Michigan Vegetable Insecticide Evaluation Studies

2013

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Evaluation of systemic and foliar insecticides for asparagus miner control

The asparagus miner (*Ophiomyia simplex* Loew; Diptera: Agromyzidae) is a putative vector for pathogenic species of *Fusarium* fungus, which is the causative agent for "early decline syndrome" in asparagus fields. *Fusarium* can decrease the life span of an asparagus field by 5-8 years, making it economically unsustainable to continue production. So, it's important to explore options for controlling the asparagus miner.

METHODS

On 16 April 2012, the MSU vegetable entomology lab planted a new experimental asparagus field in Hart, MI. 'Millenium' crowns were planted 7 inches apart into 20-foot long rows with 5 feet row spacing. Treatment plots consisted of a single 20-foot row and treatments were separated from each other by a single buffer row. This design allowed for 10 treatments, each replicated four times.

On 22 May 2012, subsoil drip irrigation lines were installed just slightly offset from the asparagus row. Drip lines originated at the north end of the plot and were crisscrossed between blocks to allow only one line for each treatment (ie., the same line runs through all four replications). At the beginning of each drip line is an injection port for applying insecticides. These individual injection ports allowed for quick application of insecticides and prevented backflow/intermixing of chemicals into the main irrigation line, and thus, into other plots.

Nine insecticide treatments and two application methods (chemigation through drip irrigation and foliar spray) were tested (Table 1). The same insecticide applications were made in 2013 as in 2012, and the same treatment arrangement was kept between the two years, to avoid confounding effects. None of the insecticides used in this trial are currently registered for use on asparagus. Drip treatments were applied twice during the season, on 14 May (first generation) and 20 August (second generation). A red dye was used to indicate when the compound had completely moved through the lines. The irrigation was turned on 30 min before and turned off 2 hours after the drip treatments were applied. The first foliar applications of Movento were made on 4 June, with a second application required 7 days later for one treatment and 14 days later for the other treatment. Foliar treatments were applied using a single-nozzle hand-held boom at 30 gallons/acre and 30 psi. The adjuvant Dyne-Amic was applied with Movento at a rate of 0.5% v/v.

Sampling for asparagus miner was conducted weekly by visually surveying and counting the total number of stems per plot and number of damaged stems per plot. Sampling started as soon as damage caused by asparagus miner larvae became first visible on the stems (in 2013, this was about a month after the drip application). The percent number of damaged stems was arcsine transformed prior to statistical analysis. Analysis of variance was used for data analysis and ad-hoc Tukey means separation was used to compare treatment means ($P < 0.05$).

RESULTS

The two Movento 240 SC treatments did not significantly reduce the percent number of damaged stems, compared to the untreated control. In 2010 and 2011, data suggested that Movento might be used to suppress asparagus miner damage early in the season, but both 2012 and 2013 data showed otherwise. Two different surfactants were tested with Movento: MSO (2012) and Dyne-Amic (2010, 2011, 2013).

Among the seven drip treatments, Platinum performed the best and consistently reduced the percent number of damaged stems, compared to the untreated control (Fig. 1). On June 18, visible signs of miner damage were relatively low across treatments and there were no significant differences among the treatments. On June 25, all of the drip insecticide treated plots had significantly less damage than the two Movento treatments and the untreated control. On July 2, only the Platinum treatment was significantly less damaged than the untreated control, all other treatments were not significantly different from the control. On July 9, Platinum and Durivo were the only two treatments that significantly reduced the percent damaged stems relative to the untreated control. On July 16, none of the insecticide treated plots were significantly different from the untreated control. Overall, asparagus miner damage was reduced from 50% in the control plots to about 30% in Platinum treated plots. The longevity of the Platinum in the asparagus stems was about 8 weeks.

Future work will focus on improving the timing of delivery of active ingredients through soil/drip application into the asparagus stem.

Table 1. Treatment list with application modes, rates, and dates for asparagus trial conducted in Hart, MI, summer 2012 and 2013.

Treatment	Insecticide class	Application mode	Rate	Application dates
Scorpion 35 SL	neonicotinoid	drip	10.5 fl oz./A	14 May, 20 August
Scorpion 35 SL	neonicotinoid	drip	13 fl oz./A	14 May, 20 August
Durivo	neonicotinoid + ryanodine receptor modulator	drip	13 fl oz./A	14 May, 20 August
Platinum 75 SG	neonicotinoid	drip	5.67 oz/A	14 May, 20 August
Coragen	ryanodine receptor modulator	drip	7.5 fl oz./A	14 May, 20 August
Admire Pro	neonicotinoid	drip	10.5 fl oz./A	14 May, 20 August
Admire Pro	neonicotinoid	drip	14 fl oz/A	14 May, 20 August
Movento 240 SC + Dyne-Amic	acetyl CoA carboxylase inhibitor + adjuvant	foliar	8.0 fl oz./A + 0.5% v/v	4 & 10 June
Movento 240 SC + Dyne-Amic	acetyl CoA carboxylase inhibitor + adjuvant	foliar	8.0 fl oz./A + 0.5% v/v	4 & 18 June
Untreated				

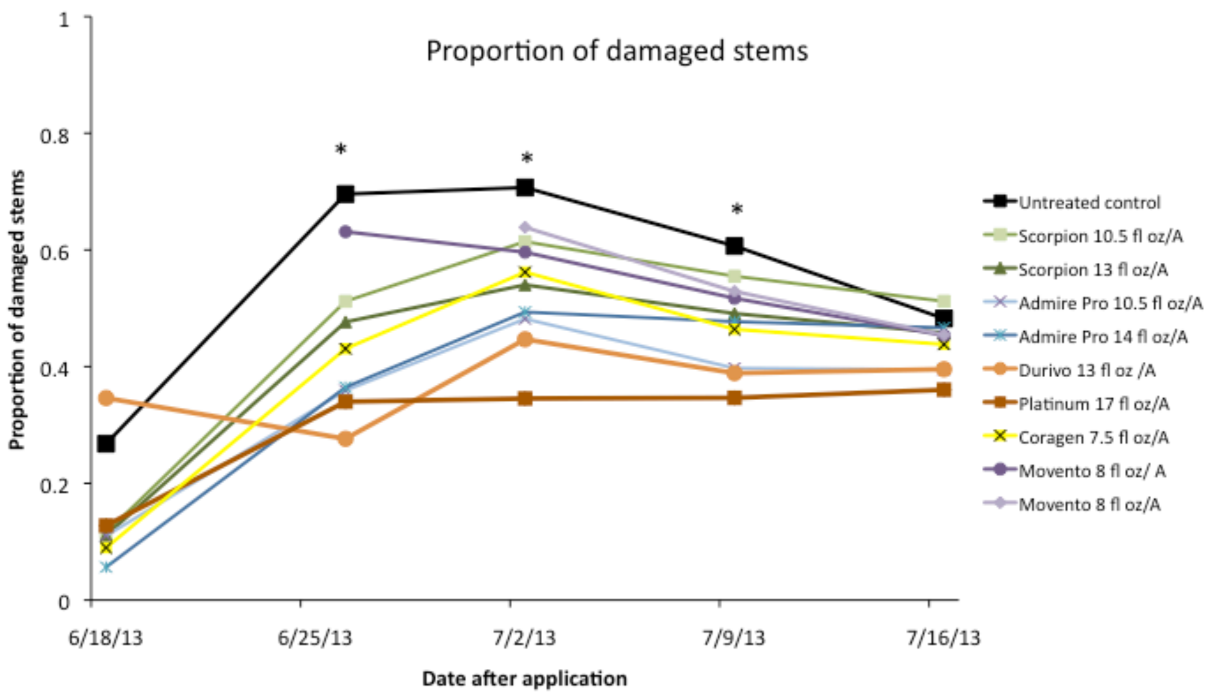

Figure 1. Asparagus stems in Platinum treated plots are significantly less damaged compared to the untreated control and some of the less successful insecticide treatments (such as Admire, Scorpion or Coragen); this pattern holds up until 7/9. Starting on 7/16 there are no significant differences any more among the treatments. Stars above lines indicate statistically significant differences among the treatments.

Field evaluation of Movento and surfactants for managing aphids on celery

Aphid (*Aphis spiraecola* Patch*,* Hemiptera: Aphididae) infestations present an annual challenge to Michigan's celery growers. Aphid infestations can be spotty, making scouting difficult and time intensive. Once present, aphid numbers can increase rapidly and lead to significant problems. They feed on the new growth, causing curled foliage that can stunt the plant. If aphids are present at harvest, it can lead to the rejection of a load for the fresh market.

Aphid control is difficult, especially since they situate themselves on the underside of the leaves and deep down in the heart of the plant where it's difficult to get good insecticide coverage. Nevertheless, current control practices rely heavily on insecticides, making it important to evaluate registered products for their efficacy in the field.

METHODS

Seven treatments including an untreated control were tested on a commercial farm in southwest Michigan for aphid management; all of the products tested are currently registered for use on celery. The study site was selected due to the presence of high aphid numbers. Celery plants at the time of the trial were about 5-6 weeks away from being harvested. Treatments were replicated four times in a randomized complete block design. Plots were 20 feet long and three rows wide.

Treatments were applied on 13 August 2013 using a single-nozzle hand-held boom (30 gallons/acre and 30 psi). Movento 240 SC (5 fl oz/A) was tested with five different brands of penetrating surfactants: Dyne-Amic, Silwet L77, Syl-Tac, HyperActive, and SuperSpread90. Two other treatments were an untreated control and a Movento 240 SC (5 fl oz/A) without surfactant.

For both trials, we made visual aphid evaluations on all the plants in the middle row of the plot. We counted the total number of plants as well as noted the rating of aphid damage on each plant. Plants were rated based on the number of aphids present; 0 = no aphids, 1 = aphids were present, but they are all dead, 2 = more aphids, and 3= fully developed colonies. Plants from each plot were evaluated 3, 8, and 13, days post-application. Plant ratings were transformed sqrt (x+0.1) prior to statistical analysis. Analysis of variance was used for data analysis and ad-hoc Tukey means separation was used to compare treatment means ($P < 0.05$).

RESULTS

Movento with any of the penetrating surfactants performed significantly better than the untreated control or Movento without surfactant (Fig. 2). Movento without a penetrating surfactant performed the same as the untreated control.

Among the surfactant treatments, Movento with Dyne-Amic and Syl-Tac significantly lowered aphid numbers compared to Movento+HyperActive, but these two treatments were not significantly different from the other surfactants (Fig. 2).

In this trial, we learnt that it's essential to apply Movento with a penetrating surfactant, and certain types of penetrating surfactant can improve the activity of Movento.

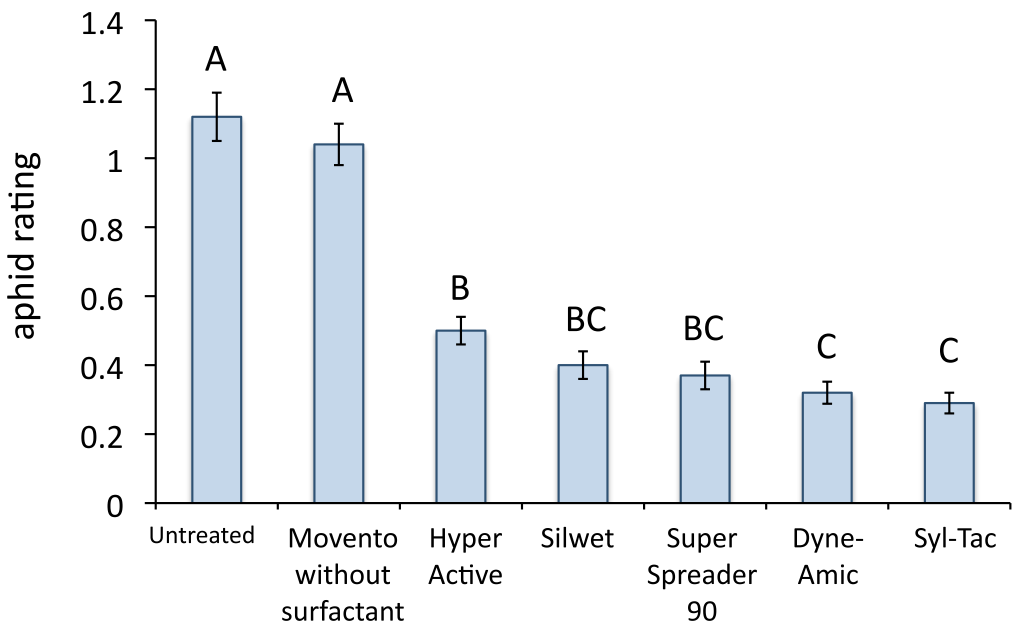

Figure 2. Insecticide trial in celery with Movento 240 SC and five penetrating surfactants. All of the surfactants were applied with 5 fl oz/A Movento. Aphids were rated per plant, on the following scale: 0 = no aphids; 1 = plant had aphids, but they all died; 2 = one/few live aphids; and 3= fully developed healthy aphid colonies. One foliar application was made on 8/13/13, and all plants in the middle row of the plot were checked for aphids 3, 8, and 13 days later.

Field insecticide evaluations of registered and experimental insecticides for managing onion thrips on onion

Onion thrips (*Thrips tabaci* Lindeman) is the most important insect pest of onions in the Great Lakes region. Adults and nymphs use their single sword-like mandible to rupture plant cells on the outer surface of leaves and other plant parts, and then suck out the contents by pressing their mouthparts onto the damaged surface. At first, damaged leaves turn silvery, but with continued severe damage, the leaves completely dry out, hampering photosynthesis and ultimately reducing plant growth and yield. Thrips are also vectors of *Iris yellow spot virus*, which causes a disease that can further reduce yield.

Currently, the most important tool for commercial onion growers to manage onion thrips is the judicious use of insecticides. Insecticides should be used as part of an integrated pest management strategy, keeping in mind the following: (1) before making an application, determine the average number of thrips on your onions, and (2) check the weather forecast, since hot, dry spells will likely increase the numbers of thrips quickly, but cool, wet weather will keep numbers low.

Most onion growers have to make multiple applications of insecticides in a season. Before choosing a product for onion thrips control, the following points should be considered: (1) there are relatively few products registered on onion, so (2) maximum application rates are quickly exceeded if the same product is applied multiple times in a season, therefore, (3) multiple products have to be used in rotation. Its important to use different products within a season, because the more often a product is used, the higher the chances are of onion thrips becoming resistant to it. So we need to find out which rotations/combinations are the most effective at suppressing onion thrips numbers while not exceeding maximum application thresholds and reducing the number of insecticide applications in a season.

METHODS

Thirteen insecticide treatments and an untreated check (Table 1) were tested for their efficacy to control onion thrips in a commercial onion field at Krummrey Farms, near Stockbridge, MI. Dry bulb onions were planted around 26 April 2012 into three-row beds, with 6 in. row spacing and beds spaced 25 in. apart. Treatments were replicated four times in a randomized complete block design. Plots were 15 ft. long. Six treatments out of the 13 focused on testing the efficacy of different types of penetrating surfactants with Movento 240 SC: we tested HyperActive, Dyne-Amic, Silwet-L77, and SuperSpread90 all co-applied with 5 fl oz/A Movento 240 SC. All other treatments in the trial included the non-ionic surfactant Dyne-Amic at a rate of 0.5% v/v to improve penetrability of the insecticide into the onion leaves.

Foliar treatments were applied using a single-nozzle hand-held boom at 50 gallons/acre and 40 psi (see Table 1 for application dates). Plots were initially sprayed on 27 June when there were about 4 leaves/plant and the density of onion thrips averaged 3 thrips/plant. Thereafter, post-spray counts of adult and nymph thrips on 10 randomly selected plants from each plot were made 5-7 days after each foliar application. Most of the treatments/rotations were designed to run for 8-weeks, however, for the threshold-based treatments, we monitored and sprayed, as needed, throughout the season.

All onion bulbs in each plot were pulled on 11 September 2013 and left in the field to finish drying. On 25 & 26 September, bulbs were taken back to the lab for grading and weighing. US No. 1 grade bulbs were graded as jumbo (≥3 in. diam.), standard (2.0 to 2.9 in. diam.), and boiler (1.5 to 1.9 in. diam.), and the number in each class was recorded and weighed; extremely small or misshapen bulbs were discarded.

Data was log (x+1) transformed prior to analysis. Analysis of variance was used for data analysis and Tukey means separation was used to compare treatment means ($P < 0.05$).

RESULTS

All treatments resulted in a significant reduction of the seasonal mean number of thrips per plant relative to the untreated control (Table 2). When testing 8-week insecticide rotations, there were differences among the insecticide treatments. Among these, the most effective were ones that had Movento 240 SC applied during the first two weeks. Among the Movento + surfactant treatments, the seasonal means were not significantly different from each other, however with just two Movento applications at the beginning of the season, thrips numbers were significantly lower than in the untreated control.

The results of this trial indicate that there are multiple insecticides (both registered and experimental) and insecticide rotations that can provide good thrips suppression in the field. However, since not all insecticides have the same efficacy, the proper sequence of insecticides has to be carefully considered to achieve the best results. The number of new and effective compounds for thrips control is increasing thus growers should remain committed to resistance management practices to help assure that these compounds will remain effective into the future.

Table 2. Treatment list, application dates, and rates for an onion thrips trial conducted in Stockbridge, MI in 2013. All insecticides in treatments 2 - 8 were co-applied with 0.5 % v/v Dyne-Amic. Treatments 9 - 14 applications were co-applied with the penetrating surfactant noted in the table.

Trt	27 Jun	3 July	10 Jul	17 Jul	24 Jul	31 Jul	7 Aug	14 Aug
1								
2	Benevia 10 OD 13.5 fl oz/A	Benevia 10 OD 13.5 fl oz/A	Lannate LV 3 pt/A	Lannate LV 3 pt/A	Radiant SC 8 fl oz/A	Radiant SC 8 fl oz/A	Agri-Mek SC 3 fl oz/A	Agri-Mek SC 3 fl oz/A
3	Movento 240 SC 5 fl oz/A	Movento 240 SC 5 fl oz/A	Benevia 10 OD 13.5 fl oz/A	Benevia 10 OD 13.5 fl oz/A	Radiant SC 8 fl oz/A	Radiant SC 8 fl oz/A	Agri-Mek SC 3 fl oz/A	Agri-Mek SC 3 fl oz/A
4	Benevia 10 OD 13.5 fl oz/A	Benevia 10 OD 13.5 fl oz/A	Benevia 10 OD 13.5 fl oz/A	Benevia 10 OD 13.5 fl oz/A	Radiant SC 8 fl oz/A	Radiant SC 8 fl oz/A	Lannate LV 3 pt/A	Lannate LV 3 pt/A
5	Movento 240 SC 5 fl oz/A	Movento 240 SC 5 fl oz/A	Agri-Mek SC 3 fl oz/A	Agri-Mek SC 3 fl oz/A	Radiant SC 8 fl oz/A	Radiant SC 8 fl oz/A	Lannate LV 3 pt/A	Lannate LV 3 pt/A
6	Movento 240 SC 5 fl oz/A	Movento 240 SC 5 fl oz/A	Agri-Mek SC 3 fl oz/A	Agri-Mek SC 3 fl oz/A	Radiant SC 8 fl oz/A	Radiant SC 8 fl oz/A	Torac 15 EC 24 fl oz	Torac 15 EC 24 fl oz
7	Movento 240 SC 5 fl oz/A	Movento 240 SC 5 fl oz/A	Agri-Mek SC 3 fl oz/A	Agri-Mek SC 3 fl oz/A	Torac 15 EC 24 fl oz	Torac 15 EC 24 fl oz	Radiant SC 8 fl oz/A	Radiant SC 8 fl oz/A
8	Movento 240 SC 5 fl oz/A	Movento 240 SC 5 fl oz/A	Agri-Mek SC 3 fl oz/A	Agri-Mek SC 3 fl oz/A	Radiant SC 10 fl oz/A	Radiant SC 10 fl oz/A	Lannate LV 3 pt/A	Lannate LV 3 pt/A
9	Movento 240 SC 5 fl oz/A + Dyne-Amic 0.5% v/v	Movento 240 SC 5 fl oz/A + Dyne-Amic 0.5% v/v						
10	Movento 240 SC 5 fl oz/A + Dyne-Amic 0.25% v/v	Movento 240 SC 5 fl oz/A + Dyne-Amic 0.25% v/v						
11	Movento 240 SC 5 fl oz/A + HyperActive	Movento 240 SC 5 fl oz/A + HyperActive						
12	Movento 240 SC 5 fl oz/A + Syl-Tac	Movento 240 SC 5 fl oz/A + Syl-Tac						
13	Movento 240 SC 5 fl oz/A + Silwet L77	Movento 240 SC 5 fl oz/A + Silwet L77						
14	Movento 240 SC 5 fl oz/A + SuperSpread90	Movento 240 SC 5 fl oz/A + SuperSpread90						

Table 3. Weekly and seasonal averages of onion thrips per plant and total yield in an insecticide trial conducted in Stockbridge, Michigan in 2013. Numbers within a column followed by different letters are statistically different from each other. For product rates, see Table 1.

Trt	1 Jul	9 Jul	16 Jul	23 Jul	30 Jul	5 Aug	13 Aug	22 Aug	Seasonal Mean	Yield (cwt/acre)
1	**10.1a**	**14.9a**	**12.4a**	**11.9a**	**5.2a**	**20.6a**	**4.4ab**	**6.2b**	**10.1a**	
2	Benevia **3.9b**	Benevia **2.4bc**	Lannate **5.2b**	Lannate **9.7a**	Radiant **9.3a**	Radiant **4.3b**	Agri-Mek **1.2bc**	Agri-Mek **6.8b**	**5.3b**	
3	Movento **7.6ab**	Movento **2.1bc**	Benevia **1.0c**	Benevia **1.4c**	Radiant **0.8b**	Radiant **1.5c**	Agri-Mek **1.6abc**	Agri-Mek **6.1b**	**3.2bc**	
4	Benevia **3.9b**	Benevia **3.5b**	Benevia **7.4b**	Benevia **5.2b**	Radiant **4.6a**	Radiant **2.8bc**	Lannate **1.3abc**	Lannate **3.4b**	**4.3b**	
5	Movento **7.4a**	Movento **2.1bc**	Agri-Mek **1.0c**	Agri-Mek **0.8c**	Radiant **1.2b**	Radiant **1.7c**	Lannate **2.7abc**	Lannate **4.3b**	**2.8c**	
6	Movento **9.5a**	Movento **4.2b**	Agri-Mek **0.9c**	Agri-Mek **0.8c**	Radiant **0.6b**	Radiant **1.2c**	Torac **0.8c**	Torac **5.5b**	**2.9c**	
7	Movento **5.0ab**	Movento **2.1bc**	Agri-Mek **1.1c**	Agri-Mek **1.2c**	Torac **1.2b**	Torac **2.7c**	Radiant **3.3abc**	Radiant **2.3b**	**2.5c**	
8	Movento **5.8ab**	Movento **1.9bc**	Agri-Mek **1.3c**	Agri-Mek **1.1c**	Radiant **0.3b**	Radiant **1.0c**	Lannate **0.7c**	Lannate **5.6ab**	**2.1c**	
9	Movento + Dyne-Amic 0.5 **6.0ab**	Movento + Dyne-Amic 0.5 **1.9bc**	**1.6c**	**2.4bc**	**3.6ab**	**3.4b**	**1.5abc**	**4.5b**	**3.5bc**	
10	Movento Dyne-Amic 0.25 **6.4ab**	Movento + Dyne-Amic 0.25 **2.9bc**	**1.6c**	**2.0bc**	**10.5a**	**6.3b**	**3.6abc**	**4.4b**	**5.1b**	
11	Movento + HyperActive **6.2ab**	Movento + HyperActive **1.8c**	**1.1c**	**3.1bc**	**2.6ab**	**8.3b**	**4.1abc**	**18.2a**	**6.5b**	
12	Movento + Syl-Tac **7.0ab**	Movento + Syl-Tac **2.3bc**	**1.6c**	**2.8bc**	**11.1a**	**5.5b**	**1.8abc**	**1.7b**	**4.2b**	
13	Movento + Silwet L77 **7.5ab**	Movento + Silwet L77 **1.7c**	**1.1c**	**1.8bc**	**1.7ab**	**5.5b**	**2.7abc**	**8.0b**	**4.2b**	
14	Movento + SuperSpread90 **6.7ab**	Movento + SuperSpread90 **2.6bc**	**1.3c**	**3.8bc**	**2.6ab**	**6.8b**	**5.3a**	**9.6b**	**5.4b**	

Field evaluations of registered and experimental insecticides for managing Colorado potato beetle on potatoes

The Colorado potato beetle (*Leptinotarsa decemlineata*, Say, Coleoptera: Chrysomelidae) is the most widespread and destructive insect pest of potato crops in the eastern United States and Canada. Its ability to develop resistance to insecticides makes it very important to continue testing the efficacy of both new insecticide chemistries and existing compounds. Such tests provide data on comparative effectiveness of products and data to help support future registrations and use recommendations.

METHODS

Fifteen insecticide treatments and an untreated check (Table 4) were tested at the MSU Montcalm Research Farm, Entrican, MI for control of Colorado potato beetle. 'Atlantic' potato seed pieces were planted 12 in. apart, with 34 in. row spacing on 3 June 2012. Treatments were replicated four times in a randomized complete block design. Plots were 50 ft. long and three rows wide with untreated guard rows bordering each plot.

Brigadier 2SC, Verimark 20SC, Admire Pro 4.6SC, and Platinum 75SG treatments were applied as in-furrow sprays at planting on 3 June 2013. Post-plant directed sprays were applied when potatoes first started emerging from the soil, on 10 June 2013. Foliar treatments were first applied at greater than 50% Colorado potato beetle egg hatch on 28 June 2013. Based on the economic threshold of more than one large larva per plant, additional first generation sprays were needed for Gladiator (11 and 18 July), Athena (11 July), Blackhawk (11 July), the low rate of Torac 15 EC (11 July), and Admire Pro (11 and 18 July); no subsequent applications were necessary for any of the Dupont treatments. All applications were made using a single-nozzle hand-held boom (30 gallons/acre and 30 psi).

Post-spray counts of first generation Colorado potato beetle adults, small larvae (1^{st} and 2^{nd} instars), and large larvae (3^{rd} and 4^{th} instars) from five randomly selected plants from the middle row of each plot were made weekly, starting on 2 July. Plots were visually rated for defoliation weekly by estimating total defoliation per plot.

The numbers of small larvae, large larvae, and adults, as well as the defoliation ratings, were transformed log (x + 1) prior to analysis. Analysis of variance was used for data analysis and ad-hoc Tukey means separation was used to compare treatment means ($P < 0.05$).

RESULTS

Except for Admire Pro and Athena, all treatments resulted in significantly fewer small larvae than the untreated control, while all treatments significantly reduced the number of large larvae per plant, compared to the untreated (Table 1). There were also significant differences in numbers of large larvae among the insecticide treatments. All three systemic products (Admire Pro, A16901, and Platinum 75 SG) performed well, with A16901 having significantly fewer large larvae than six of the foliar products. Among the foliar products, Admire Pro required weekly sprays, while F9318 and the low rate of Torac 15 EC were applied three of the four weeks. Athena, Blackhawk, and the high rate of Torac 15 EC required one subsequent application, all two weeks after the initial application. Of these, however, only Blackhawk provided reduction in average large larvae below the threshold of one per plant. Despite one fewer application for the high rate of Torac 15 EC, no significant differences in beetle life stages or defoliation were noted between the high and low rates for this product. All three Benevia 10 OD treatments required only the initial foliar application to provide first generation beetle control.

The untreated plots had significantly greater defoliation compared to all other treatments. The seasonal defoliation average was 36.6% in the untreated plots, compared to less than 6% for all other treatments. Differences in defoliation among insecticide treated plots ranged from 1.1 to 5.9%. Neonicotinoid insecticides are still providing sufficient Colorado potato beetle control for Michigan farmers, but new chemistries like Benevia 10 OD are also proving to be effective.

Table 4. Insecticide treatments for Colorado potato beetle management in a field trial conducted by MSU vegetable entomology in 2013.

Trt #	Commercial Name	Manufacturer	Formulation	Active Ingredient	Chemical Class	Rate	Type	Application Dates in 2013*
1	Untreated							
2	Brigadier 2SC	FMC	2 SC	bifenthrin	pyrethroid	25.6 oz/A	at planting	6/3
	Gladiator	FMC	0.25 EW	abamectin, z-cypernethrin	avermectin, pyrethroid	14 oz/A	foliar	6/28, 7/18
3	Capture LFR	FMC	1.5 SC	bifenthrin	pyrethroid	25.6 oz/A	at planting	6/3
	Admire PRO	FMC	4.6 SC	imidacloprid	neonicotinoid	5.22 oz/A	post-plant, directed	6/19
	Athena	FMC	0.87 EW	abamectin, bifenthrin	avermectin, pyrethroid	16 oz/A	foliar	6/28, 7/11
4	Brigadier 2 SC	FMC	2 EC	bifenthrin, imidacloprid	pyrethroid, neonicotinoid	25.6 oz/A	post-plant, directed	6/19
	Gladiator	FMC	0.25 EW	abamectin, z-cypernethrin	avermectin, pyrethroid	14 oz/A	foliar	6/28, 7/11
5	Verimark	Dupont	20SC	cyazypyr	diamide	13.5 oz /A	at planting	6/3
	Asana XL	Dupont	0.66 EC	esfenvalerate	pyrethroid	9.6 oz/A	foliar	6/28
6	Exirel	Dupont	10 SE	cyazypyr	diamide	5 oz/A	foliar	6/28
7	Platinum	Syngenta	2 SL	thiamethoxam	neonicotinoids	8 oz/A	at planting	6/3
	Benevia	Dupont	10 OD	cyazypyr	diamide	5 oz/A	foliar	6/28
8	Platinum	Syngenta	2 SL	thiamethoxam	neonicotinoids	8 oz/A	at planting	6/3
9	Benevia +	Dupont	10 OD	cyazypyr	diamide	5 oz/A	foliar	6/28
	MSO			methylated seed oil	surfactant	0.5% v/v		
10	Benevia +	Dupont	10 OD	cyazypyr	diamide	5 oz/A	foliar	6/28
	MSO			methylated seed oil	surfactant	0.5% v/v		
11	Exirel	Dupont	10 SE	cyazypyr (cyatraniliprole)	diamide	6.75 oz/A	foliar	6/28
12	Admire PRO	Bayer	4.6 SC	imidacloprid	neonicotinoid	1.3 oz/A	foliar	6/28, 7/11, 7/18
13	Blackhawk	Dow	36	spinosad	spinosyns	3.2fl oz/A	foliar	6/28, 7/11
14	Torac	Nichino	15 EC	tolfenpyrad	pyrazoles	14 oz/A	foliar	6/28, 7/11
15	Torac	Nichino	15 EC	tolfenpyrad	pyrazoles	21 oz/A	foliar	6/28
16	Admire PRO	Bayer	4.6 SC	imidacloprid	neonicotinoid	7 oz/A	at planting	6/3

* First foliar application was made at 50% egg-hatch, all subsequent foliar applications are based on 1 large larva per plant threshold.

Table 5. Mean Colorado potato beetle (CPB) per plant by date in the 2013 MSU vegetable entomology field trial. The bold numbers in the top row correspond to the treatment numbers in Table 4. Bold letters in the green colored 'small and large larvae' rows at the bottom of the table indicate significant differences among the treatments, Tukey HSD (α = 0.05).

date	**Mean CPB**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**TOTAL**
2-Jul	intact egg masses	0.7	0.7	0.25	0.5	0.5	0.3	0	0.15	0.5	0.7	0.25	0.9	0.8	0.6	0.45	0.6	0.52
	hatched egg masses	0	0	3.2	0.55	0	2.45	0	0	0.2	0.3	3.55	2.4	0	0.8	0	0.7	0.92
	small larvae	7.1	0	0.05	0.5	0	0.7	0	0	1.15	0.25	0.75	0.45	0.65	0.9	1	0	0.79
	large larvae	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0.09
	adults	0.3	0.1	0.1	0.15	0.1	0.25	0.15	0.55	0.15	0.05	0.15	0.4	0.2	0.05	0.05	0.25	0.19
5-Jul	intact egg masses	0.85	0.55	0.4	0.95	0.6	0.3	0	0	0.2	0.25	0.65	1	0.3	0.7	0.2	1.1	0.49
	hatched egg masses	1.05	2.2	3.9	0.1	1.3	2.75	0	0	2.45	2.05	1.95	3.05	0	0.25	0.45	0.05	1.52
	small larvae	2.5	0.25	1.25	5.35	0.35	0.15	0	0	0.25	0.05	0	3.65	0.4	1.25	0.3	0.1	0.94
	large larvae	2.95	0	0	0	0	0	0	0	0	0	0	0.3	0.05	0.15	0	0.15	0.21
	adults	0.55	0.35	0.35	0.35	0.75	0.3	0.25	0.1	0.15	0.2	0.1	0.2	0.25	0.1	0.05	0.1	0.26
10-Jul	intact egg masses	0.65	0.35	0.15	0.5	0.15	0.15	0.05	0	0.15	0.5	0.15	0.1	0.25	0.25	0.4	0.4	0.25
	hatched egg masses	2.05	0	1.05	0.2	0.55	0.1	0	0	0.8	0	0	1.9	0	1.25	0.6	0	0.61
	small larvae	7.85	0.7	1.9	3.15	0.35	0.3	0	0	0.8	1.35	0.5	4.7	1.9	1.25	1.55	3.45	2.09
	large larvae	10.7	0.3	1.1	3.15	0	0.05	0	0	0	0	0.05	6.95	1.45	2	0.1	0.9	1.66
	adults	0	0.25	0.35	0.25	0.25	0.3	0.3	0.1	0.15	0.25	0.25	1.25	0.3	0.1	0.1	0.2	0.26
17-Jul	intact egg masses	0	0	0	0	0.05	0.05	0	0	0.15	0	0.05	0	0.05	0	0.2	0.15	0.04
	hatched egg masses	0	0	0	0	0.25	0	0	0	0.7	0	0.4	0	0	0.25	0.55	0	0.13
	small larvae	2.05	0.65	0.15	0.65	0.05	0.45	0	0.1	0.5	0.6	0.6	0.45	0.05	0.1	0.45	1.35	0.54
	large larvae	4.05	1.65	0.3	1.25	0.25	0.6	0	0	0.25	0.8	0.55	1.35	0	0.75	0.3	1.1	0.93
	adults	0	0	0	0.05	0.05	0.1	0	0.15	0	0	0	0.05	0.05	0	0	0	0.03
24-Jul	intact egg masses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
	hatched egg masses	0	0	0	0	0	0.2	0.15	0	0	0	0	0	0.25	0.65	0	0	0.07
	small larvae	0.35	0.4	0.1	0.3	0.45	0.25	0	0.1	0.5	0.55	0.5	0	0.05	0	0.2	0	0.22
	large larvae	0.8	0.45	0.65	0.65	0.05	0.1	0	0	0.55	0.6	0.45	0	0.15	0.2	0.6	0	0.31
	adults	1.35	0.15	0.1	0.25	0.1	0.15	0.1	0.15	0	0.1	0.2	0.25	0.2	0.25	0.2	0.1	0.23
TOTAL	intact egg masses	0.44	0.32	0.16	0.39	0.26	0.16	0.01	0.03	0.2	0.29	0.22	0.4	0.28	0.31	0.25	0.45	0.26
	hatched egg masses	0.62	0.44	1.63	0.17	0.42	1.1	0.03	0	0.83	0.47	1.18	1.47	0.05	0.64	0.32	0.15	0.65
	small larvae	**3.97a**	**0.4bc**	**0.69bc**	**1.99b**	**0.24bc**	**0.37bc**	**0c**	**0.04c**	**0.64bc**	**0.56bc**	**0.47bc**	**1.85b**	**0.61bc**	**0.7bc**	**0.7bc**	**0.98bc**	**0.92**
	large larvae	**3.97a**	**0.48bc**	**0.41bc**	**1.01bc**	**0.06c**	**0.15c**	**0c**	**0c**	**0.16c**	**0.28bc**	**0.21c**	**1.72b**	**0.33bc**	**0.62bc**	**0.22c**	**0.43bc**	**0.64**
	adults	0.44	0.17	0.18	0.21	0.25	0.22	0.16	0.21	0.09	0.12	0.14	0.43	0.2	0.1	0.08	0.13	0.19

Susceptibility of Colorado potato beetle populations to imidacloprid and thiamethoxam

Imidacloprid (i.e.: Admire Pro) and thiamethoxam (i.e.: Platinum, Actara) continue to be the most common means of Colorado potato beetle management. Today, greater than 75% of the commercial potato acres in the northeastern and midwestern United States are protected by these compounds (NASS 2006). Such consistent and heavy dependency on any compound sets the stage for resistance development. Further complicating the issue is the availability of generic imidacloprid formulations; these formulations drive down product cost, which will likely lead to even greater field exposure to these compounds. All of these reasons strongly support the need to continue monitoring resistance development and to encourage growers to adopt resistance management strategies.

Our objective was to continue gathering data on susceptibility to imidacloprid and thiamethoxam in Colorado potato beetle populations collected from commercial potato fields in Michigan and other regions of the United States. To accomplish this objective, Colorado potato beetle populations were bioassayed with imidacloprid and/or thiamethoxam.

METHODS

During 2013, 11 Colorado potato beetle populations were collected from Michigan. Cooperators also provided populations from New York (1), Maine (1), and Virginia (3). One susceptible laboratory strain was also tested (Table 6). To assure only healthy beetles were tested, newly received beetles were maintained at room temperature and 16:8 L:D photoperiod and fed pesticide-free, greenhouse-grown potato foliage for 3-7 days before they were used in the bioassay.

Adult Colorado potato beetles were treated with 1 µl of acetone/insecticide solution of known concentration applied to the ventral surface of the abdomen using a 50 µl Hamilton® microsyringe. Two populations with known resistance issues (Jamesport, NY and Tuscola, MI) required two applications of 1 µl of acetone/insecticide solution per beetle to achieve the desired dose (ie., 1 µl of 20.0 µg/µl plus 1 µl of 10.0 µg/µl to get a dose of 30.0 µg/µl). A range of four to 11 concentrations, plus an acetone-only control, was selected for each population, depending on the number of available beetles and known resistance history for each population. In each bioassay, 27-40 adults were treated with each concentration (nine to 10 beetles per dish and three to four dishes per concentration). Following treatment, beetles were placed in 100 mm diam. Petri dishes lined with Whatman® No. 1 filter paper and provided with fresh potato foliage. They were kept at 25±1°C and the foliage and filter paper were checked daily and changed as needed.

Beetle response was assessed 7 days post treatment [Painter, VA was assessed after 6 days]. A beetle was classified as dead if its abdomen was shrunken, it did not move when its legs or tarsi were pinched, and its elytra were darkened. A beetle was classified as walking and healthy if it was able to grasp a pencil and walk forward normally. A beetle was classified as poisoned if its legs were extended and shaking, it was unable to right itself or grasp a pencil, and it was unable to walk forward normally at least one body length. Beetles that had died due to *Beauvaria* spp. infection were excluded from analysis; these beetles were easily recognized by their pale, petrified appearance and/or presence of white filamentous fungi. Dead and poisoned beetle numbers were pooled for analysis. Data were analyzed using standard log-probit analysis (SAS Institute, 2009).

RESULTS

The LD_{50} value (dose lethal to 50% of the beetles) for the susceptible laboratory strain was 0.042 µg/beetle for imidaclorid and 0.054 µg/beetle for thiamthoxam (Table 7).

The LD_{50} values from the field for imidacloprid ranged from 0.215 µg/beetle (Sackett Potatoes Field 2) to 4.435 µg/beetle (Sackett Ranch LJ7) for Michigan populations. The imidacloprid LD_{50} values for the out-of-state populations ranged from 0.088 µg/beetle (Aroostook, Maine) to 0.496 (Jamesport, NY). LD_{50} values for imidacloprid for all populations were significantly higher than the susceptible laboratory strain. In 2013, 60% of the Michigan samples were greater than 10-fold resistant to imidacloprid, compared to 75% in 2012, 57% in 2011, 60% in 2010, and 85% in 2009.

The LD_{50} values for thiamethoxam in Michigan ranged from 0.044 µg/beetle (Main Farms H6) to 0.478 µg/beetle (Kalkaska), and from 0.002 µg/beetle (Montgomery, VA) to 0.496 µg/beetle (Jamesport, NY) for out-of-state populations. None of the populations were greater than 10-fold resistant to thiamethoxam.

Table 6. Colorado potato beetle populations tested for susceptibility to imidacloprid and thiamethoxam in 2013.

Michigan populations

Anderson Brothers Field 23 Summer adults were collected on 12 Aug 2013 by Mark Otto, Agri-Business Consultants, Inc., from commercial potato fields in Montcalm County.

Kalkaska Summer adults were collected on 31 July 2013 from a commercial potato field near Kalkaska MI.

Main Farms Summer adults were collected by Mark Otto, Argi-Business Consultants, Inc. from commercial potato fields in Mecosta and Montcalm Counties.

Field C10 Adults were collected on Aug 7 2013.
Field H6 Adults were collected on June 28 2013.
Field R6 Adults were collected on July 30 2013.

Sackett Potatoes

Sackett Potatoes Field 2 Adults were collected on June 14 2013.
Sackett Potatoes Field 19 Adults were collected on June 14 2013.
Sackett Potatoes Field 26 Adults were collected on Aug 19 2013.
Sackett Potatoes Field 150-1 Adults were collected on June 24 2013.

Sackett Ranch

Sackett Ranch LJ7 Adults were collected on June 25 2013.
Sackett Ranch LJ7 Adults were collected on July 23 2013.
Sackett Potatoes Field 26 Adults were collected on Aug 19 2013.
Sackett Potatoes Field 150-1 Adults were collected on June 24 2013.

Out of state populations

Painter, Virginia Summer adults were collected on 25 June 2013 from untreated research plots at the Eastern Shore A.R.E.C. in Painter, VA

Whitehorn, Virginia Adults were collected on July 2, 2013 in Montgomery, Virginia.

Modestown, Virginia Adults were collected on June 24, 2013 by Helen Dogerty, from a commercial potato farm.

Aroostok, Maine Adults were collected from a research farm on Aug 8, 2013.

Jamesport New York Adults were collected on May 24, 2013 by Sandra Menasha, Cornell Cooperative Extension, from a commercial potato field in Suffolk County, NY.

Laboratory strain

New Jersey Adults obtained in 2008 from the Phillip Alampi Beneficial Insects Rearing Laboratory, New Jersey Department of Agriculture and since reared at Michigan State University without contact to insecticides.

Table 7. LD_{50} values (µg/beetle) and 95% fiducial limits for Colorado potato beetle populations treated with imidacloprid and thiamethoxam, 7 days post treatment.

IMIDACLOPRID

Michigan Populations	**LD_{50} (ug/beetle)**	**95 % confidence intervals**
Anderson Brothers Field 23*	0.370	0.184 - 0.593
Kalkaska*	4.119	1.879 - 16.505
Main Farms C10*	1.088	0.076 – 4.344
Main Farms H6^	0.536	0.386 – 0.697
Main Farms R6*	1.843	1.039 - 2.791
Sackett Potatoes Field 2^	0.215	0.104 – 0.353
Sackett Potatoes Field 19^	0.469	0.140 – 0.926
Sackett Potatoes Field 26*	0.301	0.118 – 0.570
Sackett Potatoes Field 150-1^	0.493	0.274 – 0.693
Sackett Ranch LJ7 ^	0.665	0.309 – 1.102
Sackett Ranch LJ7 *	4.435	3.283 – 6.103
Out of State Populations		
Aroostook, Maine*	0.088	0.051 – 0.129
Jamesport, New York^	5.577	3.829 – 6.971
Modestown, VA^	0.655	0.507 – 0.857
Painter, VA^	0.081	0.057 – 0.110
Montgomery, VA(Whitehorne)*	0.089	n/a
Laboratory strain		
New Jersey	0.042	0.037 – 0.055

THIAMETHOXAM

Michigan Populations	**LD_{50} (ug/beetle)**	**95 % confidence intervals**
Anderson Brothers Field 23*	0.122	0.085 – 0.168
Kalkaska*	0.478	0.291 – 0.816
Main Farms C10*	0.207	0.094 – 0.455
Main Farms H6^	0.044	0.020 – 0.080
Main Farms R6*	0.177	0.051 – 0.327
Sackett Potatoes Field 2^	0.182	0.132 – 0.236
Sackett Potatoes Field 19^	0.206	n/a
Sackett Potatoes Field 26*	0.111	0.054 – 0.199
Sackett Potatoes Field 150-1^	0.071	0.041 – 0.101
Sackett Ranch LJ7 ^	0.177	0.133 – 0.225
Sackett Ranch LJ7 *	0.377	n/a
Out of State Populations		
Aroostook, Maine*	0.021	0.014 – 0.03
Jamesport, New York^	0.496	0.376 – 0.620
Modestown, VA^	0.294	0.244 – 0.334
Painter, VA^	0.050	0.289 – 0.070
Montgomery, VA(Whitehorne)*	0.002	n/a
Laboratory strain		
New Jersey	0.054	0.0357 – 0.0947

^ Overwintered generation
* Summer generation

Evaluation of foliar insecticides for aphid and two spotted spider mite management in watermelon

METHODS
An insecticide trial with eight foliar treatments (Table 8) was set up at the Southwest Michigan Research and Extension Center in Benton Harbor, MI. Watermelons were seeded in the greenhouse on May 6, 2013, and were transplanted into the field three weeks later. Watermelon transplants were planted on black plastic, and treatment plots consisted of single rows that were 50 feet long. Each of the eight treatments were replicated five times in a randomized complete block design. Buffer rows were not included between treatment rows. Insecticides were applied only once in the growing season, on Aug. 16, 2013. All insecticide were applied at 30 gallons/acre, 30PSI and with 0.25% v/v Dyne-Amic surfactant. Sampling was done by collecting 5 younger and 5 older leaves from each of the plots on Aug. 20, 26 and Sep. 5, 2013. The 10 leaves from each plot were placed into a Ziploc bag, labeled and transported to the laboratory, where two spotted spider mites (*Tetranychus urticae* Koch), aphids (*Aphis gossypii* Glover, Hemiptera: Aphididae) and squash bug (Anasa tristis (DeGeer), Hemiptera: Coreidae) eggs were counted on the abaxial side of all leaves using a microscope. Aphids and spider mites were the only two pests that were present in our field in large enough numbers to analyze the data. Squash bug eggs were extremely sporadic.

Table 8. Insecticide treatments in the 2013 watermelon trial.

	Treatment	**Formulation**	**Active ingredient**	**Rate**
1	Untreated			
2	Portal	5 EC	fenpyroximate	32 oz/A
3	Experimental1	SL		11 oz/A
4	Experimental2	SL		16.4 oz/A
5	Brigade	2 EC	bifenthrin	6 oz/A
6	Oberon	2 SC	spiromesifen	8 fl oz/A
7	Fulfill		pymetrozine	4 oz/A
8	Lannate		methomyl	2 pt/A

RESULTS
There were 7.5 aphids per leaf on young leaves on average and 9.1 on old leaves. There were 14.3 mites on average on young and 15 mites on old leaves on average. These differences were between old and young leaves were not significantly different for either insect so the data from old and young leaves were analyzed together.

For aphid control, the most effective product was Fulfill, followed by Lannate. Brigade, the two Experimental compounds and Oberon performed similar to the untreated control. Interestingly, Portal (miticide) treated leaves had significantly fewer aphids than the untreated control (Figure 3).

For two spotted spider mites, Portal achieved the best control. Although numerically higher, Brigade, Oberon, and Fulfill treated leaves had statistically similar mite numbers as in the Portal treatment. Mite numbers in Lannate and the two Experimental compound treated plots were not significantly different from the untreated control (Figure 4).

In summary, in watermelon, the most effective product to manage aphids is Fulfill, and the most effective product to manage two spotted spider mites is Portal, among the tested products.

Figure 3. Average number of aphids per watermelon leaf. Bars with the same letters are not statistically different from each other.

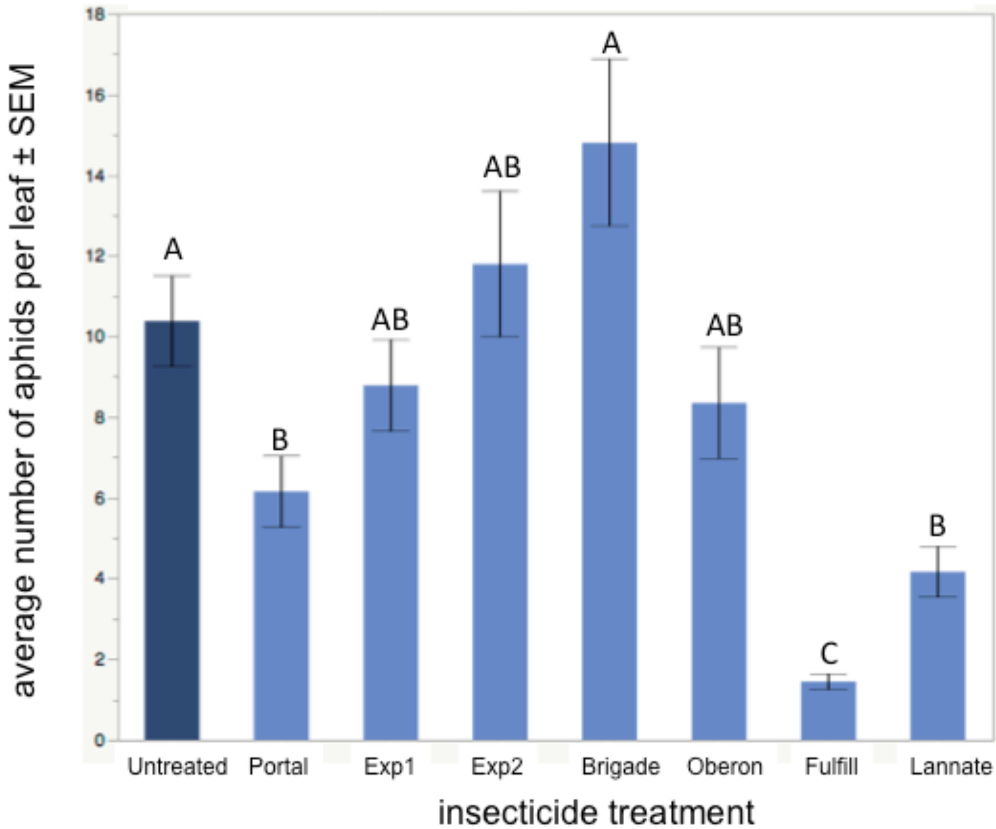

Figure 4. Average number of two spotted spider mites per watermelon leaf. Bars with the same letters are not statistically different from each other.