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Bean Leaf Beetle and Soybean Aphid Control Using Foliar Treatments in a Certified-Organic Operation—Neely-Kinyon Trial, 2010-2011

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Summary of Project

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Goal

The goal of this project is to find effective management treatments for the bean leaf beetle (*Cerotoma trifurcata)* and soybean aphid (*Aphis glycines*) for use in certified-organic soybeans. The bean leaf beetle is one of the major vectors of bean pod mottle virus, which causes seed staining and can cause a downgrading of the soybeans at market from food grade to feed grade. Feeding from the soybean aphid causes stunted plants, reduced pods and seeds, and can transmit viruses that cause mottling and distortion of the leaves and a reduced seed set. Discolored seeds may also result from this infection. The use of organic pest management treatments may help organic farmers manage bean leaf beetles and the transmission of virus or fungal agents responsible for seed coat staining and maintain the premium received for organic food-grade soybeans.

Outcome and Significance

Findings of the experiment show that there were no consistent significant differences between treatments regarding bean leaf beetle populations and seed staining or aphid populations and soybean yields. Although the project did not result in any treatments providing significant control over bean leaf beetle populations or soybean aphid populations, the experiment is still meaningful in that it has shown the inefficacy of four products on bean leaf beetle and soybean aphid populations so future experiments can concentrate on other products, biological control agents, and/or physical trapping methods.

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Introduction

Annual organic soybean (*Glycine max*) production in the U.S. has risen to more than 125,621 acres (USDA-ERS, 2012). A significant portion of the organic soybeans grown in Iowa are intended for the Japanese and domestic tofu and soymilk market. These soybeans are bred for a specific protein requirement, seed size, and a white seed color. The white seed color, however, is more of an aesthetic requirement than a food quality issue. Soybeans will enter the organic livestock feed market at a reduced price if there is purple, brown, or tan staining, which can result from one of the many factors associated with the soybean staining complex: *Cercospora kikuchii, Fusarium* spp., soybean mosaic virus, or bean pod mottle virus. Reducing the degree of soybean staining is therefore of great economic importance to organic producers who rely on the premiums associated with unstained seed.

The bean leaf beetle (*Cerotoma trifurcata*) is the main vector of bean pod mottle virus and can open infection sites for other seed-staining fungi through its feeding habits. Because bean leaf beetle adults overwinter in Iowa, survival rate increases with milder winter temperatures. First-generation adults, which require an average of 1,212 degree days with a developmental base threshold of 46 °F, usually peak during the early reproductive soybean stage (Lam et al., 2001). Second-generation adults – whose population depends on the first-generation population size – peak during the pod-filling stage. Feeding by first-generation beetles on soybean leaves rarely results in economic yield losses, however, when the second-generation adults emerge from the soil to feed on seed pods, crop damage in late summer can be considerable. The second-generation adults overwinter in soil and leaf litter where they remain until spring of the following year. The severity of the over-wintering period is a key factor in determining insect survival, with snow cover (Lam and Pedigo, 2000a) and woodland areas (Lam and Pedigo, 2000b) aiding survival.

The soybean aphid (*Aphis glycines*) is native to China and Japan, and was a new pest in Iowa in 2000. The small, yellow aphid has two distinctive black cornicles ("tailpipes") on the tip of the abdomen and develops colonies on soybean plants as winged and wingless forms. The winged form has a shiny, black head and thorax with a dark green abdomen and black cornicles. Aphids feed through piercing-sucking mouthparts and may have up to 18 generations per year, beginning with overwintering eggs on the alternate host of buckthorn trees. The eggs hatch into nymphs and two generations of wingless females develop on buckthorn, before the winged generation flies to soybean fields in the spring. In the fall, a winged generation migrates back to buckthorn. These females then produce a wingless generation that mates with winged males and lay eggs on the buckthorn trees. Soybean aphid populations build and peak during the period between late seedling stage to blooming stage. Usually in late July, the aphids move from the top of the leaves to the undersides, making control more difficult.

Honeydew and sooty mold (the excrement of the aphid and the resulting black fungus) are apparent in August and September. Stunted plants, and reduced pod and seed size may result from aphid feeding. Soybean aphids can also transmit viruses that cause mottling and distortion of the leaves and a reduced seed set. Discolored seeds may also result from this infection.

The use of organic pest management treatments may help organic farmers manage bean leaf beetles, soybean aphids, and the transmission of virus and fungal agents responsible for seed coat staining. After consulting with local farmers of the Heartland Organic Marketing Cooperative and support from the USDA-ARS National Soil Tilth Laboratory, four pest management treatments approved for use in certified-organic farming operations were selected and compared to a control (no treatment) for management of bean leaf beetle populations. These experiments were conducted at the Iowa State University Neely-Kinyon Research Farm near Greenfield, Iowa, in 2010 and 2011. The site for this experiment was certified organic by the Iowa Department of Agriculture and Land Stewardship (IDALS) Organic Certification Program.

Materials and Methods

From 2010 to 2011, organically approved treatments for bean leaf beetle and fungal control were evaluated. Blue River 29AR9 soybean aphid-resistant soybeans were planted on 3 June 2010 and 19 May 2011 in a randomized complete block design with four replications of each treatment in plots measuring 20 x 10 ft. at the Neely-Kinyon Research and Demonstration Farm. The following treatments were studied both years: PyGanic® Crop Protection EC 1.4 II (McLaughlin Gormley King Company, Minneapolis, MN) at 1.6 quart/acre, Neemix 4.5® (Certis USA, LLC, Columbia, MD) applied at 0.46 quart/acre, Neem Blend 45™ (karanja and neem oils) (Green Dance World Organics, Paw Paw, MI) at 0.23 quart/acre, MicroAF® (TerraMax, Inc., Ham Lake, MN) at 0.23 quart/acre, and a control (no sprays). Neemix 4.5® and Neem Blend 45™ were chosen for the active ingredient in both products called neem. Neem is an insect growth regulator, which interferes with an insect's ability to develop properly, thereby reducing target insect populations and damage. PyGanic® is a pyrethrin-based product, chosen for its effect on the insect's nervous system, and MicroAF® was chosen for its anti-fungal properties.

Treatments were applied every 2 weeks beginning 28 July 2010 and 1 July 2011. Bean leaf beetle sampling occurred on alternating weeks beginning 5 August 2010 and 8 July 2011 by sweeping across the soybean plants eight times, spanning a total of four rows per sweep, with a 15 in.-diameter sweep net. Insects were placed in Zip-loc bags and transported in coolers to Iowa State University. Insects were frozen until enumeration in the laboratory. All insects were identified and categorized as "pest", "neutral" and "beneficial" regarding their impact in relation to soybeans (Table 1).

Plots were maintained with rotary hoeings on 4 and 7 June 2010, and 30 May, 2 June, and 6 June 2011. Row cultivation occurred on 17 and 30 June and 10 July 2010; and 15, 20, and 29 June 2011. Due to high weed populations in research plots in 2010, plots were "walked" on 15 and 28 July. Soybeans were harvested on 8 October 2010 and 4 October 2011. The percentage of stained soybeans was determined by counting the number of stained soybeans in a 200-gram sample that was randomly collected from the harvest of each plot. Insect population, yield, and grain quality data were subjected to analysis of variance and mean separation using Fisher's Protected LSD at $p \leq 0.05$.

Results and Discussion

Bean leaf beetle populations remained low until the emergence of the second generation of beetles in early September 2010 and in late July 2011 (Table 2; Figure 1). No significant differences in bean leaf beetle populations were found between treatments; however there was a trend toward lower populations in plots treated with MicroAF®. At the bean leaf beetle population peak on 11 September 2011 (115 days after planting), the fewest numbers of beetles were collected from the Neemix 4.5®-treated plots, although there were no significant differences among treatments (Table 2). Over both seasons, the lowest bean leaf beetle populations were observed in the MicroAF® treatment (Table 2), although differences were not significant. No significant differences were found in aphid populations in 2010 (Table 3; Figure 2); however, in 2011, populations were significantly lower in plots treated with Neemix 4.5® and MicroAF® on 8 July and plots treated with PyGanic®, Neemix Blend 45®, and MicroAF® on 18 August. Average aphid population over each growing season showed trends toward lower populations in plots treated with Neemix 4.5® in 2010 and plots treated with Neemix Blend 45® in 2011.

No treatments significantly decreased total beneficial insect populations compared with the control (Table 4; Figure 3), although seasonal averages in both years showed the least amount of decrease in beneficial insect populations from control plot populations in plots treated with MicroAF®. No treatments significantly decreased total pest insect populations compared with the control (Table 5; Figure 4), although plots treated with

Neemix 4.5® showed trends toward lower seasonal average pest insect populations over both years compared with all other treatments.

In 2010 and 2011, no treatment stood out significantly as more effective in preventing staining; however, there was a trend toward the MicroAF® and Neemix Blend 45™ treatments having a lower percentage of staining than the control in both years (Table 6). The percentage of stained soybeans ranged from 0.5% to 0.7% in 2010, and 6.0% to 12.0% in 2012 (Table 6) with no significant differences among treatments. The difference in staining between 2010 and 2011 (averaging 0.6% and 9.0% respectively) correlates with the bean leaf beetle populations in those years, averaging 0.5 and 11.8 beetles per eight sweeps in 2010 and 2011, respectively. Yields ranged from 57 to 61 bu/acre in 2010, and 56 to 63 bu/acre in 2012. Although no significant yield differences were found in either year, the Neemix Blend 45™ and MicroAF® treaments showed trends toward higher yields than the control over both years. No significant differences and very few trends were found in grain quality analyses over either year, which suggests that the treatments used in this experiment had little impact on grain quality (Table 6).

Over the entire experiment, although there were very few significant differences between treatments, plots treated with MicroAF® in both years showed trends toward lower bean leaf beetle populations, lower percent staining, and higher yields than the control plots. In addition, MicroAF® showed the least amount of decrease in beneficial insect populations from the control plots. Of all treatments in this experiment, it seems MicroAF® shows the most promise in bean leaf beetle control. However, no treatment consistently stood out both years as having control potential over the soybean aphid.

Table 1. Insect classification, 2010-2011.

Pest insects	Neutral insects	Beneficial insects
Bean leaf beetles (*Cerotoma trifurcata*)	Ants (Hymenoptera: Formicidae)	Assassin bugs (Hemiptera: Reduviidae)
Corn rootworms (*Diabrotica* spp.)	Boxelder bugs (*Boisea trivittata*)	Damsel bug/ Nabids (*Nabis* spp.)
Grasshoppers (Orthoptera: Acrididae)	Click beetles (Coleoptera: Elateridae)	Green lacewings (Neuroptera: Chrysopidae)
Katydids (Orthoptera: Tettigoniidae)		Lady beetles (Coleoptera: Coccinellidae)
Leaf-footed bugs (Hemiptera: Coreidae)		Long-legged flies (Diptera: Dolichopodidae)
Leafhoppers (Hemiptera: Cicadellidae)		Minute pirate bugs (*Orius* spp.)
Soybean aphids (*Aphis glycines*)		Rove beetles (Coleoptera: Staphylinidae)
Tarnished plant bugs (*Lygus* spp.)		Spiders (Arachnida: Araneae)
Weevils (Coleoptera: Curculionidae)		Syrphid flies (Diptera: Syrphidae)
Whiteflies (Hemiptera: Aleyrodidae)		Parasitic wasps (Hymenoptera: Terebrantia)

Table 2. Bean leaf beetle populations per 8 sweeps, 2010-2011.

Treatment	50 DAP	62-63 DAP	77-78 DAP	90-91 DAP	115 DAP	Seasonal Average
2010		5 Aug.	19 Aug.	1 Sept.		
Control	---	0.00	0.00	2.25	---	0.75
PyGanic®	---	0.00	0.00	2.50	---	0.83
Neemix 4.5®	---	0.00	0.00	1.75	---	0.58
Neemix Blend 45™	---	0.00	0.00	1.00	---	0.33
MicroAF®	---	0.00	0.00	0.25	---	0.08
$LSD_{0.05}$	---	NS[z]	NS	NS	---	NS
2011	8 July	20 July	5 Aug.	18 Aug.	11 Sept.	
Control	0.50	5.50	21.25	3.00	24.75	11.00
PyGanic®	0.75	3.75	31.25	4.00	24.75	12.90
Neemix 4.5®	1.25	3.75	32.75	3.00	18.50	11.85
Neemix Blend 45™	1.00	3.25	31.25	2.25	23.50	12.25
MicroAF®	1.00	1.25	26.25	2.00	24.00	10.90
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS

[z]Means within a column are not significantly different (NS), or significantly different at $p \leq 0.05$ (Fisher's protected LSD test).

Table 3. Aphid populations per 8 sweeps, 2010-2011.

Treatment	50 DAP	62-63 DAP	77-78 DAP	90-91 DAP	115 DAP	Seasonal Average
2010		5 Aug.	19 Aug.	1 Sept.		
Control	---	17.25	2.50	4.50	---	8.08
PyGanic®	---	14.00	2.00	4.50	---	6.83
Neemix 4.5®	---	9.67	2.00	6.25	---	5.97
Neemix Blend 45™	---	10.75	1.75	7.50	---	6.67
MicroAF®	---	12.00	2.50	10.00	---	8.17
LSD $_{0.05}$	---	NS [z]	NS	NS	---	NS
2011	8 July	20 July	5 Aug.	18 Aug.	11 Sept.	
Control	0.00b	0.25	1.25	1.00ab	1.50	0.80
PyGanic®	1.00a	0.00	1.00	0.25b	0.75	0.60
Neemix 4.5®	0.00b	0.00	0.00	2.25a	1.00	0.65
Neemix Blend 45™	0.50ab	0.00	0.00	0.50b	0.00	0.20
MicroAF®	0.00b	0.00	0.00	0.75b	0.50	0.25
LSD $_{0.05}$	0.67	NS	NS	1.31	NS	NS

[z]Means within a column are not significantly different (NS), or significantly different at $p \leq 0.05$ (Fisher's protected LSD test).

Table 4. Total beneficial insect populations per 8 sweeps, 2010-2011.

Treatment	50 DAP	62-63 DAP	77-78 DAP	90-91 DAP	115 DAP	Seasonal Average
2010		5 Aug.	19 Aug.	1 Sept.		
Control	---	7.75	5.50	8.50	---	7.25
PyGanic®	---	4.25	4.50	3.50	---	4.08
Neemix 4.5®	---	4.33	5.50	5.25	---	5.03
Neemix Blend 45™	---	3.75	1.25	7.50	---	4.17
MicroAF®	---	5.50	4.75	7.50	---	5.92
$LSD_{0.05}$	---	NS[z]	NS	NS	---	NS
2011	8 July	20 July	5 Aug.	18 Aug.	11 Sept.	
Control	10.75	3.25	22.75	14.00	3.00	10.75
PyGanic®	9.25	4.00	18.50	10.00	2.25	8.80
Neemix 4.5®	6.25	3.50	22.75	8.00	2.75	8.65
Neemix Blend 45™	7.50	2.50	18.25	11.67	1.25	8.23
MicroAF®	6.00	5.00	34.00	7.25	2.00	10.85
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS

[z]Means within a column are not significantly different (NS), or significantly different at $p \leq 0.05$ (Fisher's protected LSD test).

Table 5. Total pest insect populations per 8 sweeps, 2010-2011.

Treatment	50 DAP	62-63 DAP	77-78 DAP	90-91 DAP	115 DAP	Seasonal Average
<u>2010</u>		5 Aug.	19 Aug.	1 Sept.		
Control	---	36.25	8.50	15.75	---	20.17
PyGanic®	---	35.25	6.25	10.75	---	17.42
Neemix 4.5®	---	23.00	6.50	14.25	---	14.58
Neemix Blend 45™	---	26.75	3.00	16.00	---	15.25
MicroAF®	---	25.50	5.50	23.00	---	18.00
LSD $_{0.05}$	---	NS[z]	NS	NS	---	NS
<u>2011</u>	8 July	20 July	5 Aug.	18 Aug.	11 Sept.	
Control	29.50	19.50	73.50	43.00	37.00	40.50
PyGanic®	24.50	9.00	73.75	49.00	34.25	38.10
Neemix 4.5®	26.75	12.75	95.00	33.75	25.00	38.65
Neemix Blend 45™	27.00	16.50	103.50	41.50	32.50	44.20
MicroAF®	30.25	8.25	128.75	40.25	31.00	47.70
LSD $_{0.05}$	NS	NS	NS	NS	NS	NS

[z]Means within a column are not significantly different (NS), or significantly different at $p \leq 0.05$ (Fisher's protected LSD test).

Table 6. Soybean grain quality and staining parameters, 2010-2011.

Treatment	Yield (bu/acre)	Staining (%)	Grain moisture (%)	Protein (%)	Oil (%)	Fiber (%)	Carbos
2010							
Control	57.47	0.63	9.10	35.35	17.78	4.88	24.00
PyGanic®	57.49	0.58	9.08	35.33	17.78	4.88	24.03
Neemix 4.5®	58.37	0.65	9.20	35.45	17.75	4.85	23.95
Neemix Blend 45™	61.33	0.49	9.25	35.28	17.98	4.90	23.88
MicroAF®	60.34	0.53	9.35	35.40	17.88	4.85	23.88
$LSD_{0.05}$	NS[z]	NS	NS	NS	NS	NS	NS
2011							
Control	58.46	9.20	8.73	35.48	17.83	4.85	23.85
PyGanic®	55.54	9.00	8.93	35.34	17.78	4.88	24.01
Neemix 4.5®	57.29	11.95	8.90	35.45	17.60	4.88	24.07
Neemix Blend 45™	59.97	8.73	8.65	35.13	17.90	4.89	24.09
MicroAF®	62.85	5.95	8.55	35.35	17.70	4.88	24.07
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS

[z]Means within a column are not significantly different (NS), or significantly different at $p \leq 0.05$ (Fisher's protected LSD test).

Figure 1. Bean leaf beetle populations, 2010-2011.

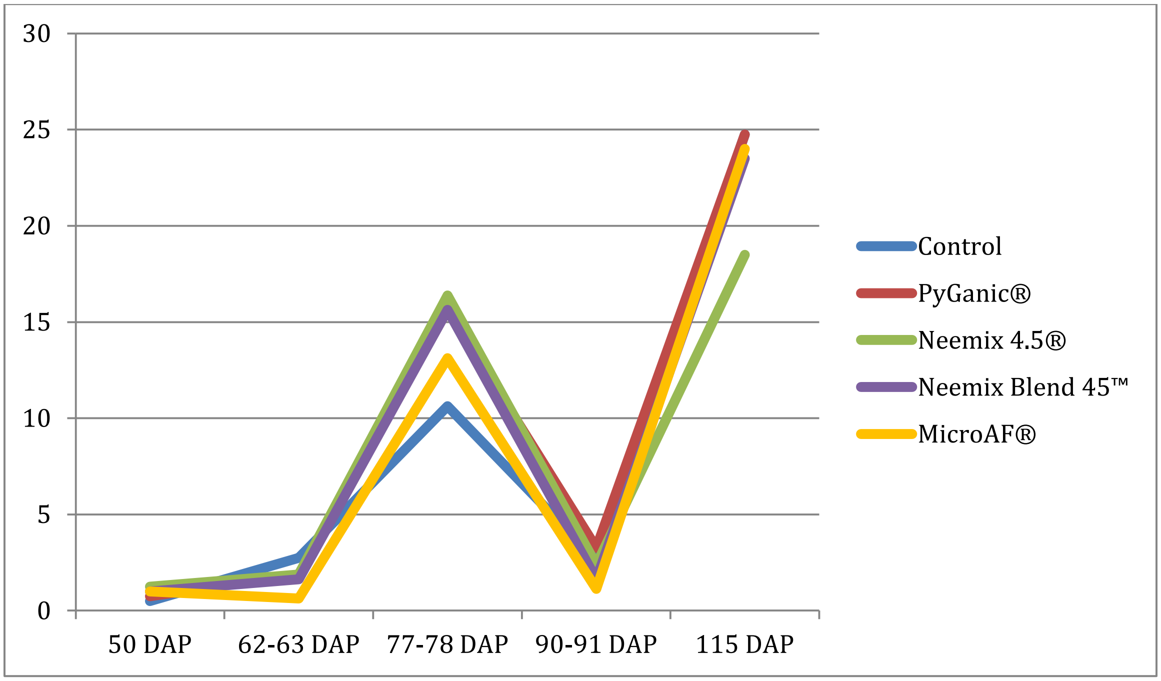


Figure 2. Aphid populations, 2010-2011.

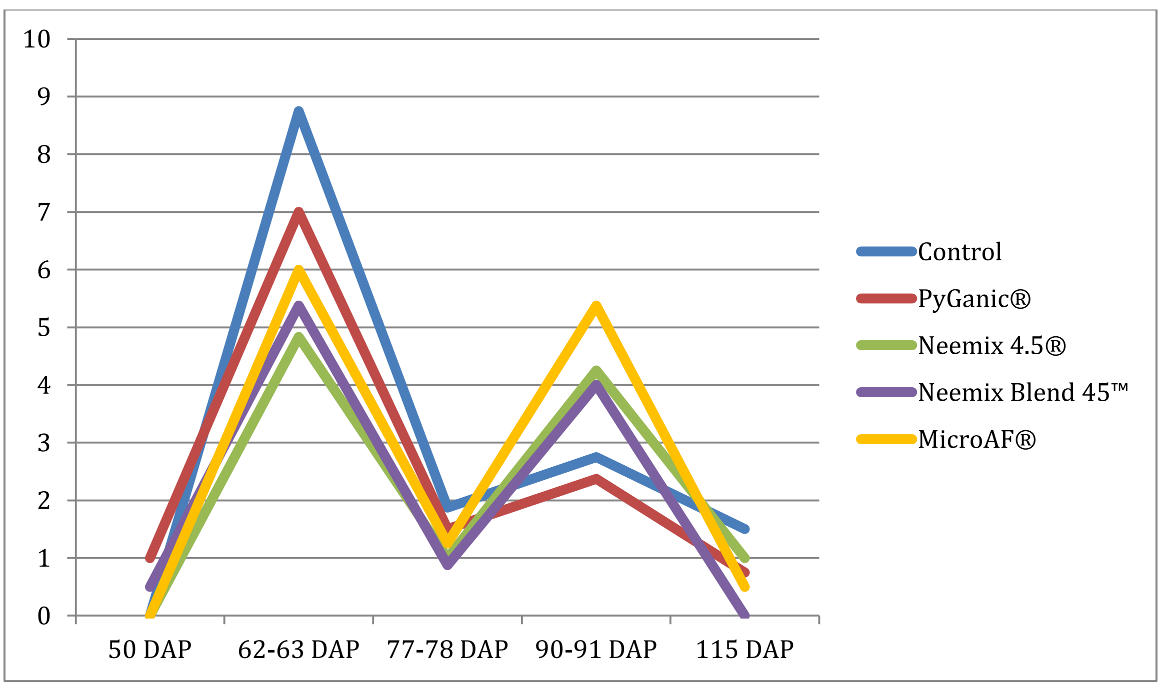


Figure 3. Total beneficial insect populations, 2010-2011.

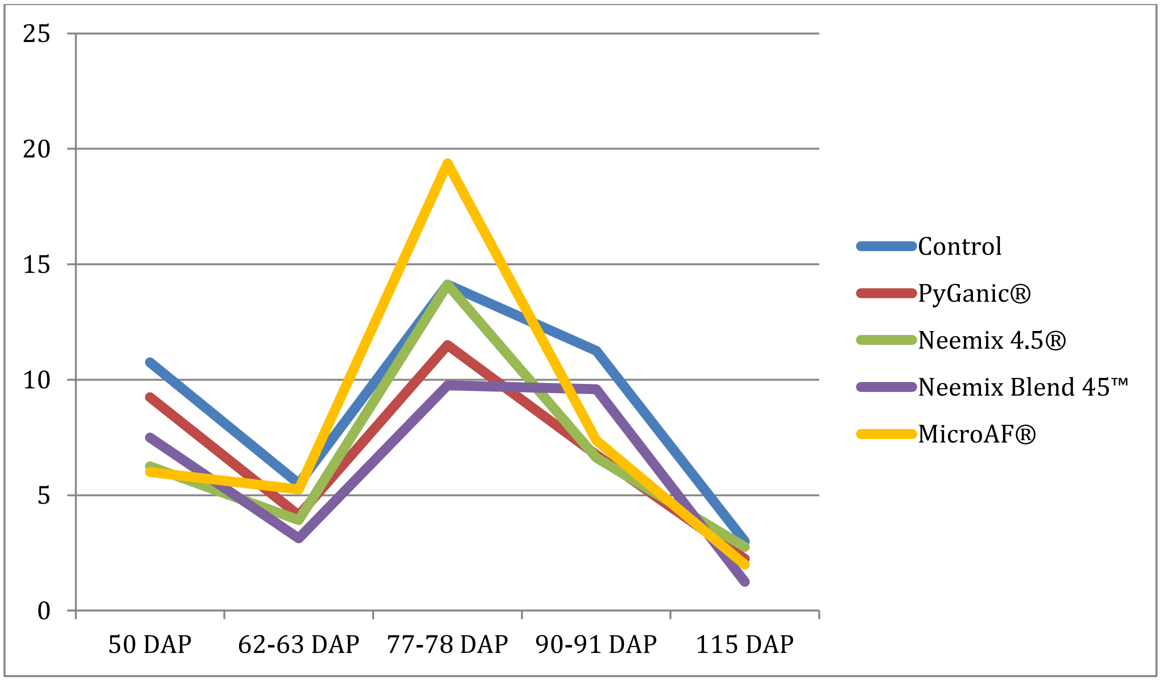
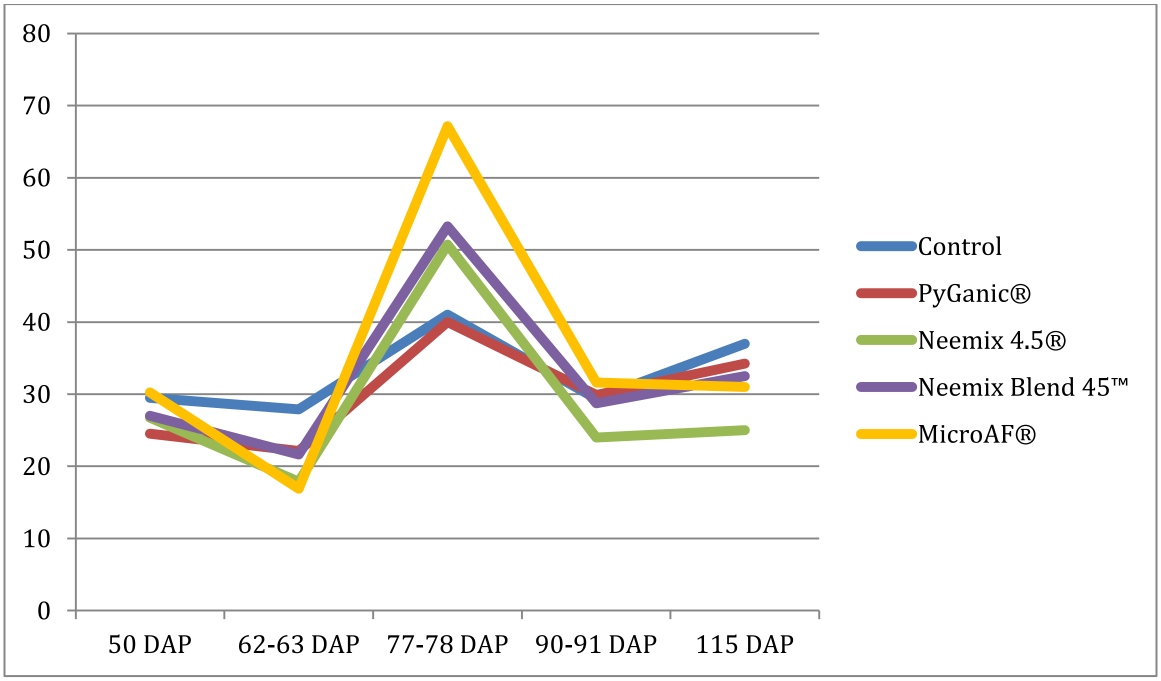


Figure 4. Total pest insect populations, 2010-2011.



Improvements for Future Experiments

Since the foliar treatments used in this experiment did not provide significant suppression of bean leaf beetle or soybean aphid populations, other organically approved foliar treatments should be sought out. However, since the MicroAF® treatment showed trends toward fewer beetle populations and lower staining percentages, it would be recommended to include MicroAF® in the next experiment.

It is possible that foliar treatments are not as effective on bean leaf beetle and soybean aphid populations as other methods might be. It would be advisable to conduct experiments comparing treatments that involve disturbing the soil where bean leaf beetles overwinter, reducing nearby host plants and overwintering sites, and the use of biological control agents.

Another problematic aspect of this experiment is the spraying schedule. A non-research producer will have a much larger field to treat, which will cost the producer time and money. Because of this, a non-research producer will monitor insect populations and compare those numbers to the economic threshold to decide whether or not to implement management tactics. Ideally, the research experiment should follow the same protocol as a producer would, so the spraying schedule should be determined based on beetle populations and the economic threshold.

Resources

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