging thrips on onion plants

To ensure that there was an adequate population of onion thrips to result in differences in feeding injury among treatments, after each insecticide application, onion thrips from a laboratory colony were added to two plants in each plot and enclosed in a cage. On the day of each application, after sprays on plants had dried, a sleeve cage made from no-see-um mesh fabric was placed over each of two plants in each plot and the base secured into the soil with a ring made from PVC pipe (1.5 in high × 6 in diam). The top of the cage was closed with a twist-tie. One day after each insecticide application, on June 28 and July 6, eight onion thrips (three adults and five larvae) from a laboratory colony (originally collected from onion fields and reared on 'Fordhook' lima bean at 25°C and 16 hr photoperiod) were added to each caged plant. The thrips colony was initiated in 2010 and approx. 100 new adults were added in each 2011 and 2012 to maintain genetic diversity. In the lab, thrips were transferred from lima bean leaves to a 1.7 ml polypropylene micro-centrifuge tube with a small paintbrush and held in a cooler on blue ice for transport to the field. One tube was placed in the neck of each caged plant and the lid opened to release the thrips. Cages were removed before the second insecticide application on July 5, and then replaced and more thrips added after sprays had dried as described above.

Thrips feeding injury onion growth measurements

Before insecticides were applied on each June 27 and July 5, and on the final sample date of July 16 (19 days after the first insecticide application and 11 days after the second application), onion thrips feeding injury was visually assessed on two "open" and two "caged" plants in each plot using the following rating scale: 1 = no thrips stippling and rasping feeding scars on the upper leaf surfaces, 2 = up to 25% of upper leaf surfaces with thrips feeding injury, 3 = 26-50% of upper leaf surfaces with injury, 4 = 51-75% of upper leaf surfaces with thrips injury, and 5 = 76-100% of upper leaf surfaces with thrips feeding injury. On July 5 and 16, because thrips injury differed between new leaves that had grown since the insecticide treatments were applied and old leaves that were present before insecticide application began, injury ratings were conducted separately for each new and old leaves. Additionally, the number of leaves per plant was counted on the same plants as assessed for thrips injury. On July 16, the bulb diameter of each open and caged sample plant was measured with a caliper.

Densities of thrips life stages and egg hatch

On July 16, after plant injury and growth data were collected, each sample onion plant (the same two open and two caged plants per plot as sampled for injury and growth; a total of 10 caged and 10 open plants for each insecticide treatment) was cut across the top of the bulb, placed in a labeled 1-gal press-seal plastic bag, and transported to the laboratory in a cooler with blue ice. In the lab, onion plant samples were processed with a washing technique. The two caged and two open plants from each plot were placed separately in a bucket with soapy water to wash off the motile life stages (adults and larvae). The soapy water with thrips was poured through a 220-mesh sieve, and thrips washed into a 20-ml glass vial with 70% ethyl alcohol for counting under a dissecting microscope at 10-20× magnification. To determine densities of thrips eggs within leaf tissue, the third youngest leaf of each plant was removed, placed in a 125-ml plastic bottle, and stained with acid fuchsin dye. The leaves were pressed between two glass plates and the eggs counted under a dissecting microscope at 20-30× magnification. To determine the number of viable thrips eggs within leaves, the fourth youngest leaf was removed and placed into a hatching chamber made from a gal-size press-seal plastic bag containing a moistened filter paper (shark skin). Hatching chambers were placed in an incubator at constant 25°C for seven days, after which the leaves and inside of the bag and filter paper were washed thoroughly with water and the solution collected on a 220-mesh sieve. The hatched larvae were washed into a 20-ml glass vial with 70% ethyl alcohol for storage until counting as described above.

Statistical analyses

Data for thrips life stage densities and plant growth were compared among insecticides and plant type (open or caged) with a two-way factorial analysis of variance (Proc Mixed; SAS ver. 9.2). When interaction or main effects were significant, means were separated with Tukey's pairwise comparison test ($\alpha = 0.1$). Normality of data was tested prior to analysis, and square root-transformed as needed. Thrips injury rating data were analyzed with chi-square tests (Pearson and Likelihood Ratio; SAS ver. 9.2). Non-transformed means and standard error results are presented.

Results and Discussion

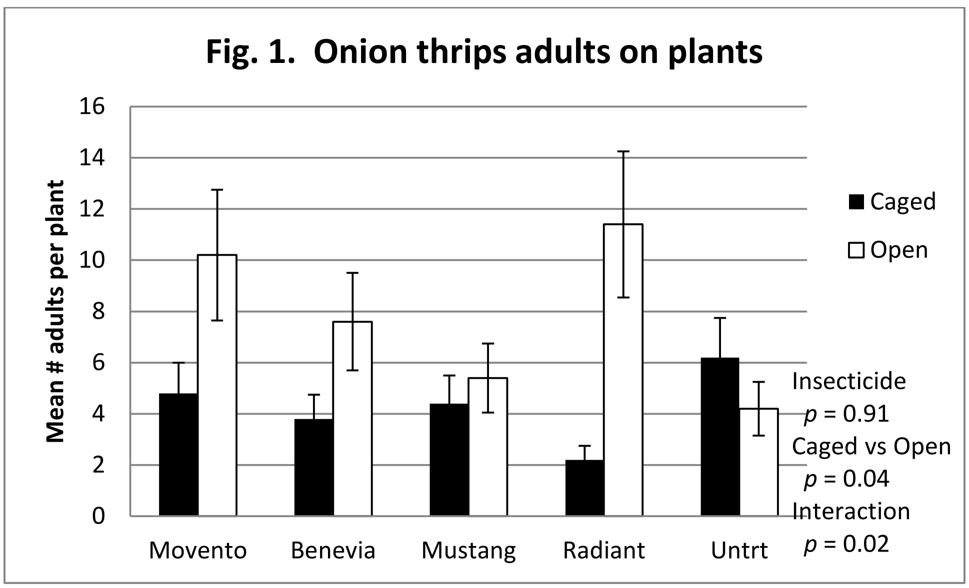
Insecticides from four different classes were evaluated:

1. Movento (spirotetramat), a tetramic acid (IRAC Class 23*) has two-way systemicity, is phloem mobile, interferes with lipid synthesis, and kills thrips by ingestion
2. Benevia (cyantraniliprole), an anthranilic diamide (28*) is upwardly systemic, xylem mobile, translaminar, interferes with muscle function, and it primarily kills thrips by ingestion
3. Mustang Max (zeta-cypermethrin), a pyrethroid (3A*) is a nerve toxin and primarily kills thrips via contact
4. Radiant (spinetoram), a spinosyn (5*) is a nerve toxin, it primarily kills thrips by ingestion, but also has some contact activity and translaminar movement (local, from upper to lower leaf surface)

*Insecticide Resistance Action Committee mode-of-action classification

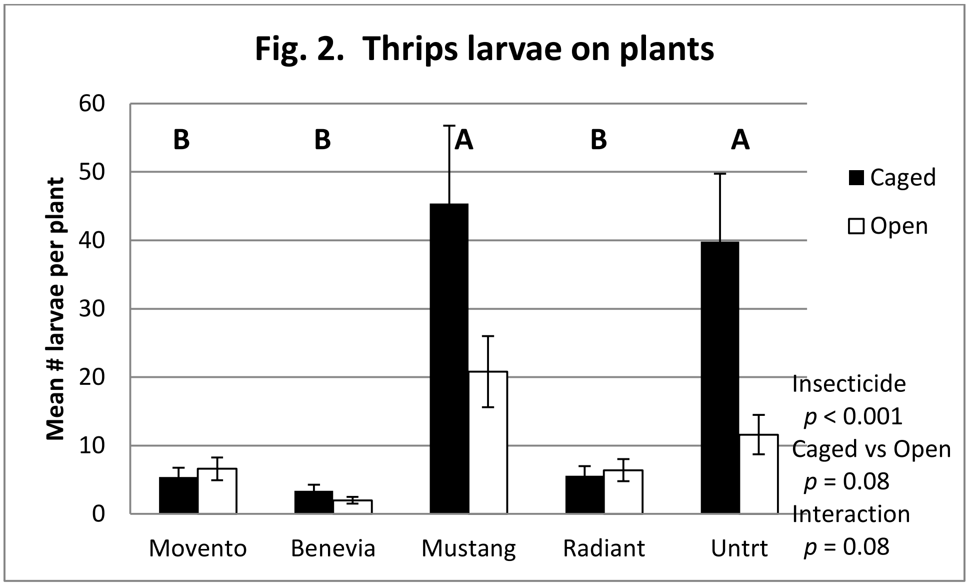
Thrips adults and larvae on plants

There was a significant interaction between insecticides and plant type (caged or open) for adult thrips densities (Fig. 1). More adults occurred on open than caged plants in all insecticide treatments; however, the reverse was observed for the untreated control. Overall there were more adults on open than caged plants, but there was no difference among insecticide treatments, including the untreated control. Greater densities of adults on open plants were most likely due to immigration post-treatment, but it is not evident why this same effect was not observed for untreated plants. Despite the ambiguity of the interaction, none of the insecticides showed good efficacy against the adult life stage of onion thrips.



There were few western flower thrips, *Frankliniella occidentalis* (Pergande), present on onion plants during the study. Means per plant ranged from 0.7 to 1.0; therefore, it can be assumed that the vast majority of thrips larvae present on plants were onion thrips.

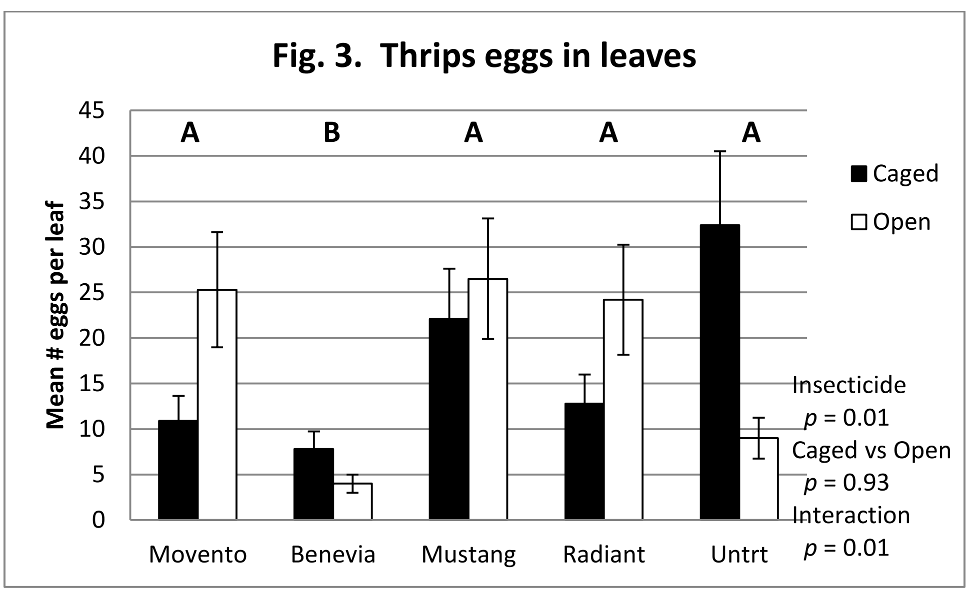
Movento, Benevia, and Radiant were highly effective in reducing larval densities on plants (Fig. 2). Larval counts did not differ between Mustang and the untreated control. There was no overall significant effect of caged plants on larval densities; however, for Mustang and the untreated control there were more larvae on caged than open plants. There was no interaction between insecticides and plant type for larval densities.



Movento, Benevia, and Radiant showed strong efficacy against thrips larvae, but not so for adults. Mustang Max was ineffective against both adults and larvae.

Thrips fecundity

There was an interaction between the insecticide treatments and plant type for egg counts in leaves (Fig. 3). For Movento and Radiant, more eggs per leaf occurred on open than caged plants, but the opposite was true for Benevia and the untreated control.

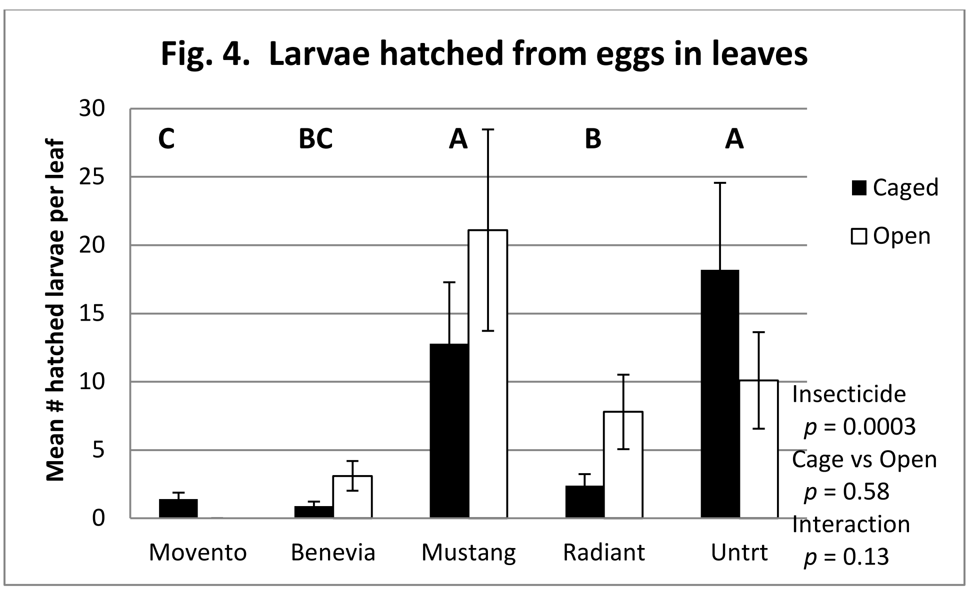


Similar to the interaction effect observed for adult densities, open plants allowed adult immigration which may have led to greater egg deposition. However, for Benevia and the untreated control, the number of eggs within the cage exceeded that of the open plant, especially for the untreated.

Overall, there was not a significant effect of caged thrips on egg counts; however, there was a highly significant difference among insecticides. Benevia was the only insecticide to reduce egg densities below the untreated control. So although Benevia did not reduce adult densities, it did reduce fecundity. Benevia has been shown to reduce thrips feeding through interference with muscle function. Reduced feeding could lead to a less fit adult that produces fewer eggs.

Egg viability

The number of larvae that hatched from eggs was not influenced by an interaction of effects or by caging plants, but was highly influenced by insecticide treatment (Fig. 4). The fewest number of larvae hatched from leaves treated with Movento, and the greatest from plants treated with Mustang or untreated. Egg hatch was also significantly reduced for plants treated with Benevia and Radiant as compared to untreated and Mustang plots.



Although Movento did not reduce fecundity of thrips adults, it greatly reduced the number of viable larvae that hatched from eggs. Inhibition of lipid synthesis in development of first instar larvae within the eggs may play a role in this effect. Benevia reduced both fecundity and egg viability. Although Radiant does not have systemic movement in the plant, it nonetheless reduced hatch of eggs. Its local, translaminar movement may increase contact of the insecticide with eggs within leaf tissue. The developing first instar larva may take up enough neurotoxin to impair hatch.

Predators

The only predatory arthropod found on plants was the banded thrips (*Aeolothrips* sp.); numbers were extremely low, no more than an average of 0.3 per plant. There was no difference among insecticide treatments, plant types, or an interaction effect.

Thrips feeding injury

When the study was initiated on June 27, plants already had a mean thrips feeding injury rating of 2.3-2.5 (a rating of 2 = up to 25% of upper leaf surface with thrips scarring; a rating of 3 = 26-50% of upper leaf surface with injury); there were no differences among insecticide treatments (Table 1). Post-treatment, on both July 5 and 16, there were significant effects of insecticides on injury ratings for new and old leaves. New leaves were those in the center of the plant that had grown since the first insecticide application, and old leaves were those in the outer portion of the plant that had formed before the trial was initiated. The lowest injury ratings for new leaves were for Benevia and Radiant (1.0-1.3, and 1.5-1.6, respectively), and the highest ratings were for the untreated control (2.3-3.6) (Table 1). The lowest feeding ratings for old leaves were for Benevia (2.6), which were lower than all other insecticides (3.0-3.7) and the untreated control (3.7-4.4). There was no difference in feeding injury between caged and open plants (data not shown).

Table 1. Average onion plant growth (number of leaves per plant and bulb diameter) and thrips injury to plants (1-5 injury rating scale) from pre-treatment on June 27 through post-treatment on July 5 and 16 (total trial period was 19 days).

Insecticide	Jun 27 (pre-trt)		Jul 5 (8 days post-trt)			Jul 16 (11 and 19 days post-trt)			
	Overall rating*^	Num leaves~	Old leaf rating*^	New leaf rating*^	Num leaves~	Old leaf rating*^	New leaf rating*^	Num leaves~	Bulb diam (in)~
Movento	2.4	8.3	3.2	1.8	9.9	3.2	2.0	11.7	1.9
Benevia	2.4	8.1	2.6	1.0	10.0	2.6	1.3	12.5	1.7
Mustang	2.3	7.8	3.5	2.0	10.1	3.7	2.7	12.0	1.9
Radiant	2.3	7.7	3.3	1.5	10.0	3.0	1.6	12.0	1.7
Untreated	2.5	8.0	3.7	2.3	10.0	4.4	3.6	11.2	1.9
P value	*0.88*	*0.34*	***0.03***	***0.0001***	*0.99*	***0.0001***	***0.0001***	*0.20*	*0.28*

*1=no thrips feeding injury, 2=up to 25% of upper leaf surface with thrips scarring, 3=26-50%, 4=51-75%, and 5=76-100%.

^Chi-square analysis used to determine if there were differences in mean ratings among insecticide treatments.
~Analysis of variance (Proc Mixed, SAS) used to determine if there were differences among insecticide treatments.

Benevia was the most effective insecticide in stopping thrips feeding which would reduce transmission of Iris yellow spot virus, if it were present in the onion plants. Radiant was the second most effective insecticide in reducing thrips feeding of the products tested.

Onion growth

At the beginning of the trial, plants had an average of 7.7-8.3 leaves per plant, and were not different among plots (Table 1). In the relatively short trial period, 19 days, there was no effect of insecticide or caging treatment on leaf number or bulb size (Table 1). By the end of the trial, plants had a mean of 11.2-12.5 leaves and bulb diameter ranged from 1.7 to 1.9 in.

Conclusions

None of the insecticides tested were effective in killing adults on plants; however, Movento, Benevia, and Radiant were all highly effective in reducing numbers of larvae on plants. In addition, Benevia significantly reduced fecundity (number of eggs laid in leaves), and Movento, Benevia, and Radiant all reduced egg viability, especially Movento. Mustang Max was the only insecticide tested that was not effective in reducing onion thrips populations. In enclosing additional onion thrips within cages and eliminating immigration on some plants, the results show few differences, except for adults where there were generally more on plants open to immigration and for larvae and eggs where there were more on caged plants for Mustang-treated (larvae only) and untreated plants. This latter effect may be due to the higher initial thrips population in caged plants that reproduced well without inhibition by insecticide activity and/or exclusion of predators. However, few predators were found on plants, and there were no differences in numbers of banded thrips among insecticide or caged plant treatments.

Benevia was the most effective in reducing feeding injury on new and old leaves on onion plants. Benevia impairs muscle function in the mouthparts which reduced thrips feeding within at least eight days of application. Reduced thrips feeding would have the added benefit of less transmission of Iris yellow spot virus if the pathogen was present in the onion field.