Wisconsin
Pest Management Center

Research Report
2008

COLLEGE OF
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& LIFE SCIENCES
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Acknowledgments

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INSECTICIDE EFFICACY RESEARCH CONDUCTED ON VEGETABLE AND FIELD CROPS

STATISTICAL ANALYSIS PROCEDURE

All data was subjected to two-way analysis of variance and insect count data was transformed using square root (X+1) prior to mean separation. Mean separation was by Least Significant Difference test at the 5% level of significance. Means are rounded for clarity, and in all tables, means in a column followed by the same letter are not significantly different.

Any questions concerning the data should be directed to Dr. Scott Chapman, chapman@entomology.wisc.edu, 608-575-6469 mobile, 608-262-9914 lab.

Section 1. Insect Control on Potatoes.

Insect management programs for Wisconsin potatoes are designed to hold key insect pests below damaging levels. Two key insect species are normally present on potatoes grown in Wisconsin, the Colorado potato beetle and the potato leafhoppers typically require control actions to avoid economic loss on potatoes.

Other potato insect pests occasionally occur in Wisconsin and these may also cause economic damage. However, management programs targeting the key pest complexes typically also control sporadic pests in the system. Therefore specific control measures for sporadic pests are only required when populations are unusually high or when pest specific insecticides are used to control the three key pests (Spintor, Rimon, Fulfill, etc.). The most frequently encountered sporadic pests found on potato include green peach aphids, potato aphids, potato flea beetles, European corn borers and other occasional lepidopteran pests such as cutworms and loopers, and soil insects such as wireworm and white grub.

Colorado potato beetles are a serious defoliating insect pest on potatoes in Wisconsin, and due to its ability to develop insecticide resistance; populations may be difficult to control. Colorado potato beetles cause damage as a defoliator in both the adult and larval stages and non-chemical control options for Colorado potato beetles are often limited in scope. Cultural manipulations such as crop rotation, to avoid over wintered adult populations, can be effective in delaying infestations and decreasing their severity. Trap crops or physical barriers (trenches) have also been used successfully in other growing regions to delay infestation. Biological regulation by beneficial insects (predators, parasitoids, etc.) is usually ineffective and growers must rely on chemical control to prevent economic damage.

Potato leafhoppers migrate yearly into Wisconsin from southeastern U.S. Both the adult and nymphal stages cause damage by feeding on the plant sap, disrupting the plants ability to translocate photosynthates. The resultant hopper burn can cause serious yield loss in potato. Potato leafhopper control options are limited since both cultural and biological controls are not effective and growers must again rely on insecticidal control when populations exceed damage thresholds.

Green peach aphids, like the potato leafhopper, feed by extracting sap from the plant. However, plant conductive tissues are not seriously damaged during feeding and extremely high populations are necessary to remove sufficient sap to cause wilting and plant death. Populations normally reach this level only late in the season and vine damage is seen in relatively small, circular patches of dead vines scattered throughout the fields. Although direct damage rarely results from aphid feeding earlier in the season, the green peach aphid is an efficient vector of several potato viruses (e.g. potato virus Y and potato leaf roll virus) and indirect damage can occur from low aphid population levels as a result of virus

transmission. In processing and fresh market potatoes, viruses rarely cause current season yield reduction and concern is primarily centered on the prevention of potato leaf roll virus spread which can reduce processing quality through expression in tubers (net necrosis). In processing potatoes, control actions are often recommended at levels of 1 aphid per leaf or below. Higher aphid levels can be tolerated in fresh market production but since aphids reproduce very quickly, population explosions can occur rapidly and control actions are normally taken at or below 4-5 aphids per leaf before damaging levels are reached. In seed potato production, virus spread must be held close to zero to achieve certification and consequently control actions are taken at extremely low aphid levels (1 green peach aphid per 10 leaves).

Control options for aphids are also limited and the primary management tool is again insecticide use. Cultural controls are not effective since winged aphids can be carried over long distances by wind. However, broad complexes of beneficial insects (both predators and parasitoids) utilize aphids as hosts and they can limit aphid populations if left undisturbed by insecticides. Beneficial insects represent an important natural aphid mortality factor which should be preserved whenever possible and used in conjunction with insecticidal control.

Although cultural and biological controls can provide some level of population reduction; key insect pests of potato are currently being managed primarily with insecticides. Chemical management programs should be designed to hold key insect pest populations below damaging levels while avoiding the potential problems associated with resistance, non-target toxicity, environmental degradation and worker safety. The following studies describe research conducted in 2005 on the control of key insect pests of potato using registered and experimental insecticides.

Part 1. Insect Control with Soil Applied Systemic Insecticides.

Systemic insecticides are those applied to the soil (or seed piece) at planting or very early in the growing season (planting-emergence). They are taken up by the plant and provide protection for an extended period of time. Since 1995 several nicotinyl, systemic insecticides have been registered on potatoes in Wisconsin and others are currently awaiting registration. Nicotinyls have been widely used by the Wisconsin potato industry because they are flexible systemic insecticides with low mammalian toxicity, low environmental impact, and have excellent efficacy against key potato pests (Colorado potato beetle and aphids).

A. Colorado Potato Beetle, Potato Leafhopper and Aphid Control with Soil Insecticides, Hancock.

The Colorado potato beetle is the foremost potato insect pest throughout the Midwestern and Eastern growing regions of the United States. Insecticide resistance is widespread in most areas and effective registered materials are becoming more limited. Since the mid 1990's soil applied, systemic insecticides

have been widely used for Colorado potato beetle control because of their effectiveness and reduced labor inputs.

Nicotinyls are extremely flexible insecticides that are currently registered on potatoes in Wisconsin. Formulations are now registered for soil application as furrow sprays, fertilizer incorporation, and layby applications, seed treatments and foliar sprays. Several nicotinyls were evaluated in a soil applied systemic insecticide trial conducted on potatoes.

Russet Burbank variety potatoes were planted on 24 April 2008 into plots consisting of 4 x 20' rows, replicated four times in a randomized block experimental design. Rows were planted on 3' centers with 12 inch plant spacing. Treatments were separated by two untreated border rows (Russet Burbank variety) to provide continual infestation while 15' alleys separated replicates.

Forty two treatments were evaluated for Colorado potato beetle, potato leafhopper and aphid control on a loamy sand textured soil at the Hancock Agricultural Research Station, Hancock, Wisconsin. The following table lists the evaluated treatments.

Table 1. Insecticide treatment list for Colorado Potato Beetle Systemic Trial. HARS, Hancock, WI 2008.

Treatment	Rate	Placement
1-Untreated	---	---
2-Tops MZ 4FS-CTL	0.04 fl oz/cwt	Seed
3-Moncoat 7.5DS-CTL	1.0 lb./cwt	Seed
4-Cyazapyr 200SC	0.066 lb. ai/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
5-Cyazapyr 200SC	0.134 lb. ai/a	In furrow
Maxim 4FS	0.8 fl oz/cwt	Seed
6-Cyazapyr 200SC	0.176 lb. ai/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
7-Cyazapyr 600FS	3.2 g/cwt	Seed
Maxim 4FS	0.08 fl oz/cwt	Seed
8-Regent 4SC	3.2 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
9-Regent 4SC	3.2 fl oz/a	In furrow
Admire Pro 4.6SC	8.7 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
10-Regent 4SC	3.2 fl oz/a	In furrow
Tops MZ 8.5DS	12 oz/cwt	Seed
11-Belay 2.13SC	7.2 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed

(Continued)

Table 1. (Continued). Insecticide treatment list for Colorado Potato Beetle Systemic Trial. HARS, Hancock, WI 2008.

Treatment	Rate	Placement
12- Belay 2.13SC	8.4 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
13- Belay 2.13SC	9.0 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
14- Belay 2.13SC	9.6 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
15- Belay 2.13SC	10.8 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
16-Admire Pro 4.6SC	8.7 fl oz/a	In furrow
TopsMZ 8.5DS	12 oz/cwt	Seed
17- Admire Pro 4.6SC	7.0 fl oz/a	In furrow
TopsMZ 8.5DS	12 oz/cwt	Seed
18- Admire 2SC	0.64 fl oz/cwt	Seed
TopsMZ 8.5DS	12 oz/cwt	Seed
19-Untreated	---	---
20-Platinum 2SL	6.0 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
21-Platinum 2SL	6.5 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
22-Platinum 2SL	8 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
23-Cruiser 5FS	0.16 fl oz/cwt	Seed
Maxim 4FS	0.08 fl oz/cwt	Seed
24- Belay 2.13SC	0.6 fl oz/cwt	Seed
25- Belay 2.13SC	0.6 fl oz/cwt	Seed
Maxim 4FS	0.08 fl oz/cwt	Seed
26- Belay 2.13SC	0.6 fl oz/cwt	Seed
TopsMZ 8.5DS	12 oz/cwt	Seed
27- Belay 2.13SC	0.6 fl oz/cwt	Seed
Mancozeb 6DS	16 oz/cwt	Seed
28- Belay 2.13SC	0.6 fl oz/cwt	Seed
MaximMZ 6.2SS	8 oz/cwt	Seed
29- Belay 2.13SC	0.4 fl oz/cwt	Seed
V10243 40DP	0.23 fl oz/cwt	Seed

(Continued)

Table 1. (Continued). Insecticide treatment list for Colorado Potato Beetle Systemic Trial. HARS, Hancock, WI 2008.

Treatment	Rate	Placement
30- Belay 2.13SC	0.6 fl oz/cwt	Seed
V10243 40DP	0.23 fl oz/cwt	Seed
31-Belay 16WG	12.0 oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
32-Belay 16WG	8 fl oz/a	Row mark
Belay 16WG	10 fl oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
33-Belay 16WG	8 fl oz/a	Blind hilling
Belay 16WG	10 fl oz/a	2nd hilling
NIS	0.25% v/v	Seed
Maxim 4FS	0.08 fl oz/cwt	Seed
34-TopsMZ Gaucho 1.25DS	12.0 oz/cwt	Seed
35-TopsMZ Gaucho 1.25DS	16.0 oz/cwt	Seed
36-Belay 16WG	16.0 oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
37-Poncho 5L	0.16 fl oz/cwt	Seed
TopsMZ 8.5DS	12.0 oz/cwt	Seed
38-Poncho 5L	0.32 fl oz/cwt	Seed
TopsMZ 8.5DS	12.0 oz/cwt	Seed
39-Venom 70SG	7.0 oz/a	In furrow
Maxim 4FS	0.08 fl oz/cwt	Seed
40-Platinum 2SC	8.0 fl oz/a	2nd hilling
Maxim 4FS	0.08 fl oz/cwt	Seed
41-Admire Pro 4.6SC	8.7 fl oz/a	2nd hilling
Maxim 4FS	0.08 fl oz/cwt	Seed
42-Belay 2.13SC	9.6 fl oz/a	2nd hilling
NIS	0.25% v/v	2nd hilling
Maxim 4FS	0.08 fl oz/cwt	Seed

Seed piece treatments (spray) were applied with a CO_2 pressurized backpack sprayer operating at 30 psi. Preweighed, cut and suberized potato seed was placed in a single layer and sprayed with half of a spray solution. The seed was allowed to dry and then it was flipped over and the remaining spray solution was applied on the other half of the seed pieces. Dust seed piece treatments were applied by adding preweighed dry formulation materials to preweighed, cut, and suberized potato seed pieces in plastic bags. Bags were shaken thoroughly and

seed pieces were hand placed (12” spacing) into open furrows at planting and covered by hilling. In furrow insecticides were applied in a 4-6” band over suberized seed pieces using a CO_2 pressurized back pack sprayer with a single hollow cone nozzle (TXVS-6) delivering 5 gpa at 30 psi. Insecticide applications at 2nd hilling were “knifed” into the side of the potato hill with a 2 row injection applicator operating by gravity flow delivering 22.5 gpa.

Colorado potato beetle (CPB) populations were surveyed weekly from 4 June through 22 July by counting CPB life stages (adults, egg masses, small and large larvae) on ten plants randomly selected from the center two rows of each plot. Damage was recorded weekly by estimating percent defoliation of each plot. Potato leafhopper adults and aphids were surveyed weekly from 17 June through 22 July by sweep sampling (25 sweeps per plot). Potato leafhopper nymph, green peach aphid and potato aphids were also surveyed weekly from 17 June through 22 July but by leaf sampling (25 leaves per plot). Hopperburn ratings were generated from visual observations of each plot and determining the level of “burn” on a scale of 0-5 with 0 having no damage to 5 where all of the leaf foliage is necrotic.

Plots were overhead irrigated with 0.4-0.6” water every 2-5 days from plant emergence to vine kill for a total of 10.5 inches of water from 5/22/08 through 8/20/08.

Plots were vine killed with an application of Credit Xtra 1 qt./a) on 5 August and a single row from the center two rows (20’) was harvested and graded for yield on 3 September. Plot maintenance was conducted by Hancock Agriculture Research Station personnel and was per commercial production.

Table 2. Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean adults per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
1	4.5 b-g	8.5 a	3.0 d-i	1.5 c-g	0.3 a	11.8 abc	22.0 e-j	25.0 j-m
2	6.3 a-g	3.8 a	0.5 i	1.3 d-g	0.3 a	11.5 abc	13.8 j	24.5 klm
3	2.8 fg	4.5 a	2.8 e-i	0.0 g	1.0 a	11.0 a	13.5 j	17.0 m
4	6.0 a-g	8.8 a	2.3 f-i	0.3 fg	0.3 a	1.8 de	14.3 ij	24.5 i-m
5	13.0 ab	8.5 a	2.8 c-i	3.3 a-f	1.5 a	1.8 de	60.3 ab	73.3 a-d
6	9.3 a-d	8.0 a	7.0 a-g	4.3 a-e	1.8 a	1.5 de	29.0 a-j	68.8 a-e
7	7.5 a-f	8.3 a	3.8 c-i	2.3 a-g	0.5 a	1.3 de	23.8 c-j	59.3 a-g
8	4.5 b-g	3.5 a	2.5 d-i	0.3 fg	0.0 a	2.5 de	20.5 e-j	35.8 e-m
9	7.8 a-e	5.8 a	3.8 c-i	3.8 a-e	1.3 a	3.8 bcd	45.0 a-d	80.0 a
10	8.8 a-e	6.0 a	4.3 a-h	1.3 c-g	0.8 a	9.0 abc	17.5 f-j	28.5 f-m
11	5.3 b-g	10.3 a	5.8 a-g	5.0 ab	0.0 a	1.5 de	30.5 b-j	41.3 b-l
12	10.0 abc	8.5 a	5.3 a-h	4.0 a-e	0.5 a	1.3 de	27.5 b-j	48.0 a-j

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 2. (Continued). Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean adults per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
13	6.0 a-g	7.5 a	5.0 a-h	2.5 a-g	0.5 a	0.8 de	20.0 g-j	59.8 a-e
14	7.8 a-e	8.3 a	7.5 a-f	3.3 a-e	0.8 a	1.0 de	34.3 a-h	48.3 c-m
15	2.3 fg	9.5 a	6.3 a-g	5.3 abc	0.8 a	1.5 de	37.3 a-g	51.3 a-i
16	7.3 a-f	11.3 a	4.0 b-i	3.8 a-e	0.3 a	1.3 de	19.0 e-j	58.5 a-g
17	4.8 b-g	6.8 a	1.0 hi	3.3 a-e	0.5 a	1.8 de	26.5 b-j	46.8 a-k
18	10.0 a-e	10.3 a	8.3 a-e	5.8 a	0.8 a	1.3 de	27.5 a-j	60.8 a-f
19	4.3 c-g	3.5 a	2.0 f-i	1.3 d-g	0.3 a	10.0 ab	16.8 hij	21.5 lm
20	2.0 g	9.5 a	3.8 b-i	6.5 ab	2.0 a	3.5 cde	33.0 a-i	42.5 a-l
21	8.3 a-e	11.3 a	6.8 a-f	2.8 a-f	1.5 a	0.3 e	24.3 c-j	52.5 a-h
22	3.5 c-g	9.3 a	4.5 a-h	3.5 a-e	1.8 a	1.8 de	27.8 b-j	38.5 c-m
23	3.0 efg	8.0 a	3.0 c-i	7.3 a	0.3 a	1.0 de	18.0 f-j	39.8 b-m
24	3.8 c-g	12.3 a	6.0 a-g	5.0 abc	2.0 a	0.5 de	17.5 e-j	42.0 b-l

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 2. (Continued). Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean adults per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
25	4.0 d-g	10.0 a	6.0 a-g	4.5 a-d	2.3 a	2.0 de	29.3 a-j	47.0 a-j
26	6.8 a-g	12.3 a	6.5 a-g	5.0 ab	0.8 a	1.5 de	26.8 b-j	45.5 a-l
27	1.5 g	10.5 a	11.5 a	3.3 a-f	0.3 a	1.8 de	28.0 a-j	47.3 a-j
28	4.8 b-g	10.8 a	3.0 c-i	4.0 a-e	2.3 a	1.8 de	49.8 abc	33.8 g-m
29	10.5 a-d	13.5 a	10.3 abc	5.0 a-e	1.3 a	1.3 de	22.0 c-j	47.5 a-l
30	4.0 c-g	11.3 a	8.0 a-d	4.0 a-e	1.3 a	2.8 de	42.3 a-e	51.8 a-k
31	12.3 a	8.3 a	4.5 a-h	3.8 a-e	0.8 a	0.8 de	33.0 a-i	38.3 d-m
32	4.0 c-g	12.0 a	5.5 a-g	5.3 a-e	1.0 a	1.8 de	54.8 a	54.8 a-h
33	7.3 a-f	6.3 a	4.8 a-h	3.5 a-e	1.3 a	2.5 de	34.0 a-h	52.5 a-i
34	6.0 a-g	8.3 a	3.8 b-i	1.8 b-g	0.3 a	0.3 e	26.5 b-j	41.3 b-m
35	5.8 a-g	5.3 a	3.8 b-i	1.8 b-g	0.8 a	0.5 de	26.0 b-j	63.0 a-e
36	5.5 a-g	12.0 a	7.8 abc	5.3 ab	0.5 a	0.5 de	39.3 a-f	75.5 abc

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 2. (Continued). Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean adults per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
37	4.5 c-g	7.8 a	5.0 a-h	2.5 a-g	1.0 a	0.5 de	24.8 c-j	25.3 h-m
38	6.3 a-g	10.3 a	9.0 ab	4.0 a-e	1.3 a	1.0 de	40.0 a-f	43.8 a-l
39	8.0 a-e	6.3 a	3.3 c-i	2.3 a-g	0.3 a	1.0 de	22.5 d-j	38.0 e-m
40	4.3 c-g	7.0 a	3.3 c-i	3.3 a-e	0.8 a	3.5 cde	29.3 b-j	50.8 a-i
41	8.8 a-e	5.8 a	2.8 c-i	1.0 efg	0.8 a	0.8 de	36.8 a-h	78.0 ab
42	4.0 c-g	5.5 a	1.8 ghi	1.5 b-g	1.3 a	1.3 de	24.8 c-j	60.5 a-g
LSD	1.08	1.04	1.05	0.91	0.53	1.03	2.07	2.47
S.D.	0.77	0.74	0.75	0.65	0.38	0.73	1.48	1.77
C.V.	30.6	25.01	33.33	33.19	28.65	43.53	28.38	26.58
F	1.507	1.378	1.562	1.616	1.102	2.380	1.622	1.985
Prob. F	0.0450	0.0922	0.0323	0.0234	0.3356	0.0001	0.0226	0.0021

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 3. Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean egg masses per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
1	12.0 abc	4.8 a	1.8 d-k	0.5 e	0.3 de	0.5 a	0.0 a	0.0 a
2	7.5 a-d	3.5 a	1.0 h-k	0.3 e	0.0 e	0.0 a	0.3 a	0.0 a
3	13.8 a	4.0 a	0.3 k	0.3 e	0.0 e	0.3 a	0.0 a	0.0 a
4	6.3 a-f	6.0 a	4.8 abc	1.8 de	0.5 cde	0.0 a	0.5 a	0.0 a
5	5.8 b-g	3.5 a	3.0 a-i	2.3 de	1.8 abc	1.3 a	0.5 a	0.0 a
6	3.0 d-j	2.3 a	3.8 a-h	1.5 de	3.0 a	1.5 a	0.8 a	0.0 a
7	6.8 a-e	3.3 a	4.8 a-d	0.8 de	0.8 cde	0.3 a	0.5 a	0.0 a
8	11.3 abc	1.5 a	0.5 jk	0.8 de	0.0 e	0.8 a	0.0 a	0.0 a
9	2.8 d-j	2.8 a	2.5 a-j	3.0 b-e	1.3 b-e	1.0 a	0.8 a	0.0 a
10	13.3 ab	3.5 a	1.5 g-k	1.3 de	0.0 e	1.3 a	0.0 a	0.0 a
11	3.3 d-j	2.3 a	4.5 a-f	1.0 de	0.5 cde	1.0 a	0.0 a	0.0 a
12	3.0 d-j	1.5 a	3.5 a-g	3.3 a-d	1.0 b-e	0.0 a	0.0 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 2. (Continued). Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean egg masses per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
13	1.5 g-j	1.5 a	4.5 a-e	2.5 b-e	0.3 de	0.5 a	0.0 a	0.0 a
14	0.3 j	3.3 a	3.3 a-i	2.8 b-e	0.3 de	0.0 a	0.5 a	0.0 a
15	0.8 ij	1.8 a	3.5 a-i	2.5 cde	1.5 bcd	1.0 a	0.0 a	0.0 a
16	1.3 hij	3.0 a	1.8 g-k	2.0 de	1.5 abc	0.3 a	0.3 a	0.0 a
17	1.5 hij	2.3 a	2.0 c-k	6.5 ab	1.8 abc	0.3 a	0.0 a	0.0 a
18	1.0 ij	2.5 a	5.0 ab	2.3 de	1.3 bcd	0.8 a	0.0 a	0.0 a
19	9.8 abc	2.3 a	0.5 jk	0.5 e	0.0 e	0.0 a	0.3 a	0.0 a
20	0.5 j	4.3 a	2.8 a-j	11.3 a	0.8 cde	1.8 a	0.3 a	0.0 a
21	1.3 hij	4.0 a	5.5 a	2.0 de	0.8 cde	0.5 a	0.3 a	0.0 a
22	1.0 ij	2.0 a	1.8 f-k	2.0 de	1.5 abc	0.8 a	0.3 a	0.0 a
23	1.3 ij	3.3 a	3.0 a-i	2.0 de	0.5 cde	0.0 a	0.0 a	0.0 a
24	0.5 j	1.8 a	2.0 b-k	2.5 b-e	0.3 de	0.5 a	0.0 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 2. (Continued). Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean egg masses per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
25	0.5 j	1.8 a	3.3 a-i	1.8 de	2.5 ab	1.5 a	0.5 a	0 a
26	0.8 ij	1.0 a	3.8 a-g	2.3 de	1.5 bcd	0.5 a	0.0 a	0.0 a
27	0.0 j	1.5 a	0.5 jk	2.8 b-e	0.5 cde	0.3 a	0.3 a	0.0 a
28	1.0 hij	1.5 a	2.8 a-j	2.5 de	1.0 cde	0.8 a	0.0 a	0.0 a
29	0.5 j	2.3 a	3.8 a-g	6.0 abc	1.3 bcd	1.0 a	0.3 a	0.0 a
30	0.0 j	1.8 a	1.8 e-k	2.5 cde	0.5 cde	0.8 a	0.3 a	0.0 a
31	3.0 d-j	1.8 a	2.8 a-j	2.5 cde	0.5 cde	0.5 a	0.3 a	0.0 a
32	1.3 hij	3.8 a	6.0 a	1.8 de	1.0 b-e	0.0 a	0.3 a	0.0 a
33	2.3 e-j	3.0 a	3.0 a-i	0.8 de	1.3 bcd	0.8 a	0.8 a	0.0 a
34	2.0 f-j	2.5 a	3.0 a-i	2.3 de	0.5 cde	0.0 a	0.0 a	0.0 a
35	0.8 ij	3.3 a	3.3 a-i	1.3 de	0.3 de	0.0 a	0.3 a	0.0 a
36	1.3 hij	2.0 a	1.3 ijk	1.8 de	1.0 cde	1.0 a	0.8 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 2. (Continued). Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean egg masses per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
37	1.3 hij	3.0 a	5.8 a	2.5 b-e	0.5 cde	0.3 a	0.0 a	0.0 a
38	0.3 j	0.8 a	2.5 a-j	2.0 de	1.0 b-e	0.5 a	0.3 a	0.0 a
39	6.0 b-f	1.8 a	1.8 d-k	0.8 de	0.3 de	0.0 a	0.0 a	0.0 a
40	6.0 b-g	2.0 a	4.3 a-g	2.8 b-e	0.8 cde	0.8 a	0.0 a	0.0 a
41	5.5 c-h	2.8 a	3.5 a-i	1.0 de	1.0 cde	0.0 a	0.3 a	0.0 a
42	4.8 c-i	1.8 a	1.5 g-k	1.8 de	0.3 de	1.0 a	0.0 a	0.0 a
LSD	1.03	0.74	0.71	0.84	0.44	0.43	0.27	0.00
S.D.	0.74	0.53	0.51	0.60	0.32	0.31	0.19	0.00
C.V.	39.24	29.33	26.97	35.49	24.41	25.34	17.75	0.00
F	4.131	0.945	2.203	1.572	2.004	1.220	0.948	0.000
Prob. F	0.0001	0.5697	0.0005	0.0305	0.0019	0.2029	0.5648	1.0000

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 4. Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean larvae per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
1	0.0 a	8.8 b	60.0 abc	72.3 ab	29.3 e-m	1.0 a	0.0 a	0.0 a
2	0.3 a	7.5 bc	51 bcd	59.5 a-d	29.0 b-k	4.8 a	0.0 a	0.0 a
3	5.5 a	19.5 a	68.8 ab	80.0 a	28.8 b-k	4.8 a	0.0 a	0.0 a
4	0.0 a	0.0 d	32.3 de	61.5 a-d	64.3 a	11.5 a	0.0 a	0.0 a
5	0.0 a	0.0 d	8.5 f-j	8.3 hij	22.3 e-m	9.5 a	0.0 a	0.0 a
6	0.0 a	0.0 d	0.8 j	7.5 hij	20.5 e-m	16.5 a	1.0 a	0.0 a
7	0.0 a	2.0 cd	11.5 fgh	31.0 e-h	26.0 b-k	9.0 a	0.0 a	0.0 a
8	3.3 a	1.3 cd	39.3 cd	48.8 b-e	28.3 b-k	15.0 a	0.0 a	0.0 a
9	0.0 a	2.0 cd	0.0 j	8.3 hij	6.8 lm	14.3 a	0.5 a	0.0 a
10	3.3 a	9.5 b	58.3 abc	64.3 abc	30.5 b-k	10.0 a	0.0 a	0.0 a
11	0.0 a	0.0 d	3.0 hij	16.0 g-j	41.0 a-f	18.5 a	1.0 a	0.0 a
12	0.0 a	0.0 d	0.0 j	18.0 f-j	39.5 a-g	14.0 a	3.5 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 4. (Continued). Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean larvae per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
13	0.0 a	0.0 d	5.0 hij	15.8 g-j	44.3 a-f	10.3 a	0.0 a	0.0 a
14	0.0 a	0.0 d	0.0 j	3.0 j	18.0 g-m	8.8 a	0.5 a	0.0 a
15	0.0 a	0.0 d	0.0 j	2.0 j	8.0 m	17.3 a	2.0 a	0.0 a
16	0.0 a	0.0 d	0.3 j	10.5 hij	32.8 b-k	15.0 a	0.3 a	0.3 a
17	0.0 a	0.0 d	0.8 j	15.5 g-j	25.8 c-l	7.0 a	0.0 a	0.0 a
18	0.0 a	0.0 d	1.3 j	42.0 c-f	53.3 ab	12.5 a	0.0 a	0.0 a
19	0.0 a	28.5 a	72.0 a	84.5 a	48.5 a-d	3.0 a	0.0 a	0.0 a
20	0.0 a	0.0 d	1.3 j	22.3 f-j	42.5 a-h	11.8 a	1.0 a	0.0 a
21	0.0 a	0.0 d	0.8 j	9.8 hij	42.3 a-g	15.3 a	1.3 a	0.0 a
22	0.0 a	0.0 d	0.0 j	5.0 ij	15.5 j-m	5.0 a	0.3 a	0.0 a
23	0.0 a	0.0 d	0.0 j	21.8 f-j	43.8 a-e	13.8 a	1.5 a	0.0 a
24	0.0 a	0.0 d	0.8 j	2.0 j	15.8 i-m	4.3 a	0.0 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 4. (Continued). Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean larvae per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
25	0.0 a	0.0 d	0.0 j	6.0 hij	24.3 c-m	4.0 a	0.0 a	0.0 a
26	0.0 a	0.0 d	0.8 j	5.8 hij	19.5 h-m	10.5 a	0.8 a	0.0 a
27	0.0 a	0.0 d	0.0 j	5.3 hij	37.5 a-j	9.5 a	4.8 a	0.0 a
28	0.0 a	0.0 d	0.0 j	9.0 hij	20.3 e-m	8.8 a	0.0 a	0.0 a
29	0.0 a	0.0 d	0.0 j	12.3 g-j	37.3 a-i	12.5 a	1.3 a	0.0 a
30	0.0 a	0.0 d	0.5 j	10.0 hij	28.0 b-k	19.8 a	0.0 a	0.0 a
31	0.0 a	0.0 d	6.8 g-j	14.8 g-j	24.3 c-k	21.0 a	0.0 a	0.0 a
32	0.0 a	0.0 d	4.0 hij	12.8 g-j	18.0 f-m	6.5 a	0.0 a	0.0 a
33	0.0 a	0.0 d	9.3 f-i	3.0 j	16.0 j-m	6.0 a	0.8 a	0.0 a
34	0.0 a	0.0 d	3.3 hij	30.8 e-i	47.0 a-d	11.3 a	0.8 a	0.0 a
35	0.0 a	0.0 d	0.0 j	13.8 g-j	50.8 abc	11.8 a	0.0 a	0.0 a
36	0.0 a	0.0 d	0.0 j	2.8 j	12.0 klm	4.0 a	2.8 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 4. (Continued). Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean larvae per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
37	0.0 a	0.0 d	6.0 f-j	16.8 f-j	27.8 b-k	6.0 a	0.3 a	0.0 a
38	0.0 a	0.0 d	1.0 ij	8.0 hij	12.3 klm	3.3 a	1.5 a	0.0 a
39	0.0 a	2.5 bcd	43.0 cd	49.0 b-e	51.3 abc	8.8 a	1.0 a	0.0 a
40	0.0 a	0.0 d	17.0 efg	18.5 f-j	18.3 f-m	8.0 a	1.0 a	0.0 a
41	0.0 a	1.5 cd	18.5 ef	9.0 hij	24.3 d-m	14.0 a	0.3 a	0.0 a
42	0.0 a	0.0 d	30.5 de	37.3 d-g	32.3 b-k	15.5 a	3.3 a	0.0 a
LSD	0.59	1.13	1.71	2.40	2.2	1.86	0.71	0.04
S.D.	0.42	0.80	1.22	1.72	1.57	1.33	0.51	0.03
C.V.	39.59	59.95	44.5	41.19	29.98	43.37	42.00	3.19
F	0.952	4.275	15.130	6.330	2.524	1.401	1.138	1.000
Prob. F	0.5592	0.0001	0.0001	0.0001	0.0001	0.0813	0.2897	0.4831

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 5. Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean larvae per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
1	0.0 a	0.0 a	6.0 bc	85.8 b	42.8 d-h	28.3 c-k	3.0 a	0.0 a
2	0.0 a	0.0 a	5.3 bc	74.5 bc	71.0 ab	28.3 d-k	5.8 a	0.5 a
3	0.0 a	0.0 a	15.5 a	123.8 a	79.5 ab	30.5 b-k	2.5 a	1.5 a
4	0.0 a	0.0 a	0.0 e	30.3 d	66.8 abc	40.0 a-f	6.0 a	0.0 a
5	0.0 a	0.0 a	0.3 e	0.0 j	9.5 l-p	21.5 g-k	7.0 a	0.5 a
6	0.0 a	0.0 a	0.0 e	2.3 g-j	11.3 j-p	16.5 h-k	2.8 a	3.8 a
7	0.0 a	0.0 a	0.0 e	9.0 e-h	38.8 d-g	29.5 b-k	4.0 a	1.0 a
8	0.0 a	0.0 a	4.0 cd	50.3 cd	53.8 bcd	30.8 a-j	7.0 a	0.0 a
9	0.0 a	0.0 a	0.0 e	0.0 j	10.8 k-p	20.5 e-k	7.3 a	0.5 a
10	0.0 a	0.0 a	6.5 bc	89.8 ab	82.8 ab	26.8 b-k	1.0 a	0.0 a
11	0.0 a	0.0 a	0.0 e	1.8 g-j	16.8 h-o	49.3 ab	6.5 a	0.0 a
12	0.0 a	0.0 a	0.0 e	12.3 ef	38.5 c-f	41.5 a-e	6.3 a	0.3 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 5. (Continued). Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean larvae per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
13	0.0 a	0.0 a	0.0 e	3.0 f-j	23.8 f-m	48.5 ab	10.0 a	0.3 a
14	0.0 a	0.0 a	0.0 e	0.3 ij	5.5 op	23.3 d-k	11.8 a	0.3 a
15	0.0 a	0.0 a	0.0 e	0.0 j	4.3 p	15.5 ijk	9.0 a	0.5 a
16	0.0 a	0.0 a	0.0 e	1.5 hij	25.3 f-l	32.3 a-j	3.3 a	0.0 a
17	0.0 a	0.0 a	0.0 e	0.5 ij	19.8 f-n	40.5 a-f	4.8 a	0.0 a
18	0.0 a	0.0 a	0.0 e	8.5 e-j	50.5 b-e	38.5 a-g	6.5 a	0.3 a
19	0.0 a	0.0 a	8.5 b	91 ab	91.8 a	27.5 b-k	1.8 a	0.8 a
20	0.0 a	0.0 a	0.0 e	4.3 f-j	31.5 d-i	44.0 a-e	9.5 a	0.0 a
21	0.0 a	0.0 a	0.0 e	3.8 f-j	23.0 f-m	28.8 b-k	5.8 a	1.3 a
22	0.0 a	0.0 a	0.3 e	0.3 ij	6.0 nop	16.0 jk	10.0 a	0.3 a
23	0.0 a	0.0 a	0.0 e	2.8 f-j	29.3 e-k	38.0 a-h	4.0 a	1.0 a
24	0.0 a	0.0 a	0.0 e	1.3 ij	4.5 op	20.0 g-k	5.3 a	0.5 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 5. (Continued). Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean larvae per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
25	0.0 a	0.0 a	0.3 e	0.3 ij	10.8 l-p	12.3 k	5.8 a	0.8 a
26	0.0 a	0.0 a	0.0 e	0.8 ij	9.5 m-p	26.8 b-k	2.8 a	0.5 a
27	0.0 a	0.0 a	0.0 e	0.0 j	11.8 j-p	28.5 b-k	5.8 a	1.8 a
28	0.0 a	0.0 a	0.0 e	0.0 j	11.0 k-p	16.3 ijk	6.3 a	0.0 a
29	0.0 a	0.0 a	0.0 e	0.0 j	26.5 e-k	44.3 a-d	5.8 a	0.5 a
30	0.0 a	0.0 a	0.0 e	1.0 ij	9.8 l-p	26.8 b-k	7.8 a	0.0 a
31	0.0 a	0.0 a	0.0 e	3.3 f-j	20.3 f-n	46.8 abc	12.3 a	0.3 a
32	0.0 a	0.0 a	0.0 e	1.3 ij	10.8 j-p	37.3 a-g	10.5 a	0.5 a
33	0.0 a	0.0 a	0.0 e	3.0 f-j	7.0 nop	16.3 ijk	5.5 a	0.0 a
34	0.0 a	0.0 a	0.0 e	5.3 e-j	29.0 d-j	53.5 a	14.0 a	0.5 a
35	0.0 a	0.0 a	0.0 e	2.3 f-j	20.8 f-n	46.3 a-d	12.8 a	0.5 a
36	0.0 a	0.0 a	0.0 e	0.0 j	11.3 k-p	29.0 b-k	5.8 a	0.8 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 5. (Continued). Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean adults per 10 plants							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
37	0.0 a	0.0 a	0.0 e	6.8 e-i	31.3 d-i	47.8 ab	6.3 a	0.8 a
38	0.0 a	0.0 a	0.0 e	0.8 ij	3.5 p	24.5 d-k	5.5 a	0.3 a
39	0.0 a	0.0 a	0.0 e	48.3 cd	83.0 ab	53.8 a	0.5 a	0.0 a
40	0.0 a	0.0 a	0.5 e	10.5 efg	15.0 i-p	19.8 f-k	5.8 a	0.5 a
41	0.0 a	0.0 a	0.3 e	18.0 e	18.5 g-o	35.5 a-i	5.3 a	1.5 a
42	0.0 a	0.0 a	1.3 de	40.3 d	33.5 d-i	21.5 e-k	6.8 a	0.3 a
LSD	0.00	0.00	0.73	1.60	2.00	1.98	1.64	0.50
S.D.	0.00	0.00	0.52	1.14	1.43	1.41	1.17	0.36
C.V.	0.00	0.00	41.51	36.76	29.45	25.89	48.13	30.47
F	0.000	0.000	5.376	25.125	8.758	2.307	0.938	1.118
Prob. F	1.0000	1.0000	0.0001	0.0001	0.0001	0.0002	0.5815	0.3147

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 6. Percent defoliation ratings from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean defoliation per plot							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
1	0.0 a	0.0 a	1.3 a	6.3 ab	27.5 ab	32.5 a	33.8 b-e	71.3 a-g
2	0.0 a	0.0 a	1.3 a	7.5 a	30.0 ab	37.5 a	53.8 ab	88.8 a
3	0.0 a	0.0 a	0.0 a	7.5 a	32.5 a	47.5 a	65.0 a	88.8 a
4	0.0 a	0.0 a	0.0 a	0.0 f	3.8 cde	7.5 c	36.3 bcd	75.0 a-e
5	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	3.8 gh	47.5 e-i
6	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	2.5 h	32.5 i
7	0.0 a	0.0 a	0.0 a	0.0 f	2.5 de	2.5 c	6.3 fgh	47.5 e-i
8	0.0 a	0.0 a	0.0 a	2.5 de	5.0 cde	11.3 c	27.5 c-f	73.8 a-f
9	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	1.3 h	50.0 d-i
10	0.0 a	0.0 a	0.0 a	3.8 cd	16.3 bcd	31.3 ab	55.0 ab	77.5 a-d
11	0.0 a	0.0 a	0.0 a	0.0 f	1.3 de	5.0 c	15.0 d-h	66.3 a-h
12	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	6.3 fgh	56.3 c-i

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 6. (Continued). Percent defoliation ratings from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean defoliation per plot							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
13	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	6.3 c	6.3 fgh	60.0 b-i
14	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	5.0 fgh	55.0 c-i
15	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	0.0 h	72.5 a-g
16	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	2.5 c	6.3 fgh	45.0 ghi
17	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	2.5 c	10.0 fgh	51.3 d-i
18	0.0 a	0.0 a	0.0 a	0.0 f	2.5 de	6.3 c	8.8 fgh	53.8 d-i
19	0.0 a	0.0 a	0.0 a	5.0 bc	18.8 abc	31.3 ab	50.0 abc	82.5 abc
20	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	2.5 c	8.8 fgh	70.0 a-h
21	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	1.3 c	3.8 gh	60.0 b-i
22	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	1.3 h	53.8 d-i
23	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	6.3 c	12.5 e-h	70.0 a-h
24	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	0.0 h	42.5 hi

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 6. (Continued). Percent defoliation ratings from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean defoliation per plot							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
25	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	1.3 h	46.3 f-i
26	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	1.3 h	63.8 a-h
27	0.0 a	0.0 a	0.0 a	0.0 f	1.3 de	0.0 c	5.0 fgh	52.5 d-i
28	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	7.5 fgh	73.8 a-f
29	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	3.8 c	26.3 d-g	62.5 a-h
30	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	11.3 e-h	63.8 a-h
31	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	6.3 fgh	57.5 c-i
32	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	3.8 gh	58.8 c-i
33	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	1.3 h	57.5 c-i
34	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	6.3 c	11.3 e-h	62.5 a-h
35	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	6.3 c	10.0 fgh	61.3 a-h
36	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	0.0 h	66.3 a-h

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 6. (Continued). Percent defoliation ratings from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean defoliation per plot							
	4 June (43 dap)	10 June (49 dap)	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
37	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	5.0 c	17.5 d-h	87.5 ab
38	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	0.0 c	0.0 h	53.8 d-i
39	0.0 a	0.0 a	0.0 a	2.5 de	8.8 cde	15.0 bc	52.5 ab	87.5 ab
40	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	1.3 c	1.3 h	52.5 d-i
41	0.0 a	0.0 a	0.0 a	0.0 f	0.0 e	1.3 c	6.3 fgh	51.3 d-i
42	0.0 a	0.0 a	0.0 a	1.3 ef	2.5 de	3.8 c	5.0 fgh	46.3 f-i
LSD	0.00	0.00	0.00	2.17	15.27	16.82	22.5	27.88
S.D.	0.00	0.00	0.00	1.55	10.91	12.01	16.07	19.91
C.V.	0.00	0.00	0.00	179.46	300.34	182.64	115.14	32.21
F	0.000	0.000	0.000	7.051	2.389	3.763	4.845	1.860
Prob. F	1.0000	1.0000	1.0000	0.0001	0.0001	0.0001	0.0001	0.0049

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 7. Potato leafhopper adults sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean adults per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
1	2.0 abc	3.0 c-h	1.0 ab	1.7 b-e	1.0 d-g	2.5 d-g
2	1.5 b-e	5.3 a-d	0.0 c	1.7 b-e	2.7 de	3.0 efg
3	1.8 a-e	1.5 e-i	0.7 abc	2.4 a-d	1.3 d-g	4.0 d-g
4	2.0 a-e	6.0 abc	0.8 abc	1.0 cde	2.7 def	8.5 b-e
5	3.3 ab	7.0 a	1.3 a	3.5 ab	5.8 ab	8.0 ab
6	1.8 a-e	6 abc	1.0 a	2.3 abc	7.0 a	8.0 a
7	2.0 abc	6.8 ab	1.0 ab	3.5 a	4.3 bc	9.0 a-d
8	3.3 a	5.0 a-e	0.5 abc	1.5 a-d	2.0 def	8.0 abc
9	0.0 g	1.3 f-i	0.0 c	0.5 cde	1.5 d-g	1.7 d-g
10	3.3 a	4.5 a-e	0.0 c	1.0 cde	3.5 def	6.0 d-g
11	0.0 g	0.3 hi	0.3 bc	0.0 e	0.8 d-g	1.5 efg
12	0.3 fg	1.8 e-i	0.0 c	0.3 de	0.0 g	0.0 g

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 7. (Continued). Potato leafhopper adults sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean adults per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
13	0.0 g	0.3 hi	0.0 c	0.0 e	1.0 d-g	0.7 fg
14	0.5 efg	1.8 e-i	0.0 c	0.3 de	0.0 g	0.0 g
15	1.3 c-f	0.0 i	0.5 abc	0.0 e	0.8 d-g	0.0 g
16	0.3 fg	2.0 d-i	0.3 bc	0.8 cde	2.3 cd	3.0 c-g
17	1.0 c-g	0.8 f-i	0.5 abc	1.5 a-e	0.8 efg	1.3 d-g
18	0.5 efg	2.0 d-i	0.0 c	0.3 de	0.8 d-g	1.0 d-g
19	2.0 a-d	3.3 b-f	0.0 c	1.5 cde	1.3 d-g	1.0 fg
20	0.3 fg	0.3 hi	0.0 c	0.3 de	0.5 efg	3.5 d-g
21	0.5 efg	1.5 e-i	0.3 bc	0.3 de	0.5 efg	0.7 fg
22	0.0 g	1.3 f-i	0.3 bc	0.0 e	0.5 efg	1.3 d-g
23	0.3 fg	0.5 ghi	0.0 c	0.5 cde	1.3 d-g	0.3 g
24	0.0 g	0.8 ghi	0.0 c	1.0 cde	1.0 d-g	1.3 d-g

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 7. (Continued). Potato leafhopper adults sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean adults per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
25	0.3 fg	0.0 i	0.5 abc	0.3 de	0.0 g	1.7 d-g
26	0.3 fg	0.0 i	0.0 c	0.5 cde	1.0 d-g	1.0 fg
27	0.8 d-g	0.0 i	0.0 c	0.5 cde	0.0 g	2.3 c-g
28	0.0 g	4.3 c-g	0.0 c	0.3 de	0.0 g	0.0 g
29	0.3 fg	0.0 i	0.0 c	0.5 cde	0.3 fg	1.3 d-g
30	0.0 g	0.0 i	0.0 c	0.5 cde	0.5 efg	1.3 d-g
31	0.5 efg	0.0 i	0.0 c	1.0 cde	0.8 d-g	1.3 d-g
32	0.3 fg	0.0 i	0.0 c	0.5 cde	0.5 efg	0.0 g
33	0.3 fg	0.3 hi	0.0 c	0.3 de	0.3 fg	0.0 g
34	0.5 efg	1.0 f-i	0.3 bc	0.8 cde	0.5 efg	4.3 b-f
35	0.5 efg	1.0 f-i	0.0 c	0.5 cde	1.8 def	2.3 d-g
36	0.0 g	0.5 ghi	0.3 bc	0.3 de	0.3 fg	1.5 d-g

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 7. (Continued). Potato leafhopper adults sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean adults per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
37	0.5 efg	1.0 f-i	0.0 c	0.5 cde	1.3 d-g	4.0 d-g
38	0.0 g	0.3 hi	0.0 c	0.5 cde	0.5 efg	3.0 b-g
39	0.5 efg	1.0 f-i	0.3 bc	0.5 cde	0.5 efg	2.0 fg
40	0.0 g	0.5 ghi	0.3 bc	0.0 e	0.0 g	2.3 d-g
41	0.3 fg	0.5 ghi	0.0 c	0.8 cde	0.8 d-g	6.0 a-d
42	0.3 fg	0.3 hi	0.0 c	0.3 de	0.3 fg	1.3 d-g
LSD	0.44	0.77	0.27	0.54	0.54	0.81
S.D.	0.32	0.55	0.19	0.38	0.38	0.58
C.V.	24.97	36.97	17.94	30.18	27.91	39.52
F	3.570	3.595	1.562	1.534	4.073	2.160
Prob. (F)	0.0001	0.0001	0.0324	0.0383	0.0001	0.0006

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 8. Potato leafhopper nymphs sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean nymphs per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
1	0.0 a	0.5 a	1.8 a-e	10.8 bc	4.3 b	3.0 c-f
2	0.0 a	0.3 a	0.4 de	6.1 cd	6.0 bc	1.0 ef
3	0.0 a	0.0 a	1.4 a-e	5.8 cde	1.7 bcd	1.0 ef
4	0.0 a	0.0 a	2.8 a	10.0 b	9.7 a	5.5 c
5	0.0 a	0.0 a	0.3 de	10.3 ab	6.0 a	6.7 b
6	0.0 a	0.5 a	1.8 abc	9.8 b	6.5 a	7.3 a
7	0.0 a	0.3 a	1.3 a-e	10.5 ab	8.3 a	4.5 cd
8	0.0 a	0.0 a	1.5 a-d	6.5 bc	1.3 bcd	3.3 cd
9	0.0 a	0.0 a	0.0 e	0.0 f	0.0 d	1.7 c-f
10	0.0 a	0.8 a	1.5 a-d	7.0 bc	0.0 d	0.0 f
11	0.0 a	0.0 a	0.0 e	0.0 f	0.0 d	1.0 def
12	0.0 a	0.0 a	0.0 e	0.3 f	0.0 d	0.3 ef

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 8. (Continued). Potato leafhopper nymphs sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean nymphs per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
13	0.0 a	0.0 a	0.5 cde	1.0 ef	0.0 d	0.0 f
14	0.0 a	0.0 a	0.0 e	0.3 f	0.0 d	0.0 f
15	0.0 a	0.0 a	0.0 e	0.0 f	0.0 d	0.0 f
16	0.0 a	0.0 a	0.0 e	0.0 f	0.3 d	0.0 f
17	0.0 a	0.0 a	0.0 e	0.0 f	0.3 d	0.3 ef
18	0.0 a	0.0 a	1.0 b-e	0.0 f	0.0 d	0.7 def
19	0.0 a	0.8 a	3.8 ab	16.0 a	1.3 bcd	3.5 cde
20	0.0 a	0.0 a	0.0 e	0.0 f	0.0 d	0.0 f
21	0.0 a	0.0 a	0.0 e	0.3 f	0.0 d	0.0 f
22	0.0 a	0.0 a	0.0 e	0.0 f	0.0 d	0.0 f
23	0.0 a	0.0 a	0.3 de	1.0 ef	0.0 d	0.0 f
24	0.0 a	0.0 a	0.8 cde	0.0 f	0.0 d	0.0 f

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 8. (Continued). Potato leafhopper nymphs sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean nymphs per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
25	0.0 a	0.0 a	0.3 de	0.0 f	0.0 d	0.0 f
26	0.0 a	0.0 a	0.0 e	0.3 f	0.3 d	0.0 f
27	0.0 a	0.0 a	0.0 e	0.3 f	0.0 d	0.0 f
28	0.0 a	0.0 a	0.0 e	0.0 f	0.0 d	0.0 f
29	0.0 a	0.0 a	0.0 e	2 def	0.0 d	0.7 def
30	0.0 a	0.0 a	0.0 e	0.0 f	0.8 cd	0.0 f
31	0.0 a	0.0 a	0.3 de	0.5 f	0.0 d	0.0 f
32	0.0 a	0.0 a	0.0 e	0.0 f	0.0 d	0.0 f
33	0.0 a	0.0 a	0.3 de	0.8 f	0.0 d	0.0 f
34	0.0 a	0.0 a	0.3 de	0.8 f	0.0 d	0.0 f
35	0.0 a	0.0 a	0.0 e	0.8 f	0.0 d	0.0 f
36	0.0 a	0.0 a	0.0 e	0.0 f	0.0 d	1.5 def

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 8. (Continued). Potato leafhopper nymphs sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean nymphs per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
37	0.0 a	0.3 a	0.0 e	0.3 f	0.0 d	0.0 f
38	0.0 a	0.0 a	0.3 de	0.0 f	0.3 d	0.0 f
39	0.0 a	0.0 a	0.3 de	0.3 f	5.3 b	0.0 f
40	0.0 a	0.0 a	0.0 e	0.0 f	0.0 d	0.0 f
41	0.0 a	0.0 a	0.0 e	0.3 f	0.0 d	0.0 f
42	0.0 a	0.0 a	0.0 e	1.5 def	0.0 d	0.5 def
LSD	0.00	0.19	0.49	0.78	0.67	0.50
S.D.	0.00	0.14	0.35	0.55	0.48	0.36
C.V.	0.00	13.21	30.35	35.91	37.35	30.25
F	0.000	1.296	1.689	9.206	5.253	1.356
Prob. (F)	1.0000	0.1404	0.0148	0.0001	0.0001	0.0001

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 9. Hopperburn ratings from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean hopperburn per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
1	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
2	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
4	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
5	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
6	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
7	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
8	0.0 a	0.0 a	0.0 a	0.3 a	0.0 a	0.0 a
9	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
10	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
11	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
12	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 9. (Continued). Hopperburn ratings from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean hopperburn per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
13	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
14	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
15	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
16	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
17	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
18	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
19	0.0 a	0.0 a	0.0 a	0.3 a	0.3 a	0.5 a
20	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
21	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
22	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
23	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
24	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 9. (Continued). Hopperburn ratings from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean hopperburn per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
25	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
26	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
27	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
28	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
29	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
30	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
31	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
32	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
33	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
34	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
35	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
36	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 9. (Continued). Hopperburn ratings from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean hopperburn per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
37	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
38	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
39	0.0 a	0.0 a	0.0 a	0.0 a	0.3 a	0.0 a
40	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
41	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
42	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
LSD	0.00	0.00	0.00	0.16	0.19	0.24
S.D.	0.00	0.00	0.00	0.11	0.14	0.17
C.V.	0.00	0.00	0.00	908.19	619.1	662.88
F	0.000	0.000	0.000	0.943	1.415	1.32
Prob. (F)	1.0000	1.0000	1.0000	0.5744	0.0783	0.157

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 9. Aphids sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean aphids per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
1	0.0 a	5.3 a	1.5 a	2.3 bcd	0.0 a	0.0 a
2	0.0 a	1.0 b-e	1.1 a	0.3 cd	0.0 a	0.0 a
3	0.8 a	1.5 bcd	1.8 a	0.6 bcd	0.0 a	0.0 a
4	0.0 a	2.8 ab	2.3 a	0.3 cd	0.0 a	0.0 a
5	0.0 a	0.0 e	1.5 a	0.0 d	0.0 a	0.0 a
6	0.3 a	0.8 b-e	1.8 a	0.0 d	0.3 a	0.3 a
7	0.0 a	1.3 b-e	0.3 a	1.5 bc	0.0 a	0.0 a
8	0.0 a	2.8 ab	1.3 a	3.5 a	0.0 a	0.0 a
9	0.0 a	0.0 e	0.0 a	0.0 d	0.0 a	0.0 a
10	0.8 a	1.5 b-e	2.8 a	0.0 d	0.0 a	0.0 a
11	0.0 a	0.0 e	0.8 a	0.0 d	0.0 a	0.0 a
12	0.0 a	0.3 de	0.0 a	0.3 cd	0.0 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 9. (Continued). Aphids sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean aphids per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
13	0.0 a	0.0 e	0.8 a	1.0 bcd	0.0 a	0.0 a
14	0.0 a	0.0 e	0.0 a	0.0 d	0.0 a	0.0 a
15	0.0 a	0.0 e	0.0 a	0.3 cd	0.0 a	0.0 a
16	0.0 a	0.0 e	0.5 a	0.0 d	0.0 a	0.0 a
17	0.0 a	0.0 e	0.8 a	0.0 d	0.0 a	0.0 a
18	0.3 a	0.0 e	0.8 a	0.0 d	0.0 a	0.0 a
19	0.0 a	2.0 abc	1.3 a	0.3 cd	0.3 a	0.0 a
20	0.0 a	0.0 e	0.3 a	0.0 d	0.0 a	0.0 a
21	0.0 a	0.0 e	0.3 a	0.0 d	0.0 a	0.0 a
22	0.0 a	0.0 e	0.0 a	0.0 d	0.0 a	0.0 a
23	0.0 a	0.0 e	0.3 a	2.3 ab	0.0 a	0.0 a
24	0.0 a	0.0 e	0.3 a	0.0 d	0.0 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 9. (Continued). Aphids sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean aphids per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
25	0.0 a	0.0 e	0.5 a	0.0 d	0.0 a	0.0 a
26	0.0 a	0.3 de	0.3 a	0.0 d	0.0 a	0.0 a
27	0.0 a	0.3 de	0.0 a	0.0 d	0.0 a	0.0 a
28	0.0 a	0.0 e	0.0 a	0.0 d	0.0 a	0.0 a
29	0.0 a	0.0 e	0.0 a	0.0 d	0.0 a	0.0 a
30	0.0 a	0.0 e	0.0 a	0.0 d	0.0 a	0.0 a
31	0.0 a	0.0 e	0.0 a	1.8 bcd	0.0 a	0.0 a
32	0.0 a	0.0 e	2.3 a	0.0 d	0.0 a	0.0 a
33	0.0 a	0.0 e	0.0 a	0.3 cd	0.0 a	0.0 a
34	0.0 a	1.0 b-e	0.3 a	0.5 bcd	0.0 a	0.0 a
35	0.0 a	1.3 b-e	0.0 a	0.0 d	0.0 a	0.0 a
36	0.0 a	0.0 e	0.0 a	0.8 bcd	0.0 a	0.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 9. (Continued). Aphids sampled from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Mean aphids per plot					
	17 June (56 dap)	24 June (63 dap)	1 July (70 dap)	8 July (77 dap)	16 July (86 dap)	22 July (92 dap)
37	0.0 a	0.0 e	0.8 a	0.0 d	0.0 a	0.0 a
38	0.0 a	0.3 de	0.0 a	0.0 d	0.0 a	0.0 a
39	0.0 a	0.5 cde	0.5 a	0.3 cd	0.0 a	0.0 a
40	0.0 a	0.3 de	0.0 a	0.0 d	0.0 a	0.0 a
41	0.0 a	0.0 e	0.5 a	0.0 d	0.0 a	0.0 a
42	0.0 a	0.0 e	1.3 a	0.0 d	0.0 a	0.0 a
LSD	0.15	0.52	0.54	0.50	0.06	0.04
S.D.	0.10	0.37	0.39	0.30	0.05	0.03
C.V.	10.31	31.75	32.20	30.00	4.52	3.19
F	1.356	2.285	1.249	1.700	0.968	1.000
Prob. (F)	0.1036	0.0003	0.1766	0.0000	0.5340	0.4831

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
✳Plots are dead.

Table 10. Plant stands at emergence of Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate	Placement	Plant stands (per 20')
1-Untreated	---	---	19.8 a
2-Tops MZ 4FS-CTL	0.04 fl oz/cwt	Seed	20.0 a
3-Moncoat 7.5DS-CTL	1.0 lb./cwt	Seed	20.0 a
4-Cyazapyr 200SC Maxim 4FS	0.066 lb. ai/a 0.08 fl oz/cwt	In furrow Seed	19.3 a
5-Cyazapyr 200SC Maxim 4FS	0.134 lb. ai/a 0.8 fl oz/cwt	In furrow Seed	19.8 a
6-Cyazapyr 200SC Maxim 4FS	0.176 lb. ai/a 0.08 fl oz/cwt	In furrow Seed	19.3 a
7-Cyazapyr 600FS Maxim 4FS	3.2 g/cwt 0.08 fl oz/cwt	Seed Seed	20.0 a
8-Regent 4SC Maxim 4FS	3.2 fl oz/a 0.08 fl oz/cwt	In furrow Seed	19.5 a
9-Regent 4SC Admire Pro 4.6SC Maxim 4FS	3.2 fl oz/a 8.7 fl oz/a 0.08 fl oz/cwt	In furrow In furrow Seed	19.8 a
10-Regent 4SC Tops MZ 8.5DS	3.2 fl oz/a 12 oz/cwt	In furrow Seed	19.8 a
11- Belay 2.13SC Maxim 4FS	7.2 fl oz/a 0.08 fl oz/cwt	In furrow Seed	20.0 a
12- Belay 2.13SC Maxim 4FS	8.4 fl oz/a 0.08 fl oz/cwt	In furrow Seed	20.0 a
13- Belay 2.13SC Maxim 4FS	9.0 fl oz/a 0.08 fl oz/cwt	In furrow Seed	20.0 a
14- Belay 2.13SC Maxim 4FS	9.6 fl oz/a 0.08 fl oz/cwt	In furrow Seed	19.8 a
15- Belay 2.13SC Maxim 4FS	10.8 fl oz/a 0.08 fl oz/cwt	In furrow Seed	20.0 a
16-Admire Pro 4.6SC TopsMZ 8.5DS	8.7 fl oz/a 12 oz/cwt	In furrow Seed	19.5 a
17- Admire Pro 4.6SC TopsMZ 8.5DS	7.0 fl oz/a 12 oz/cwt	In furrow Seed	20.0 a

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 10. (Continued). Plant stands at emergence of Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate	Placement	Plant stands (per 20')
18- Admire 2SC	0.64 fl oz/cwt	Seed	20 a
TopsMZ 8.5DS	12 oz/cwt	Seed	
19-Untreated	---	---	19.8 a
20-Platinum 2SL	6.0 fl oz/a	In furrow	18.8 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
21-Platinum 2SL	6.5 fl oz/a	In furrow	19.5 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
22-Platinum 2SL	8 fl oz/a	In furrow	19.8 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
23-Cruiser 5FS	0.16 fl oz/cwt	Seed	19.8 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
24- Belay 2.13SC	0.6 fl oz/cwt	Seed	19.5 a
25- Belay 2.13SC	0.6 fl oz/cwt	Seed	19.8 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
26- Belay 2.13SC	0.6 fl oz/cwt	Seed	19.8 a
TopsMZ 8.5DS	12 oz/cwt	Seed	
27- Belay 2.13SC	0.6 fl oz/cwt	Seed	19.5 a
Mancozeb 6DS	16 oz/cwt	Seed	
28- Belay 2.13SC	0.6 fl oz/cwt	Seed	19.8 a
MaximMZ 6.2SS	8 oz/cwt	Seed	
29- Belay 2.13SC	0.4 fl oz/cwt	Seed	19.3 a
V10243 40DP	0.23 fl oz/cwt	Seed	
30- Belay 2.13SC	0.6 fl oz/cwt	Seed	20.0 a
V10243 40DP	0.23 fl oz/cwt	Seed	
31-Belay 16WG	12.0 oz/a	In furrow	19.3 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
32-Belay 16WG	8 fl oz/a	Row mark	
Belay 16WG	10 fl oz/a	In furrow	19.5 a
Maxim 4FS	0.08 fl oz/cwt	Seed	

(continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Table 10. (Continued). Plant stands at emergence of Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate	Placement	Plant stands (per 20')
33-Belay 16WG	8 fl oz/a	Blind hilling	
Belay 16WG	10 fl oz/a	2nd hilling	20.0 a
NIS	0.25% v/v	Seed	
Maxim 4FS	0.08 fl oz/cwt	Seed	
34-TopsMZ Gaucho 1.25DS	12.0 oz/cwt	Seed	20.0 a
35-TopsMZ Gaucho 1.25DS	16.0 oz/cwt	Seed	20.0 a
36-Belay 16WG	16.0 oz/a	In furrow	20.0 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
37-Poncho 5L	0.16 fl oz/cwt	Seed	20.0 a
TopsMZ 8.5DS	12.0 oz/cwt	Seed	
38-Poncho 5L	0.32 fl oz/cwt	Seed	19.8 a
TopsMZ 8.5DS	12.0 oz/cwt	Seed	
39-Venom 70SG	7.0 oz/a	In furrow	19.3 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
40-Platinum 2SC	8.0 fl oz/a	2nd hilling	20.0 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
41-Admire Pro 4.6SC	8.7 fl oz/a	2nd hilling	10.9 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
42-Belay 2.13SC	9.6 fl oz/a	2nd hilling	
NIS	0.25% v/v	2nd hilling	19.3 a
Maxim 4FS	0.08 fl oz/cwt	Seed	
LSD			0.85
S.D.			0.61
C.V.			3.09
F			1.058
Prob. (*F*)			0.3953

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).

Part 2. Insect Control with Foliar Insecticides.

A. Colorado Potato Beetle Control with Foliar Insecticides – Arlington 2008.

Colorado potato beetles are considered a key insect pest of potatoes in Wisconsin. Colorado potato beetles overwinter in and around potato fields, typically emerging during late May and early June depending on seasonal temperatures. Colorado potato beetles have a history of rapidly developing resistance to insecticides and they can be difficult to control. Integrated pest management practices for Colorado potato beetles target the larval stages and more specifically the small (1st and 2nd instar) larvae. First generation larval numbers peak in Wisconsin during mid to late June.

In a study conducted at the Entomology Research Farm, Arlington, Wisconsin, experimental and registered foliar insecticides were evaluated for efficacy on all life stages of Colorado potato beetle.

Superior variety potatoes were planted on 29 April 2008 into two 30' row plots, replicated four times in a randomized complete block design. All plots were separated by 15' of cultivated alleyway and replicates were 15' apart. Spartan (sulfentrazone) at 4 ounces product per acre (oz. pr./a) and Dual II Magnum (metolachlor) at 1.5 pints product per acre (pt. pr./a) was applied post hilling on 10 May for weed control. Hand weeding provided additional weed control.

Orthene 97 (acephate) at the rate of 1 pound product per acre (lb. pr./a) was applied on 28 June for potato leafhopper adult control.

Thirteen registered and six experimental insecticides were evaluated at the following rates:

Registered:

- Brigade 2EC (0.075 and 0.096 lb. a.i./a)
- Coragen 1.67SC (0.046, and 0.066 lb. a.i./a) with MSO at 0.25% v/v
- Belay 2.13SC (0.03, 0.0466 lb. a.i./a)
- Assail 30WG (0.075 lb. a.i./a)
- Actara 25WG (0.047 lb. a.i./a)
- Provado 1.67SC (0.49 lb. a.i./a)
- Belay 50WG (0.047 lb. a.i./a)
- Leverage 2.7SE (0.079 lb. a.i./a)
- Endigo 2.06SC (0.73 lb. a.i./a)
- Asana 0.66E (0.05 lb. a.i./a) with PBO at 0.26 lb. a.i./a
- Rimon 0.83EC (0.0584, and 0.078 lb. a.i./a)
- Agrimek 0.15EC (0.0094 and 0.014 lb. a.i./a)
- Vydate L (0.5 lb. a.i./a)
- Spintor 2SC (0.07 and 0.094 lb. a.i./a)
- Radiant 1SC (0.047 and 0.0625 lb. a.i./a)
- Thiodan 3EC (0.332 lb. a.i./a)
- Imidan 70WP (0.93 lb. a.i./a)
- Mustang Max 0.8EC (0.0294 lb. a.i./a)
- Venom 70SG (0.0437 and 0.066 lb. a.i./a)
- Novodor (2.75 and 2.0 lb./a)

Experimental:

Cyazapyr 10OD (0.088 and 0.134 lb. a.i./a)
Alverde 2SC (0.07 and 0.094 lb. a.i./a) with MSO at 0.25% v/v
Volian Flexi 40WG (0.1 lb. a.i./a)
Voliam Xpress 2ZC (0.081, 0.114, and 0.145 lb. a.i./a) with NIS at 0.25% v/v

All materials were applied with a CO_2 backpack sprayer operating at 30 psi, delivering 25 gpa through four flat fan nozzles (8004VS XR) spaced at 18".

Insecticides were applied on 23 June 2008 for first generation Colorado potato beetle (CPB) larval efficacy. First generation CPB efficacy was evaluated at 3, 7, 9, 16 and 22 days after the first insecticide application (23 June). CPB populations were monitored with plant counts. All life stages of the CPB (adults, eggs, small and large larvae) were counted on ten randomly chosen plants per plot.

Plant foliage was rated for defoliation on each survey date from 25 June through 15 July. The study was not harvested for yield due to the low insect pressure.

Table 1. Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean adults per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Brigade 2EC	0.075	0.3 cd	0.0 a	0.0 b	1.3 a	3.0 g-l
Brigade 2EC	0.096	0.0 d	0.0 a	0.0 b	0.0 a	2.3 f-l
Cyazapyr 10OD	0.044	0.3 cd	0.5 a	0.0 b	0.8 a	0.3 kl
Cyazapyr 10OD	0.088	0.3 cd	0.0 a	0.0 b	1.0 a	1.5 i-l
Cyazapyr 10OD	0.134	0.0 d	0.3 a	0.8 b	0.5 a	0.5 kl
Cyazapyr 10OD[2]	0.088	0.3 cd	0.0 a	0.0 b	0.5 a	0.0 l
Cyazapyr 10SE	0.088	0.3 cd	0.3 a	0.0 b	1.0 a	1.0 kl
Coragen 2SC[2]	0.0456	0.5 bcd	0.0 a	0.0 b	0.3 a	0.5 kl
Coragen 2SC[2]	0.066	0.5 a-d	0.3 a	0.0 b	0.3 a	1.0 jkl
Alverde 2SC[2]	0.07	1.0 abc	0.0 a	0.0 b	2.0 a	1.3 i-l
Alverde 2SC[2]	0.094	0.0 d	0.0 a	0.3 b	0.0 a	1.5 i-l
Belay 2.13SC	0.03	0.0 d	0.8 a	0.0 b	0.5 a	0.5 kl

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 1. (Continued). Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean adults per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Belay 2.13SC	0.047	0.3 cd	0.0 a	0.3 b	1.0 a	1.3 jkl
Untreated	---	0.8 a-d	0.0 a	0.0 b	0.0 a	7.0 b-e
Assail 30WG	0.075	0.3 cd	0.0 a	0.0 b	0.3 a	0.0 l
Actara 50WG	0.047	0.0 d	0.0 a	0.0 b	0.0 a	0.8 kl
Provado 1.67SC	0.049	0.0 d	0.0 a	0.0 b	0.0 a	0.3 kl
Belay 50WG	0.047	0.0 d	0.0 a	0.0 b	0.0 a	0.8 kl
Belay 50WG Warrior 1CS	0.047 0.03	0.3 cd	0.0 a	0.0 b	0.3 a	0.5 kl
Belay 2.13SC	0.047	0.0 d	0.3 a	0.0 b	0.0 a	0.8 kl
Belay 2.13SC Warrior 1CS	0.047 0.03	0.0 d	0.3 a	0.0 b	0.5 a	1.8 h-l
Leverage 2.7SC	0.079	0.3 cd	0.0 a	0.0 b	0.0 a	2.0 f-l
Endigo 2SC	0.073	0.0 d	0.0 a	0.0 b	0.0 a	0.5 kl
Untreated	---	1.0 abc	0.0 a	0.5 b	0.3 a	10.8 ab

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 1. (Continued). Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean adults per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Asana XL[3]	0.05	0.5 bcd	0.0 a	0.3 b	0.0 a	2.5 f-l
Rimon 0.83EC	0.0584	1.3 abc	0.3 a	0.0 b	0.5 a	2.3 f-l
Rimon 0.83EC	0.078	0.3 cd	0.3 a	0.5 b	1.3 a	2.3 e-l
Agrimek 0.15EC	0.0094	0.8 a-d	0.0 a	0.3 b	0.5 a	1.0 kl
Agrimek 0.15EC	0.014	0.0 d	0.0 a	0.0 b	1.0 a	1.5 i-l
Vydate L 1EC	0.5	0.3 cd	0.0 a	0.5 b	0.8 a	2.0 h-l
Spintor 2SC	0.07	0.5 a-d	0.5 a	0.0 b	0.0 a	6.0 b-g
Spintor 2SC	0.094	0.3 cd	0.0 a	0.8 b	0.0 a	5.0 c-i
Untreated	---	0.3 cd	0.0 a	0.3 b	0.0 a	12.8 a
Radiant 1SC	0.047	1.0 abc	0.0 a	0.3 b	0.0 a	2.8 e-l
Radiant 1SC	0.0625	1.0 abc	0.0 a	0.3 b	0.5 a	2.8 e-l
Thiodan 1EC	0.332	0.0 d	0.0 a	0.0 b	0.3 a	1.8 h-l

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05). All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 1. (Continued). Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean adults per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Imidan 70WP	0.93	0.3 cd	0.0 a	0.3 b	0.0 a	5.8 b-f
Voliam Flexi 40WG[1]	0.1	0.0 d	0.0 a	0.3 b	0.8 a	3.0 d-k
Voliam Xpress 2SC[1]	0.081	0.5 a-d	0.3 a	0.3 b	0.0 a	2.8 e-l
Voliam Xpress 2SC[1]	0.114	0.0 d	0.0 a	0.0 b	1.0 a	1.3 kl
Voliam Xpress 2SC[1]	0.145	0.0 d	0.0 a	0.0 b	0.0 a	0.5 kl
Endigo 2SC	0.057	1.3 ab	0.3 a	0.3 b	0.8 a	1.5 i-l
Mustang Max 0.8EC	0.0294	1.0 abc	0.3 a	0.0 b	1.3 a	2.0 f-l
Venom 70SG	0.0437	0.3 cd	0.5 a	3.3 a	1.0 a	8.3 abc
Venom 70SG	0.0656	1.5 a	0.5 a	2.3 a	1.5 a	4.3 c-j
Novodor	2.75 lb./a	0.8 a-d	0.0 a	0.3 b	0.3 a	5.3 b-h
Novodor	2.0 lb./a	0.5 a-d	0.0 a	0.8 b	0.3 a	7.3 bcd
LSD		0.34	0.20	0.36	0.42	0.86
S.D.		0.24	0.14	0.26	0.30	0.61
C.V.		21.00	13.65	23.45	25.65	35.52
F		1.441	1.008	1.605	1.172	3.883
Prob. (*F*)		0.0466	0.4712	0.0147	0.2296	0.0001

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 2. Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Brigade 2EC	0.075	2.0 a	0.3 a	0.5 a	0.3 a	0.0 a
Brigade 2EC	0.096	2.8 a	0.3 a	0.0 a	0.5 a	0.8 a
Cyazapyr 10OD	0.044	2.0 a	0.3 a	0.0 a	0.0 a	0.0 a
Cyazapyr 10OD	0.088	2.3 a	0.0 a	0.3 a	0.3 a	0.0 a
Cyazapyr 10OD	0.134	1.5 a	0.3 a	0.0 a	0.5 a	0.0 a
Cyazapyr 10OD[2]	0.088	2.5 a	0.0 a	0.0 a	0.3 a	0.3 a
Cyazapyr 10SE	0.088	2.8 a	0.0 a	0.0 a	0.0 a	0.3 a
Coragen 2SC[2]	0.0456	3.3 a	0.0 a	0.0 a	0.3 a	0.3 a
Coragen 2SC[2]	0.066	2.3 a	0.0 a	0.0 a	0.0 a	0.3 a
Alverde 2SC[2]	0.07	1.5 a	0.0 a	0.0 a	0.0 a	0.3 a
Alverde 2SC[2]	0.094	3.5 a	0.5 a	0.0 a	0.5 a	0.0 a
Belay 2.13SC	0.03	2.0 a	0.5 a	0.0 a	0.5 a	0.0 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 2. (Continued). Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Belay 2.13SC	0.047	3.0 a	0.0 a	0.0 a	0.0 a	1.3 a
Untreated	---	2.3 a	0.0 a	0.0 a	0.0 a	0.3 a
Assail 30WG	0.075	2.8 a	0.0 a	0.3 a	0.0 a	0.0 a
Actara 50WG	0.047	2.8 a	0.0 a	0.0 a	0.0 a	0.0 a
Provado 1.67SC	0.049	2.0 a	0.0 a	0.0 a	0.3 a	0.5 a
Belay 50WG	0.047	2.5 a	0.0 a	0.0 a	0.3 a	0.0 a
Belay 50WG Warrior 1CS	0.047 0.03	1.3 a	0.0 a	0.3 a	0.0 a	0.3 a
Belay 2.13SC	0.047	1.8 a	0.0 a	0.0 a	0.0 a	0.5 a
Belay 2.13SC Warrior 1CS	0.047 0.03	1.5 a	0.5 a	0.3 a	0.5 a	0.3 a
Leverage 2.7SC	0.079	2.3 a	0.0 a	0.0 a	0.0 a	0.0 a
Endigo 2SC	0.073	2.0 a	0.0 a	0.3 a	0.0 a	0.3 a
Untreated	---	4.5 a	0.0 a	0.3 a	0.3 a	0.0 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05). All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 2. (Continued). Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Asana XL[3]	0.05	2.0 a	0.0 a	0.3 a	0.3 a	0.0 a
Rimon 0.83EC	0.0584	1.3 a	0.3 a	0.5 a	0.3 a	0.3 a
Rimon 0.83EC	0.078	1.0 a	0.3 a	0.5 a	0.3 a	0.3 a
Agrimek 0.15EC	0.0094	1.5 a	0.0 a	0.5 a	0.8 a	0.0 a
Agrimek 0.15EC	0.014	0.5 a	0.5 a	0.3 a	0.0 a	0.3 a
Vydate L 1EC	0.5	6.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Spintor 2SC	0.07	1.3 a	0.8 a	0.0 a	0.0 a	0.3 a
Spintor 2SC	0.094	1.0 a	0.3 a	0.3 a	0.0 a	0.0 a
Untreated	---	0.8 a	0.0 a	0.0 a	0.3 a	0.0 a
Radiant 1SC	0.047	0.5 a	0.0 a	0.5 a	0.5 a	0.3 a
Radiant 1SC	0.0625	1.8 a	0.0 a	0.0 a	0.3 a	0.0 a
Thiodan 1EC	0.332	1.5 a	0.3 a	0.0 a	0.0 a	0.3 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 2. (Continued). Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Imidan 70WP	0.93	1.5 a	0.3 a	0.3 a	0.0 a	0.0 a
Voliam Flexi 40WG[1]	0.1	2.8 a	0.0 a	0.0 a	0.0 a	0.0 a
Voliam Xpress 2SC[1]	0.081	1.3 a	0.8 a	0.0 a	0.3 a	0.0 a
Voliam Xpress 2SC[1]	0.114	5.5 a	0.0 a	0.8 a	0.3 a	0.0 a
Voliam Xpress 2SC[1]	0.145	2.8 a	0.0 a	0.0 a	0.0 a	0.3 a
Endigo 2SC	0.057	3.3 a	0.0 a	0.5 a	0.3 a	0.0 a
Mustang Max 0.8EC	0.0294	2.8 a	0.5 a	0.3 a	0.3 a	0.0 a
Venom 70SG	0.0437	0.5 a	0.3 a	0.8 a	0.5 a	0.0 a
Venom 70SG	0.0656	3.3 a	0.3 a	0.3 a	1.0 a	0.0 a
Novodor	2.75 lb./a	2.3 a	0.3 a	0.3 a	0.3 a	0.3 a
Novodor	2.0 lb./a	4.8 a	0.0 a	0.3 a	0.3 a	0.0 a
LSD		0.73	0.20	0.24	0.25	0.25
S.D.		0.52	0.15	0.17	0.18	0.18
C.V.		30.66	13.75	15.95	16.56	16.79
F		1.179	1.319	0.965	0.959	0.926
Prob. (*F*)		0.2220	0.1018	0.5461	0.5564	0.6158

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 3. Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Brigade 2EC	0.075	20.5 a	0.3 j	2.0 e	4.8 f-l	1.0 a
Brigade 2EC	0.096	33.3 a	0.0 j	0.3 e	0.0 m	0.0 a
Cyazapyr 10OD	0.044	26.0 a	0.0 j	0.0 e	0.3 lm	0.0 a
Cyazapyr 10OD	0.088	23.5 a	2.0 hij	0.0 e	0.0 m	0.0 a
Cyazapyr 10OD	0.134	30.5 a	0.0 j	0.3 e	0.0 m	0.3 a
Cyazapyr 10OD[2]	0.088	37.0 a	0.0 j	0.0 e	0.0 m	0.0 a
Cyazapyr 10SE	0.088	33.3 a	0.0 j	0.3 e	0.0 m	0.0 a
Coragen 2SC[2]	0.0456	45.5 a	0.0 j	0.0 e	2.3 j-m	0.0 a
Coragen 2SC[2]	0.066	35.8 a	0.8 ij	0.0 e	0.3 lm	0.0 a
Alverde 2SC[2]	0.07	36.3 a	0.3 j	0.0 e	1.3 lm	0.0 a
Alverde 2SC[2]	0.094	16.5 a	0.0 j	0.0 e	0.5 lm	1.5 a
Belay 2.13SC	0.03	16.8 a	0.0 j	0.0 e	2.8 i-m	3.3 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 3. (Continued). Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Belay 2.13SC	0.047	16.0 a	0.0 j	0.0 e	0.0 m	0.5 a
Untreated	---	32.5 a	24.0 d	33.5 bc	9.0 c-h	0.0 a
Assail 30WG	0.075	20.8 a	0.0 j	0.0 e	0.5 lm	0.0 a
Actara 50WG	0.047	18.3 a	0.3 j	0.8 e	2.0 klm	0.3 a
Provado 1.67SC	0.049	17.8 a	0.3 j	0.0 e	8.5 d-i	4.5 a
Belay 50WG	0.047	16.3 a	0.0 j	0.0 e	0.5 lm	0.0 a
Belay 50WG Warrior 1CS	0.047 0.03	17.3 a	0.0 j	0.0 e	0.0 m	0.0 a
Belay 2.13SC	0.047	15.5 a	0.0 j	0.0 e	3.0 g-m	0.0 a
Belay 2.13SC Warrior 1CS	0.047 0.03	37.5 a	0.0 j	0.0 e	0.0 m	0.0 a
Leverage 2.7SC	0.079	14.5 a	0.0 j	0.3 e	0.0 m	1.0 a
Endigo 2SC	0.073	36.5 a	0.0 j	0.0 e	0.0 m	1.0 a
Untreated	---	43.5 a	40.8 ab	54.3 a	16.5 abc	0.0 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 3. (Continued). Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Asana XL[3]	0.05	26.0 a	0.5 ij	1.3 e	6.0 e-k	0.0 a
Rimon 0.83EC	0.0584	25.0 a	1.8 hij	0.0 e	0.5 lm	0.0 a
Rimon 0.83EC	0.078	33.5 a	4.8 fgh	0.0 e	2.0 j-m	0.0 a
Agrimek 0.15EC	0.0094	35.0 a	0.0 j	0.0 e	8.3 e-j	1.5 a
Agrimek 0.15EC	0.014	22.0 a	0.0 j	1.3 e	7.5 d-h	0.5 a
Vydate L 1EC	0.5	17.0 a	1.3 hij	3.8 e	8.0 d-h	0.0 a
Spintor 2SC	0.07	12.5 a	1.0 ij	2.3 e	10.5 c-g	4.8 a
Spintor 2SC	0.094	34.5 a	1.0 ij	0.8 e	15.3 a-d	1.8 a
Untreated	---	34.0 a	50.0 a	26.8 d	13.5 a-e	0.0 a
Radiant 1SC	0.047	20.5 a	0.3 j	0.8 e	10.5 b-f	2.3 a
Radiant 1SC	0.0625	33.8 a	0.0 j	0.5 e	12.0 a-e	0.0 a
Thiodan 1EC	0.332	17.8 a	4.5 fgh	3.8 e	3.5 h-m	0.8 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05). All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 3. (Continued). Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Imidan 70WP	0.93	21.3 a	27.0 cd	42.8 ab	13.8 a-e	1.5 a
Voliam Flexi 40WG[1]	0.1	25.8 a	0.3 j	0.0 e	0.5 lm	0.0 a
Voliam Xpress 2SC[1]	0.081	30.5 a	0.3 j	0.0 e	0.0 m	0.5 a
Voliam Xpress 2SC[1]	0.114	10.3 a	0.3 j	0.0 e	0.3 lm	0.3 a
Voliam Xpress 2SC[1]	0.145	22.5 a	0.0 j	0.0 e	0.3 lm	0.0 a
Endigo 2SC	0.057	20.3 a	0.0 j	0.0 e	0.0 m	3.0 a
Mustang Max 0.8EC	0.0294	22.8 a	0.3 j	3.0 e	3.0 g-m	0.0 a
Venom 70SG	0.0437	39.5 a	0.3 j	1.5 e	19.8 a	0.3 a
Venom 70SG	0.0656	24.0 a	0.5 ij	2.0 e	13.3 a-e	0.0 a
Novodor	2.75 lb./a	28.0 a	12.3 e	22.0 cd	13.0 a-e	2.3 a
Novodor	2.0 lb./a	22.5 a	8.3 efg	22.8 cd	17.5 ab	2.0 a
LSD		2.24	0.91	1.13	1.10	0.74
S.D.		1.60	0.65	0.81	0.79	0.53
C.V.		32.26	37.69	41.80	37.14	44.72
F		1.219	20.161	18.324	9.108	1.051
Prob. (*F*)		0.1797	0.0001	0.0001	0.0001	0.3987

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 4. Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Brigade 2EC	0.075	0.8 a	0.5 g	2.0 gh	8.3 efg	6.8 g-k
Brigade 2EC	0.096	2.0 a	0.0 g	0.0 h	2.0 h-k	1.0 mno
Cyazapyr 10OD	0.044	1.0 a	0.0 g	0.0 h	0.0 k	0.8 mno
Cyazapyr 10OD	0.088	0.3 a	0.3 g	0.0 h	0.0 k	0.0 o
Cyazapyr 10OD	0.134	2.3 a	0.3 g	0.5 h	0.5 jk	0.3 no
Cyazapyr 10OD[2]	0.088	3.0 a	0.0 g	0.0 h	0.0 k	0.5 no
Cyazapyr 10SE	0.088	0.3 a	0.0 g	0.5 h	0.0 k	0.3 no
Coragen 2SC[2]	0.0456	2.3 a	0.0 g	0.0 h	0.3 k	0.0 o
Coragen 2SC[2]	0.066	3.5 a	0.0 g	0.0 h	0.3 k	0.0 o
Alverde 2SC[2]	0.07	9.5 a	0.5 g	0.0 h	3.0 h-k	0.5 no
Alverde 2SC[2]	0.094	0.0 a	0.0 g	0.0 h	1.0 jk	0.3 no
Belay 2.13SC	0.03	0.5 a	0.0 g	0.0 h	1.8 ijk	3.5 j-o

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 4. (Continued). Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Belay 2.13SC	0.047	0.3 a	0.0 g	0.0 h	0.0 k	0.0 o
Untreated	---	3.5 a	28.8 b	69.3 ab	63.5 ab	6.8 g-l
Assail 30WG	0.075	2.3 a	0.0 g	0.0 h	0.3 k	0.5 no
Actara 50WG	0.047	0.5 a	0.0 g	0.0 h	3.0 g-k	1.5 mno
Provado 1.67SC	0.049	4.5 a	0.3 g	0.0 h	2.5 h-k	9.5 b-h
Belay 50WG	0.047	3.5 a	0.0 g	0.3 h	0.3 k	2.0 l-o
Belay 50WG Warrior 1CS	0.047 0.03	7.0 a	0.0 g	0.0 h	0.3 k	0.5 no
Belay 2.13SC	0.047	3.8 a	0.0 g	0.0 h	1.3 ijk	0.8 mno
Belay 2.13SC Warrior 1CS	0.047 0.03	2.0 a	0.0 g	0.0 h	0.0 k	0.0 o
Leverage 2.7SC	0.079	2.0 a	0.0 g	0.3 h	1.0 jk	0.8 mno
Endigo 2SC	0.073	3.3 a	0.0 g	0.0 h	0.0 k	0.0 o
Untreated	---	5.3 a	42.8 a	52.0 b	73.5 a	15.5 a-f

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 4. (Continued). Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Asana XL[3]	0.05	2.0 a	0.0 g	1.0 gh	11.3 ef	8.5 f-j
Rimon 0.83EC	0.0584	5.3 a	1.0 g	0.5 h	1.0 jk	1.0 mno
Rimon 0.83EC	0.078	6.0 a	1.0 g	0.5 h	0.8 jk	0.5 no
Agrimek 0.15EC	0.0094	0.5 a	0.0 g	0.0 h	5.5 f-i	9.5 d-j
Agrimek 0.15EC	0.014	5.0 a	0.5 g	0.8 h	4.5 g-j	8.3 g-k
Vydate L 1EC	0.5	0.5 a	2.0 efg	2.5 gh	21.5 d	7.8 e-j
Spintor 2SC	0.07	5.3 a	0.8 g	3.0 fgh	34.8 c	15.8 a-d
Spintor 2SC	0.094	1.0 a	0.8 g	2.3 gh	16.5 de	6.3 g-l
Untreated	---	5.5 a	42.3 a	66.5 a	74.8 a	10.3 g-k
Radiant 1SC	0.047	5.5 a	0.3 g	1.0 gh	20.8 d	9.8 c-i
Radiant 1SC	0.0625	4.0 a	0.0 g	0.3 h	7.8 fgh	8.3 d-j
Thiodan 1EC	0.332	2.5 a	4.8 de	17.3 d	33.5 c	4.0 i-n

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 4. (Continued). Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Imidan 70WP	0.93	2.3 a	9.8 c	12.3 de	65.5 ab	20.3 ab
Voliam Flexi 40WG[1]	0.1	6.0 a	0.0 g	0.0 h	0.0 k	0.8 no
Voliam Xpress 2SC[1]	0.081	4.8 a	0.5 g	0.3 h	1.8 ijk	2.5 k-o
Voliam Xpress 2SC[1]	0.114	0.8 a	0.0 g	0.5 h	1.0 jk	0.5 no
Voliam Xpress 2SC[1]	0.145	0.3 a	0.0 g	0.0 h	0.0 k	0.0 o
Endigo 2SC	0.057	0.0 a	0.0 g	0.0 h	0.0 k	1.5 mno
Mustang Max 0.8EC	0.0294	1.8 a	0.5 g	0.3 h	2.0 h-k	5.3 h-m
Venom 70SG	0.0437	6.5 a	1.3 fg	1.5 gh	21.5 d	12.3 a-g
Venom 70SG	0.0656	0.8 a	0.8 g	5.8 fg	22.5 d	15.5 a-d
Novodor	2.75 lb./a	2.3 a	10.3 c	12.5 de	59.5 ab	19.5 a
Novodor	2.0 lb./a	0.8 a	7.8 cd	30.3 c	49.5 b	11.8 a-g
LSD		1.30	0.76	1.06	1.08	1.07
S.D.		0.93	0.55	0.76	0.77	0.76
C.V.		54.40	33.21	38.72	25.36	35.36
F		1.100	25.031	23.379	45.803	8.625
Prob. (*F*)		0.3231	0.0001	0.0001	0.0001	0.0001

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 5. Percent defoliation ratings from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean defoliation per plot				
		25 June	30 June	2 July	9 July	15 July
Brigade 2EC	0.075	0.0 a	0.0 d	0.0 d	2.8 de	0.0 g
Brigade 2EC	0.096	0.0 a	0.0 d	0.0 d	0.5 e	0.0 g
Cyazapyr 10OD	0.044	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Cyazapyr 10OD	0.088	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Cyazapyr 10OD	0.134	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Cyazapyr 10OD[2]	0.088	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Cyazapyr 10SE	0.088	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Coragen 2SC[2]	0.0456	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Coragen 2SC[2]	0.066	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Alverde 2SC[2]	0.07	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Alverde 2SC[2]	0.094	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Belay 2.13SC	0.03	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 5. (Continued). Percent defoliation ratings from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean defoliation per plot				
		25 June	30 June	2 July	9 July	15 July
Belay 2.13SC	0.047	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Untreated	---	0.0 a	2.5 b	7.5 a	43.8 a	62.5 b
Assail 30WG	0.075	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Actara 50WG	0.047	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Provado 1.67SC	0.049	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Belay 50WG	0.047	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Belay 50WG Warrior 1CS	0.047 0.03	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Belay 2.13SC	0.047	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Belay 2.13SC Warrior 1CS	0.047 0.03	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Leverage 2.7SC	0.079	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Endigo 2SC	0.073	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Untreated	---	0.0 a	1.3 c	5.0 b	32.5 b	55.0 b

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 5. (Continued). Percent defoliation ratings from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean defoliation per plot				
		25 June	30 June	2 July	9 July	15 July
Asana XL[3]	0.05	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Rimon 0.83EC	0.0584	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Rimon 0.83EC	0.078	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Agrimek 0.15EC	0.0094	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Agrimek 0.15EC	0.014	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Vydate L 1EC	0.5	0.0 a	0.0 d	0.0 d	0.0 e	1.3 fg
Spintor 2SC	0.07	0.0 a	0.0 d	0.0 d	0.0 e	3.8 fg
Spintor 2SC	0.094	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Untreated	---	0.0 a	6.3 a	8.8 a	50.0 a	80.0 a
Radiant 1SC	0.047	0.0 a	0.0 d	0.0 d	0.0 e	1.3 fg
Radiant 1SC	0.0625	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Thiodan 1EC	0.332	0.0 a	0.0 d	0.0 d	1.3 de	0.0 g

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 5. (Continued). Percent defoliation ratings from Russet Burbank variety potatoes treated with foliar insecticides. Arlington Agricultural Research Station, Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants				
		25 June	30 June	2 July	9 July	15 July
Imidan 70WP	0.93	0.0 a	0.0 d	0.0 d	10.0 d	21.3 d
Voliam Flexi 40WG[1]	0.1	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Voliam Xpress 2SC[1]	0.081	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Voliam Xpress 2SC[1]	0.114	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Voliam Xpress 2SC[1]	0.145	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Endigo 2SC	0.057	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Mustang Max 0.8EC	0.0294	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Venom 70SG	0.0437	0.0 a	0.0 d	0.0 d	0.0 e	2.5 fg
Venom 70SG	0.0656	0.0 a	0.0 d	0.0 d	0.0 e	0.0 g
Novodor	2.75 lb./a	0.0 a	0.0 d	0.0 d	5.0 de	12.5 def
Novodor	2.0 lb./a	0.0 a	0.0 d	0.0 d	5.0 de	8.8 efg
LSD		0.00	0.89	1.67	9.29	11.32
S.D.		0.00	0.63	1.19	6.63	8.08
C.V.		0.00	329.79	261.01	184.48	127.36
F		0.000	8.766	8.456	9.917	17.378
Prob. (*F*)		1.0000	0.0001	0.0001	0.0001	0.0001

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Part 2. Insect Control with Foliar Insecticides.

B. Colorado Potato Beetle Control with Foliar Insecticides – Hancock 2008.

Colorado potato beetles are a very adaptive insect and they can develop resistance to insecticides rapidly. Colorado potato beetles are exposed to a wide range of insecticides across the potato growing regions of Wisconsin however 80+% are treated with some nicotinyl insecticide at planting. The main potato production region in Wisconsin is located in the central sands area. Potatoes grown at the Hancock Agricultural Research Station in central Wisconsin provide an opportunity to evaluate insecticides in an environment of high beetle pressure from individuals that are more likely to have developed resistance to certain insecticides.

In a study conducted at the Hancock Agricultural Research Station, Hancock, Wisconsin, experimental and registered foliar insecticides were evaluated for efficacy on all life stages of Colorado potato beetle.

Russet Burbank variety potatoes were planted on 21 April 2008 into two 20' row plots, replicated four times in a randomized complete block design with replications separated by 15' of cultivated alleyway. Lorox (linuron) at 1 pound product per acre was applied post hilling on 6 May for weed control. Hand weeding provided additional weed control.

Plots were overhead irrigated with 0.2-0.6" water every 2-5 days from plant emergence to vine kill for a total of 18.35 inches.

Twenty registered and four experimental insecticides were evaluated at the following rates:

Registered:

Brigade 2EC (0.075 and 0.096 lb. a.i./a)
Coragen 1.67SC (0.046, and 0.066 lb. a.i./a) with MSO at 0.25% v/v
Belay 2.13SC (0.03, 0.0466 lb. a.i./a)
Assail 30WG (0.075 lb. a.i./a)
Actara 25WG (0.047 lb. a.i./a)
Provado 1.67SC (0.49 lb. a.i./a)
Belay 50WG (0.047 lb. a.i./a)
Leverage 2.7SE (0.079 lb. a.i./a)
Endigo 2.06SC (0.73 lb. a.i./a)
Asana 0.66E (0.05 lb. a.i./a) with PBO at 0.26 lb. a.i./a
Rimon 0.83EC (0.0584, and 0.078 lb. a.i./a)
Agrimek 0.15EC (0.0094 and 0.014 lb. a.i./a)
Vydate L (0.5 lb. a.i./a)
Spintor 2SC (0.07 and 0.094 lb. a.i./a)
Radiant 1SC (0.047 and 0.0625 lb. a.i./a)
Thiodan 3EC (0.332 lb. a.i./a)
Imidan 70WP (0.93 lb. a.i./a)
Mustang Max 0.8EC (0.0294 lb. a.i./a)
Venom 70SG (0.0437 and 0.066 lb. a.i./a)

Novodor (2.75 and 2.0 lb./a)

Experimental:

Cyazapyr 10OD (0.088 and 0.134 lb. a.i./a)
Alverde 2SC (0.07 and 0.094 lb. a.i./a) with MSO at 0.25% v/v
Volian Flexi 40WG (0.1 lb. a.i./a)
Voliam Xpress 2ZC (0.081, 0.114, and 0.145 lb. a.i./a) with NIS at 0.25% v/v

All materials were applied with a CO_2 backpack sprayer operating at 30 psi, delivering 24.8 gpa through four flat fan nozzles (8004VS XR) spaced at 18".

Insecticides were applied on 18 June 2008 and 25 June 2008 for first generation Colorado potato beetle (CPB) larval efficacy. First generation CPB efficacy was evaluated at 2 and 6 days after the first insecticide application (18 June) and 3, 7, 16 and 23 days after the second insecticide application on 25 June. CPB populations were monitored with plant counts. All life stages of the CPB (adults, eggs, small and large larvae) were counted on ten randomly chosen plants per plot.

Plant foliage was rated for defoliation on each survey date from 20 June through 16 July. The study was not harvested for yield due to second generation feeding pressure.

Table 1. Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean adults per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Brigadier 2EC	0.075	0.5 a	2.0 a-f	1.3 a	1.8 a	1.0 c-g	17.0 d-h
Brigadier 2EC	0.096	0.3 a	3.5 ab	1.0 a	2.0 a	2.3 b-f	7.5 h-q
Cyazapyr 10OD	0.044	0.3 a	1.8 a-f	0.0 a	0.8 a	0.8 d-g	12.0 g-m
Cyazapyr 10OD	0.088	0.5 a	1.0 c-g	0.5 a	0.3 a	2.5 b-f	9.5 h-q
Cyazapyr 10OD	0.134	0.0 a	1.0 c-g	0.3 a	0.5 a	0.5 d-g	9.8 g-o
Cyazapyr 10OD[2]	0.088	0.3 a	1.3 b-g	0.0 a	1.3 a	1.5 c-g	1.3 q
Cyazapyr 10SE	0.088	0.0 a	2.3 a-e	0.3 a	0.3 a	3.5 bcd	4.3 k-q
Coragen 2SC[2]	0.0456	0.3 a	0.3 fg	0.0 a	0.8 a	1.8 b-g	5.0 j-q
Coragen 2SC[2]	0.066	1.0 a	1.3 c-g	0.3 a	0.3 a	1.5 b-g	7.3 h-q
Alverde 2SC[2]	0.07	0.3 a	0.5 efg	0.0 a	0.0 a	2.0 b-g	3.0 m-q
Alverde 2SC[2]	0.094	0.0 a	0.0 g	0.3 a	0.3 a	0.3 fg	9.3 h-p
Belay 2.13SC	0.03	0.0 a	2.3 a-f	0.5 a	0.3 a	1.0 c-g	9.5 g-o

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 1. (Continued). Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean adults per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Belay 2.13SC	0.047	0.0 a	0.8 d-g	0.0 a	1.3 a	2.3 b-f	10.3 g-n
Untreated	---	0.3 a	0.3 fg	0.3 a	0.0 a	1.5 b-g	17.3 d-i
Assail 30WG	0.075	0.5 a	0.8 efg	0.3 a	1.0 a	1.5 b-g	8.5 h-q
Actara 50WG	0.047	0.8 a	0.8 efg	0.3 a	0.8 a	0.5 d-g	4.8 l-q
Provado 1.67SC	0.049	0.5 a	2.0 a-f	0.8 a	0.5 a	0.0 g	6.8 j-q
Belay 50WG	0.047	1.0 a	0.5 efg	0.3 a	1.0 a	1.8 b-g	2.0 pq
Belay 50WG Warrior 1CS	0.047 0.03	0.3 a	2.3 a-e	0.0 a	0.8 a	3.5 abc	6.3 j-q
Belay 2.13SC	0.047	0.3 a	0.0 g	0.3 a	0.3 a	0.8 d-g	4.5 l-q
Belay 2.13SC Warrior 1CS	0.047 0.03	0.3 a	1.0 c-g	0.5 a	1.3 a	2.3 b-f	3.5 l-q
Leverage 2.7SC	0.079	1.3 a	2.3 a-e	0.5 a	2.8 a	1.0 c-g	5.3 j-q
Endigo 2SC	0.073	0.5 a	1.3 c-g	0.5 a	1.3 a	0.8 d-g	5.5 j-q
Untreated	---	1.3 a	0.3 fg	1.0 a	0.5 a	2.0 b-f	5.8 j-q

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 1. (Continued). Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean adults per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Asana XL[3]	0.05	0.5 a	1.0 c-g	0.0 a	0.5 a	1.5 c-g	2.3 opq
Rimon 0.83EC	0.0584	2.0 a	1.3 b-g	1.8 a	0.3 a	1.8 b-g	8.0 h-q
Rimon 0.83EC	0.078	0.5 a	1.0 c-g	0.0 a	0.8 a	0.3 fg	6.0 j-q
Agrimek 0.15EC	0.0094	1.0 a	0.5 efg	0.5 a	0.3 a	0.3 fg	6.8 h-q
Agrimek 0.15EC	0.014	0.8 a	0.5 efg	0.8 a	0.3 a	0.0 g	6.3 j-q
Vydate L 1EC	0.5	0.8 a	0.5 efg	0.0 a	0.0 a	0.5 d-g	8.0 h-q
Spintor 2SC	0.07	1.3 a	1.0 c-g	0.8 a	0.8 a	1.0 c-g	10.5 g-o
Spintor 2SC	0.094	0.0 a	2.8 abc	1.0 a	1.5 a	1.0 c-g	12.8 f-l
Untreated	---	1.0 a	1.3 c-g	0.3 a	0.0 a	1.3 c-g	7.3 h-q
Radiant 1SC	0.047	0.8 a	1.5 b-g	0.5 a	0.5 a	1.5 c-g	7.5 h-q
Radiant 1SC	0.0625	1.0 a	0.8 efg	0.0 a	0.8 a	1.0 c-g	15.8 e-k
Thiodan 1EC	0.332	1.5 a	1.0 c-g	0.5 a	0.0 a	0.0 g	6.8 h-q

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05). All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 1. (Continued). Colorado potato beetle adults sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean adults per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Imidan 70WP	0.93	0.5 a	0.5 efg	0.3 a	0.0 a	1.0 d-g	6.0 j-q
Voliam Flexi 40WG[1]	0.1	0.5 a	0.5 efg	0.3 a	0.5 a	0.5 d-g	7.5 i-q
Voliam Xpress 2SC[1]	0.081	1.5 a	1.5 b-g	1.0 a	1.5 a	0.5 efg	8.0 h-q
Voliam Xpress 2SC[1]	0.114	1.0 a	1.5 b-g	1.0 a	1.8 a	0.5 d-g	8.8 g-o
Voliam Xpress 2SC[1]	0.145	1.3 a	1.3 b-g	1.0 a	1.3 a	1.8 b-g	14.3 e-j
Endigo 2SC	0.057	1.0 a	1.0 c-g	0.5 a	1.3 a	3.0 b-e	76.3 a
Mustang Max 0.8EC	0.0294	1.8 a	0.5 efg	1.0 a	1.5 a	1.0 d-g	49.3 b
Venom 70SG	0.0437	1.3 a	0.3 fg	1.0 a	1.5 a	1.8 b-g	36.5 bc
Venom 70SG	0.0656	0.5 a	1.5 b-g	0.0 a	0.8 a	2.5 b-f	20.3 d-g
Novodor	2.75 lb./a	0.5 a	0.0 g	0.0 a	0.0 a	2.0 b-g	31.3 cd
Novodor	2.0 lb./a	0.3 a	0.5 efg	0.3 a	0.8 a	4.0 ab	26.8 cde
LSD		0.42	0.58	0.36	0.5	0.69	1.49
S.D.		0.30	0.42	0.26	0.36	0.50	1.07
C.V.		24.13	29.83	22.12	28.51	33.67	33.72
F		1.393	1.638	1.359	1.231	1.670	6.332
Prob. (*F*)		0.0640	0.0116	0.0796	0.1688	0.0091	0.0001

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 2. Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Brigadier 2EC	0.075	2.0 a	1.3 a	0.8 def	0.3 cd	0.0 d	0.5 a
Brigadier 2EC	0.096	1.5 a	1.0 a	1.8 a-e	1.0 ab	0.5 a-d	0.0 a
Cyazapyr 10OD	0.044	2.0 a	0.5 a	0.5 def	0.0 d	0.5 bcd	0.5 a
Cyazapyr 10OD	0.088	2.3 a	0.8 a	0.3 ef	0.5 bcd	0.3 cd	0.0 a
Cyazapyr 10OD	0.134	3.5 a	0.0 a	0.3 ef	0.0 d	0.0 d	0.3 a
Cyazapyr 10OD[2]	0.088	2.8 a	0.5 a	0.0 f	0.0 d	0.5 bcd	0.3 a
Cyazapyr 10SE	0.088	1.3 a	0.8 a	0.8 def	0.0 d	1.8 ab	0.8 a
Coragen 2SC[2]	0.0456	1.5 a	1.5 a	0.8 def	0.8 abc	1.3 abc	0.0 a
Coragen 2SC[2]	0.066	3.5 a	1.5 a	0.3 ef	0.0 d	1.5 ab	0.3 a
Alverde 2SC[2]	0.07	3.3 a	1.8 a	0.5 def	0.0 d	0.3 cd	0.0 a
Alverde 2SC[2]	0.094	4.8 a	0.8 a	0.3 ef	0.0 d	0.5 a-d	0.3 a
Belay 2.13SC	0.03	2.8 a	0.5 a	1.3 b-f	0.5 bcd	1.5 abc	0.0 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 2. (Continued). Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Belay 2.13SC	0.047	2.8 a	1.8 a	0.5 def	1.0 abc	0.5 bcd	0.5 a
Untreated	---	1.5 a	0.5 a	1.0 c-f	0.0 d	0.0 d	0.0 a
Assail 30WG	0.075	3.3 a	1.0 a	0.8 def	0.3 cd	0.0 d	0.3 a
Actara 50WG	0.047	3.0 a	0.8 a	1.0 b-f	0.5 bcd	0.0 d	0.0 a
Provado 1.67SC	0.049	3.5 a	2.3 a	0.8 def	0.8 abc	0.0 d	0.0 a
Belay 50WG	0.047	3.0 a	0.5 a	0.3 ef	0.8 abc	1.3 a-d	0.3 a
Belay 50WG Warrior 1CS	0.047 0.03	5.5 a	0.3 a	0.5 def	0.0 d	1.0 a-d	1.5 a
Belay 2.13SC	0.047	4.5 a	1.0 a	0.8 def	0.0 d	1.8 ab	0.0 a
Belay 2.13SC Warrior 1CS	0.047 0.03	1.8 a	0.8 a	0.3 ef	0.3 cd	1.3 abc	0.8 a
Leverage 2.7SC	0.079	4.3 a	1.3 a	1.3 b-f	1.3 ab	0.3 cd	0.0 a
Endigo 2SC	0.073	5.0 a	1.3 a	0.3 ef	0.3 cd	1.0 a-d	0.5 a
Untreated	---	5.8 a	3.5 a	3.0 abc	0.0 d	0.0 d	0.0 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05). All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 2. (Continued). Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Asana XL[3]	0.05	3.8 a	0.8 a	0.3 ef	0.8 abc	0.0 d	0.5 a
Rimon 0.83EC	0.0584	6.0 a	2.3 a	2.5 ab	0.5 bcd	1.8 a	0.0 a
Rimon 0.83EC	0.078	3.0 a	2.8 a	3.3 a	0.5 bcd	1.5 ab	0.0 a
Agrimek 0.15EC	0.0094	3.3 a	0.3 a	0.8 def	0.8 abc	0.0 d	0.0 a
Agrimek 0.15EC	0.014	3.8 a	1.8 a	0.3 ef	0.0 d	0.0 d	0.0 a
Vydate L 1EC	0.5	5.0 a	1.3 a	0.5 def	0.0 d	1.0 a-d	0.0 a
Spintor 2SC	0.07	1.3 a	1.0 a	1.8 a-e	0.3 cd	1.3 abc	0.3 a
Spintor 2SC	0.094	4.5 a	1.5 a	1.0 b-f	0.3 cd	0.0 d	0.3 a
Untreated	---	2.3 a	0.8 a	1.8 a-d	0.0 d	0.0 d	0.0 a
Radiant 1SC	0.047	3.3 a	1.0 a	0.8 def	0.3 cd	0.3 cd	0.0 a
Radiant 1SC	0.0625	2.8 a	2.3 a	1.8 a-d	0.0 d	0.3 cd	5.0 a
Thiodan 1EC	0.332	7.0 a	1.8 a	0.8 def	0.0 d	0.3 cd	0.8 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 2. (Continued). Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Imidan 70WP	0.93	2.8 a	1.3 a	0.5 def	0.0 d	0.3 cd	0.0 a
Voliam Flexi 40WG[1]	0.1	4.0 a	0.8 a	0.3 ef	0.0 d	0.0 d	0.5 a
Voliam Xpress 2SC[1]	0.081	4.0 a	1.5 a	2.8 ab	0.8 abc	0.5 bcd	0.5 a
Voliam Xpress 2SC[1]	0.114	4.0 a	0.5 a	0.8 def	0.0 d	0.8 a-d	0.8 a
Voliam Xpress 2SC[1]	0.145	2.5 a	1.3 a	1.0 b-f	1.3 a	1.0 a-d	0.3 a
Endigo 2SC	0.057	0.8 a	1.0 a	1.5 a-e	0.0 d	0.8 a-d	0.5 a
Mustang Max 0.8EC	0.0294	1.3 a	0.0 a	1.3 b-f	0.3 cd	0.5 bcd	0.0 a
Venom 70SG	0.0437	1.8 a	1.8 a	0.5 def	0.0 d	0.3 cd	0.3 a
Venom 70SG	0.0656	2.5 a	0.8 a	0.5 def	0.0 d	0.0 d	0.0 a
Novodor	2.75 lb./a	2.0 a	0.8 a	0.3 ef	0.0 d	0.0 d	0.0 a
Novodor	2.0 lb./a	2.5 a	1.0 a	1.3 b-f	0.5 bcd	0.3 cd	0.0 a
LSD		0.79	0.54	0.48	0.28	0.43	0.44
S.D.		0.57	0.39	0.34	0.20	0.30	0.31
C.V.		29.08	27.40	25.88	18.03	25.21	28.53
F		1.368	1.399	1.670	1.915	1.700	0.990
Prob. (*F*)		0.0752	0.0617	0.0090	0.0013	0.0072	0.5027

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 3. Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Brigadier 2EC	0.075	2.5 fgh	24.0 d-h	13.0 def	21.5 bcd	28.3 abc	0.0 a
Brigadier 2EC	0.096	0.5 h	5.8 j-o	0.0 k	4.3 e-i	8.0 g-p	5.0 a
Cyazapyr 10OD	0.044	3.0 fgh	0.0 o	0.0 k	0.0 i	0.3 rs	1.8 a
Cyazapyr 10OD	0.088	0.3 h	0.0 o	0.0 k	0.0 i	0.0 s	0.5 a
Cyazapyr 10OD	0.134	3.3 e-h	0.0 o	0.0 k	0.0 i	0.0 s	0.0 a
Cyazapyr 10OD[2]	0.088	4.0 e-h	0.0 o	0.0 k	0.0 i	0.3 rs	0.3 a
Cyazapyr 10SE	0.088	5.5 e-h	0.0 o	0.0 k	0.0 i	0.0 s	0.0 a
Coragen 2SC[2]	0.0456	2.8 fgh	1.3 no	0.5 ijk	0.0 i	2.8 m-s	0.3 a
Coragen 2SC[2]	0.066	2.5 fgh	0.3 no	0.0 k	0.0 i	0.3 rs	0.0 a
Alverde 2SC[2]	0.07	1.5 gh	6.8 h-o	5.5 f-k	2.3 i	1.5 o-s	0.5 a
Alverde 2SC[2]	0.094	4.3 e-h	7.8 i-o	0.0 k	0.3 i	1.5 qrs	0.0 a
Belay 2.13SC	0.03	0.0 h	1.5 l-o	1.3 h-k	4.8 e-i	13.3 c-k	0.3 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 3. (Continued). Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Belay 2.13SC	0.047	0.0 h	7.5 j-o	0.0 k	0.3 i	1.5 p-s	0.5 a
Untreated	---	37.0 b	70.3 ab	75.5 b	35.5 a	14.8 b-i	0.0 a
Assail 30WG	0.075	0.0 h	0.3 no	0.0 k	2.0 hi	9.3 f-n	1.3 a
Actara 50WG	0.047	6 e-h	1.5 l-o	3.8 g-k	10.0 d-h	8.3 f-o	1.8 a
Provado 1.67SC	0.049	0.0 h	4.8 k-o	5.8 f-k	19.8 bcd	31.5 a	4.3 a
Belay 50WG	0.047	0.0 h	0.0 o	0.0 k	0.3 i	2.0 n-s	3.8 a
Belay 50WG Warrior 1CS	0.047 0.03	0.0 h	0.0 o	0.0 k	0.0 i	4.3 m-s	5.3 a
Belay 2.13SC	0.047	0.0 h	0.0 o	1.3 h-k	0.8 i	11.5 e-m	2.3 a
Belay 2.13SC Warrior 1CS	0.047 0.03	0.0 h	2.8 k-o	0.5 ijk	0.0 i	0.3 rs	2.3 a
Leverage 2.7SC	0.079	0.0 h	3.0 k-o	0.5 ijk	4.3 ghi	17.3 a-h	0.8 a
Endigo 2SC	0.073	0.5 h	0.0 o	1.5 h-k	0.0 i	0.8 qrs	5.5 a
Untreated	---	23.5 bc	60.5 abc	72.0 b	23.5 abc	17.5 a-h	0.8 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05). All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 3. (Continued). Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Asana XL[3]	0.05	0.0 h	12.3 f-m	15.0 def	16.0 bcd	21.3 a-e	4.3 a
Rimon 0.83EC	0.0584	9.3 d-g	16.5 e-k	7.0 f-k	0.5 i	3.8 k-s	3.5 a
Rimon 0.83EC	0.078	3.8 e-h	5.0 k-o	7.5 f-i	0.3 i	0.0 s	1.8 a
Agrimek 0.15EC	0.0094	19.3 c-f	26.8 e-j	8.0 e-h	0.8 i	18.5 a-g	0.0 a
Agrimek 0.15EC	0.014	0.5 h	0.8 no	1.8 h-k	15.0 bcd	28.3 ab	0.5 a
Vydate L 1EC	0.5	0.3 h	2.0 k-o	0.5 ijk	0.8 i	17.3 a-g	1.8 a
Spintor 2SC	0.07	1.5 fgh	2.8 k-o	0.8 ijk	0.8 i	4.8 m-s	1.0 a
Spintor 2SC	0.094	0.0 h	0.3 no	0.0 k	1.0 i	1.5 p-s	0.0 a
Untreated	---	22.3 bcd	48.5 bcd	85.8 b	18.3 bcd	22.0 a-d	0.0 a
Radiant 1SC	0.047	0.0 h	2.8 k-o	1.0 h-k	0.0 i	2.5 m-s	0.8 a
Radiant 1SC	0.0625	0.0 h	9.3 h-o	0.0 k	0.3 i	3.5 l-s	2.3 a
Thiodan 1EC	0.332	4.5 e-h	21.3 e-j	19.3 def	17.0 bcd	18.3 a-g	0.5 a

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05). All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 3. (Continued). Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Imidan 70WP	0.93	3.0 e-h	12.3 g-n	10.3 f-j	28.3 abc	12.0 d-l	0.5 a
Voliam Flexi 40WG[1]	0.1	0.5 h	0.5 no	0.0 k	0.0 i	0.0 s	0.0 a
Voliam Xpress 2SC[1]	0.081	2.5 fgh	3.8 k-o	1.3 h-k	1.5 i	4.0 m-s	2.3 a
Voliam Xpress 2SC[1]	0.114	13.3 cde	0.5 no	0.5 ijk	1.0 i	2.5 m-s	0.0 a
Voliam Xpress 2SC[1]	0.145	7.5 e-h	0.5 no	0.3 jk	0.8 i	3.0 m-s	3.0 a
Endigo 2SC	0.057	0.0 h	2.8 k-o	0.0 k	1.0 i	1.5 qrs	0.0 a
Mustang Max 0.8EC	0.0294	33.0 bcd	29.3 def	11.5 ef	3.3 hi	17.0 b-i	1.8 a
Venom 70SG	0.0437	2.5 e-h	17.3 e-k	29.3 cd	27.0 ab	2.8 n-s	0.3 a
Venom 70SG	0.0656	6.0 e-h	38.0 def	12.8 efg	16.5 cde	7.5 i-r	1.8 a
Novodor	2.75 lb./a	25.0 bc	35.5 cde	42.5 c	11.8 c-g	19.0 b-i	0.0 a
Novodor	2.0 lb./a	22.8 bc	31.8 d-g	50.0 c	24.0 abc	20.0 a-f	0.0 a
LSD		1.71	2.12	1.61	1.44	1.52	0.99
S.D.		1.22	1.52	1.15	1.03	1.09	0.70
C.V.		58.93	54.90	45.30	47.18	40.98	51.71
F		6.218	7.478	17.828	8.012	6.593	1.163
Prob. (*F*)		0.0001	0.0001	0.0001	0.0001	0.0001	0.2401

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 4. Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Brigadier 2EC	0.075	0.0 g	4.5 fgh	3.0 e-h	25.0 d	60.0 a-e	11.8 ab
Brigadier 2EC	0.096	0.0 g	0.8 gh	1.0 gh	2.3 h-l	21.3 h-m	4.8 b-i
Cyazapyr 10OD	0.044	1.0 efg	0.0 h	0.0 h	0.5 kl	0.0 t	1.8 g-l
Cyazapyr 10OD	0.088	0.8 efg	0.0 h	0.0 h	0.0 l	0.3 t	0.0 l
Cyazapyr 10OD	0.134	0.0 g	0.3 gh	0.0 h	0.0 l	0.5 t	0.0 l
Cyazapyr 10OD[2]	0.088	0.8 efg	0.0 h	0.0 h	0.0 l	0.0 t	0.0 l
Cyazapyr 10SE	0.088	0.0 g	0.0 h	0.0 h	0.3 kl	0.5 t	0.0 l
Coragen 2SC[2]	0.0456	3.5 cde	1.8 gh	0.5 gh	0.0 l	3.3 p-t	0.5 jkl
Coragen 2SC[2]	0.066	0.0 g	0.8 gh	0.0 h	0.0 l	0.8 st	0.0 l
Alverde 2SC[2]	0.07	0.5 fg	0.0 h	0.0 h	0.0 l	9.0 m-s	0.5 jkl
Alverde 2SC[2]	0.094	0.0 g	0.8 gh	0.0 h	0.5 jkl	2.0 q-t	1.3 h-l
Belay 2.13SC	0.03	0.0 g	2.0 gh	0.3 h	3.0 h-l	34.0 f-j	3.5 c-l

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 4. (Continued). Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Belay 2.13SC	0.047	0.0 g	0.0 h	0.3 h	0.8 jkl	14.3 k-p	1.5 h-l
Untreated	---	11.5 b	38.5 ab	73.8 a	74.8 ab	47.0 a-g	2.3 d-l
Assail 30WG	0.075	0.0 g	0.0 h	0.0 h	2.3 h-l	29.5 f-k	2.5 d-l
Actara 50WG	0.047	0.0 g	0.3 gh	0.8 gh	4.8 g-j	54.8 a-e	7.0 b-f
Provado 1.67SC	0.049	0.0 g	0.8 gh	1.5 fgh	10.3 efg	59.0 a-e	6.8 b-e
Belay 50WG	0.047	0.0 g	0.3 gh	0.0 h	1.5 i-l	16.0 j-o	4.0 c-l
Belay 50WG Warrior 1CS	0.047 0.03	0.0 g	0.0 h	0.0 h	0.8 jkl	7.8 o-t	2.0 f-l
Belay 2.13SC	0.047	0.0 g	0.3 gh	0.0 h	1.3 i-l	19.8 i-n	1.5 h-l
Belay 2.13SC Warrior 1CS	0.047 0.03	0.0 g	0.0 h	0.0 h	0.0 l	2.0 q-t	0.8 i-l
Leverage 2.7SC	0.079	0.0 g	0.0 h	0.5 gh	3.8 h-k	26.3 g-l	15.8 a
Endigo 2SC	0.073	0.0 g	0.0 h	0.0 h	0.0 l	3.0 q-t	7.5 b-f
Untreated	---	5.3 cd	34.5 bc	49.3 b	64.8 b	67.8 abc	4.5 b-j

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05). All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 4. (Continued). Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Asana XL[3]	0.05	0.0 g	2.8 gh	3.8 d-h	14.0 e	48.8 a-f	9.3 abc
Rimon 0.83EC	0.0584	2.3 d-g	1.3 gh	0.3 h	5.5 ghi	8.8 m-r	3.0 c-l
Rimon 0.83EC	0.078	1.0 efg	3.3 gh	1.5 fgh	0.0 l	0.5 t	0.8 i-l
Agrimek 0.15EC	0.0094	5.8 c-f	21.5 de	1.0 gh	2.5 h-l	41.8 d-h	6.5 b-g
Agrimek 0.15EC	0.014	0.0 g	0.8 gh	0.3 h	3.3 h-l	71.5 a	5.8 b-h
Vydate L 1EC	0.5	0.0 g	2.5 gh	0.3 h	1.8 i-l	29.8 f-k	6.8 b-f
Spintor 2SC	0.07	0.0 g	2.3 gh	0.0 h	0.5 kl	19.8 i-n	7.3 b-f
Spintor 2SC	0.094	0.0 g	1.5 gh	0.0 h	1.0 jkl	3.0 q-t	0.8 i-l
Untreated	---	6.3 c	23.0 d	47.5 b	61.8 b	62.5 a-d	10.8 ab
Radiant 1SC	0.047	0.0 g	1.8 gh	0.3 h	1.0 jkl	17.0 j-o	7.5 a-d
Radiant 1SC	0.0625	0.0 g	0.5 gh	0.0 h	0.0 l	25.0 i-n	9.0 abc
Thiodan 1EC	0.332	2.5 d-g	3.3 gh	3.8 d-h	26.0 d	62.3 a-d	6.8 b-f

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 4. (Continued). Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Imidan 70WP	0.93	0.0 g	5.8 efg	8.0 c-f	33.0 cd	68.5 a-d	5.5 b-i
Voliam Flexi 40WG[1]	0.1	0.0 g	0.3 gh	0.0 h	0.3 kl	0.5 t	0.3 kl
Voliam Xpress 2SC[1]	0.081	0.0 g	1.0 gh	0.8 gh	1.0 jkl	11.5 l-q	1.8 e-l
Voliam Xpress 2SC[1]	0.114	1.8 efg	1.8 gh	0.5 gh	1.8 i-l	2.3 q-t	1.5 g-l
Voliam Xpress 2SC[1]	0.145	3.3 d-g	0.3 gh	0.0 h	0.3 kl	8.8 n-t	2.3 d-l
Endigo 2SC	0.057	1.0 efg	0.0 h	1.5 gh	0.0 l	3.3 p-t	0.3 kl
Mustang Max 0.8EC	0.0294	2.5 d-g	17.8 d	6.5 c-g	14.0 ef	18.5 j-n	6.8 b-h
Venom 70SG	0.0437	3.0 c-f	16.8 d	9.8 cde	28.8 cd	55.5 a-e	7.5 b-j
Venom 70SG	0.0656	2.3 d-g	19.0 d	15.5 c	28.0 cd	57.8 a-e	8.3 bcd
Novodor	2.75 lb./a	3.3 d-g	11.5 def	15.0 cd	25.0 cd	41.8 c-g	2.3 e-l
Novodor	2.0 lb./a	1.0 efg	19.0 cd	34.0 b	37.3 c	65.3 a-d	3.3 c-l
LSD		0.81	1.38	1.43	1.08	1.78	1.15
S.D.		0.58	0.99	1.02	0.77	1.27	0.82
C.V.		41.85	49.67	52.13	28.87	28.55	40.77
F		5.545	9.008	13.867	35.425	16.151	3.223
Prob. (*F*)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 5. Percent defoliation ratings from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean defoliation per plot					
		20 June	24 June	27 June	2 July	9 July	16 July
Brigadier 2EC	0.075	0.0 a	0.0 c	0.0 d	0.0 d	5.0 d-g	8.8 f
Brigadier 2EC	0.096	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	2.5 f
Cyazapyr 10OD	0.044	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Cyazapyr 10OD	0.088	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Cyazapyr 10OD	0.134	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Cyazapyr 10OD[2]	0.088	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Cyazapyr 10SE	0.088	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Coragen 2SC[2]	0.0456	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Coragen 2SC[2]	0.066	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Alverde 2SC[2]	0.07	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Alverde 2SC[2]	0.094	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Belay 2.13SC	0.03	0.0 a	0.0 c	0.0 d	0.0 d	1.3 fg	1.3 f

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 5. (Continued). Percent defoliation ratings from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean defoliation per plot					
		20 June	24 June	27 June	2 July	9 July	16 July
Belay 2.13SC	0.047	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Untreated	---	0.0 a	0.0 c	5.0 b	10.0 b	38.8 a	55.0 b
Assail 30WG	0.075	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Actara 50WG	0.047	0.0 a	0.0 c	0.0 d	0.0 d	2.5 fg	3.8 f
Provado 1.67SC	0.049	0.0 a	0.0 c	0.0 d	0.0 d	6.3 def	6.3 f
Belay 50WG	0.047	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Belay 50WG Warrior 1CS	0.047 0.03	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Belay 2.13SC	0.047	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Belay 2.13SC Warrior 1CS	0.047 0.03	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Leverage 2.7SC	0.079	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	3.8 f
Endigo 2SC	0.073	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	1.3 f
Untreated	---	0.0 a	0.0 c	1.3 c	6.3 c	26.3 b	46.3 bc

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 5. (Continued). Percent defoliation ratings from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean defoliation per plot					
		20 June	24 June	27 June	2 July	9 July	16 July
Asana XL[3]	0.05	0.0 a	0.0 c	0.0 d	0.0 d	5.0 d-g	8.8 f
Rimon 0.83EC	0.0584	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Rimon 0.83EC	0.078	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Agrimek 0.15EC	0.0094	1.3 a	1.3 b	0.0 d	0.0 d	0.0 g	1.3 f
Agrimek 0.15EC	0.014	0.0 a	0.0 c	0.0 d	0.0 d	5.0 d-g	5.0 f
Vydate L 1EC	0.5	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	1.3 f
Spintor 2SC	0.07	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	2.5 f
Spintor 2SC	0.094	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	0.0 f
Untreated	---	0.0 a	0.0 c	1.3 c	6.3 c	20.0 c	47.5 bc
Radiant 1SC	0.047	0.0 a	0.0 c	0.0 d	0.0 d	0.0 g	1.3 f
Radiant 1SC	0.0625	0.0 a	0.0 c	0.0 d	0.0 d	8.8 de	0.0 f
Thiodan 1EC	0.332	0.0 a	0.0 c	0.0 d	0.0 d	3.8 efg	6.3 f

(Continued)

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Table 5. (Continued). Percent defoliation ratings from Russet Burbank variety potatoes treated with foliar insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean egg masses per 10 plants					
		20 June	24 June	27 June	2 July	9 July	16 July
Imidan 70WP	0.93	0.0 a	0.0 c	0.0 d	1.3 d	10.0 d	26.3 de
Voliam Flexi 40WG[1]	0.1	0.0 a	0.0 a	0.0 d	0.0 d	0.0 g	0.0 f
Voliam Xpress 2SC[1]	0.081	0.0 a	0.0 a	0.0 d	0.0 d	0.0 g	0.0 f
Voliam Xpress 2SC[1]	0.114	0.0 a	0.0 a	0.0 d	0.0 d	0.0 g	0.0 f
Voliam Xpress 2SC[1]	0.145	0.0 a	0.0 a	0.0 d	0.0 d	0.0 g	0.0 f
Endigo 2SC	0.057	0.0 a	0.0 a	0.0 d	0.0 d	0.0 g	15.0 ef
Mustang Max 0.8EC	0.0294	0.0 a	0.0 a	0.0 d	0.0 d	1.3 fg	26.3 de
Venom 70SG	0.0437	0.0 a	0.0 a	0.0 d	0.0 d	2.5 fg	32.5 cd
Venom 70SG	0.0656	0.0 a	0.0 a	0.0 d	0.0 d	1.3 fg	36.3 cd
Novodor	2.75 lb./a	0.0 a	0.0 a	0.0 d	0.0 d	1.3 fg	26.3 de
Novodor	2.0 lb./a	0.0 a	0.0 a	1.3 c	0.0 d	8.8 de	43.8 bc
LSD		0.49	0.75	1.01	1.51	5.62	15.18
S.D.		0.35	0.53	0.72	1.08	4.01	10.84
C.V.		1442.22	738.45	231.29	135.6	111.23	112.76
F		1.000	2.086	12.14	30.719	16.268	10.217
Prob. (*F*)		0.4848	0.0003	0.0001	0.0001	0.0001	0.0001

Means in a column followed by the same letter are not significantly different (Least Significant Difference Test, P = 0.05).
All treatments applied 18 June and 25 June.
[1]NIS added at 0.25% v/v, [2]MSO added at 0.25% v/v, [3]PBO added at 4 fl oz/a.

Section 1. Part 2-C

Title: Novaluron, (Rimon® 0.83 EC), Insecticide / Ovicide
Experiments against Colorado Potato Beetle: (2008)

Principal Investigator (s)

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Scott Chapman, Associate Research Specialist, 537 Russell Laboratories, University of Wisconsin, Madison 53706 chapman@entomology.wisc.edu (608) 262-9914.

Experimental Site: Arlington Agricultural Experiment Station, Arlington, Wisconsin.

Project Objective: Evaluate varying rates & timing of foliar applied Rimon (N=3), a conventional standard (Alverde®), and an untreated control (UTC) targeting first egg deposition of Colorado Potato Beetle (CPB).

Experimental Design: Treatments arranged in randomized, complete-block design with 3 novaluron application rate & time interval combinations, a single metaflumizone application, and an UTC replicated 4 times for a total of 20 experimental plots (**Fig. 1**).

Treatments: (N=5)		# Applications	Rate
1) novaluron	(Rimon 0.83 EC)	2 (14 days)	12.0 fl oz / A
NIS 0.023 % V/V	(Silwet)	2 (14 days)	
2) novaluron	(Rimon 0.83 EC)	2 (14 days)	6.0 fl oz / A
metaflumizone	(Alverde)	2 (14 days)	2.375
NIS 0.023 % V/V	(Silwet)	2 (14 days)	
3) metaflumizone	(Alverde)	2 (14 days)	4.75
NIS 0.023 % V/V	(Silwet)	2 (14 days)	
4) novaluron	(Rimon 0.83 EC)	4 (7 days)	6.0 fl oz / A
NIS 0.023 % V/V	(Silwet)	2 (14 days)	
5) UTC			

Plot Size / Row Spacing / Seed Spacing:

- 16 rows (48 ft) X 42 ft = 2,016 sq ft/plot (0.046 ac)
- 12 ft spacing between plots

Crop and Cultivar: *Solanum tuberosum* cv. 'Superior'

Treatment Evaluations: Foliar insecticides were applied at the appearance of the first eggs using a tractor-mounted, CO_2 pressurized, sprayer with a 30' boom operating at 30 psi delivering 29.4 gpa through 12 flat-fan nozzles (8003VS-XR) spaced 20" apart @ 4 mph. CPB populations were surveyed weekly by counting all lifestages (eggs, larvae, adults) on 10 randomly selected plants from the center 2 rows of each experimental plot. A total of 10, recently deposited CPB egg masses were collected from each replicate / treatment combination and % emergence recorded. Total yield was also recorded at the conclusion of the experiment from each treatment.

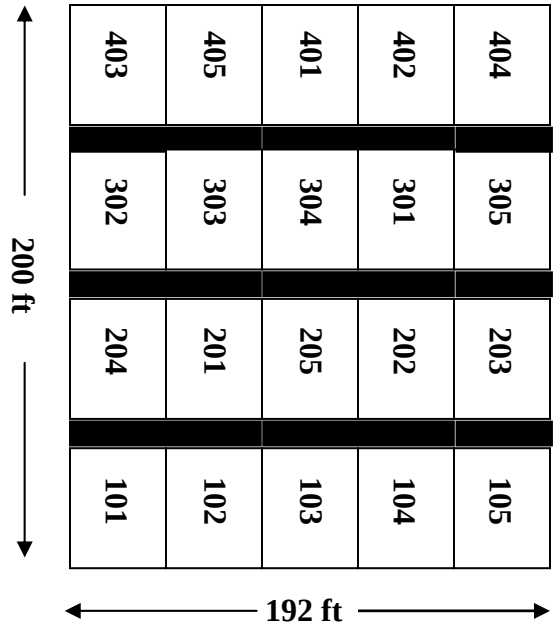

Figure 1. Experimental plot layout for evaluation of foliar novaluron (Rimon) treatments following appearance of first CPB eggs at the Arlington AES, Arlington, Wisconsin 2008. Experimental plot size 48 ft X 42 ft with 4 replicates resulting in an experiment size (192' X 200'), (0.88 acres). Experimental replicates separated by 12' spacing.

University of Wisconsin-Madison

Protocol ID: Study Director:
Location: Investigator: Dr. Jeff Wyman

Reps: 4 Plots: 48 by 42 feet
Spray vol: 28.9 gal/ac Mix size: 20 gallons (min 6.4201)

Trt No.	Type	Treatment Name	Form Conc	Form Unit	Form Type	Rate	Rate Unit	Other Rate	Other Rate Unit	Growth Stage	Appl Code	Amt Product to Measure
1	INSE	Rimon	0.83	LB/G	EC	12	fl oz/a					245.6 ml/mx
	ADJ	Silwet	100	%	L	0.023	% v/v					17.41 ml/mx
2	INSE	Rimon	0.83	LB/G	EC	6	fl oz/a					122.8 ml/mx
	INSE	Alverde	2	LB/GAL	SC	2.375	fl oz/a					48.6 ml/mx
	ADJ	Silwet	100	%	L	0.023	% v/v					17.41 ml/mx
3	INSE	Alverde	2	LB/GAL	SC	4.75	fl oz/a					97.2 ml/mx
	ADJ	Silwet	100	%	L	0.023	% v/v					17.41 ml/mx
4	INSE	Rimon	0.83	LB/G	EC	6	fl oz/a					122.8 ml/mx
	ADJ	Silwet	100	%	L	0.023	% v/v					17.41 ml/mx
5	CHK	UTC										

Sort Order: Treatment

Product quantities required for listed treatments and applications in one trial:

Amount*	Unit	Treatment Name	Lot Code
613.916	ml	Rimon 0.83 EC	
87.055	ml	Silwet 100 L	
182.256	ml	Alverde 2 SC	

* 'Per area' calculations based on spray volume= 28.9 gal/ac, mix size= 20 gallons (mix size basis).
* Product amount calculations increased 25 % for overage adjustment.
* 'Per volume' calculations use spray volume= 28.9 gal/ac, mix size= 20 gallons.

Results and Discussion: The experiment was planted 6 May 2008 and during which germination conditions were very good for first ground cracking which occurred approximately 2 weeks later on 16 May. During the first half of the growing season (e.g. June 13-23), very wet conditions prevailed over the plot with over 9 inches of precipitation recorded in this 10 day interval. Foliar applications of experimental treatments were applied on 16, 23, and 30 June plus 6 July. The plot was later vine killed on 22 and 29 August using 2 foliar applications of Reglone. Colorado potato beetle pressure at the experimental site was considered to be above average for what is typically observed at the Arlington AES provided that we experienced ideal conditions for CPB overwintering under a continuous snow cover. Only a single, foliar application of Asana XL was applied on 14 July to control developing populations of potato leafhopper which has exceeded threshold in a portion of the experimental plots.

Very few differences in the mean number of adult CPB were observed among sample dates in the experimental plots. Overwintering adult CPB had invaded the plots shortly after emergence from the soil and began mating and laying eggs within the first week of colonization. Early in the test, significantly fewer adult CPB were observed on the majority of foliar treatments (Table 1) and again during the emergence of the 2nd generation on the last sample dates. In all cases, the foliar treatments performed well to lower total adult numbers during the course of the

experiment. In addition, few significant differences in the mean number of small larvae (L1 – L3) were detected among experimental treatments (Table 2). The greatest overall differences occurred between experimental treatments and the untreated control plot in the earliest sample date (25 June). Thereafter, all treatments contained significantly fewer small larvae than the UTC. Similarly, the different treatments examined in the study performed equally well in controlling developing populations of large CPB larvae, which can rapidly damage and defoliate young plants. Very few differences in mean numbers of large larvae (L4 & L5) were observed and this again occurred on the earliest sample date (Table 3). Few significant differences in the mean number of egg masses were recorded among experimental plots (Table 4). No clear pattern emerged among the various treatments over time in the reduction of total counted egg masses. In general, all treatments containing metaflumizone performed best over sample dates followed by the treatments containing novaluron alone. This likely resulted from the residual control of adult beetles in plots treated with metaflumizone.

Notable differences were observed, however, in the number of viable egg masses collected throughout the experimental plots over time (Table 5). Specifically, novaluron treatments significantly reduced egg viability in 5 of the 6 sample dates compared to the metaflumizone standard which performed similar to the UTC. The novaluron treatment containing the highest rate (12.0 fl oz / acre) had the greatest overall reduction in egg mass viability compared the lower rates of novaluron. Finally, total yield and quality estimates among a sub-sample of tubers harvested from the plots revealed very few differences among the experimental treatments (Table 6). Only the untreated control under performed with respect to total cwt / acre and mean proportion of marketable tubers / acre in different USDA grades.

Summary. The Rimon® foliar applications performed equal to the foliar standard (Alverde™) in protecting the potato crop from damaging populations of the CPB throughout the entire first generation. Furthermore, the novaluron provided significant reductions in the number of viable egg masses compared with the Alverde foliar standard and the UTC suggesting that this material does provide very adequate ovicidal control.

Table 1. Mean (± SE) number of adult Colorado potato beetles counted on 10 plants in experimental plots located at the Arlington, Agricultural Experiment Station (AES), Arlington, WI.

Treatment	Trt No	Rate	Number of Applications (days)[2]	Mean (± SE) Number of Adult CPB / 10 plants[1]					
				16 June	25 June	2 July	10 July	17 July	23 July
Rimon 0.83 EC	1	12.0 fl oz/ac	2 (14 days)	3.0 ± 0.9 b	1.8 ± 0.8 b	0.5 ± 0.5	0.5 ± 0.5 bc	4.5 ± 1.7 b	8.2 ± 3.2 b
Rimon 0.83 EC Alverde 2SC	2	6.0 fl oz/ac 2.375 fl oz/ac	2 (14 days)	0.0 a	0.5 ± 0.3 ab	0.0	0.0 a	0.0 a	0.5 ± 0.3 ab
Alverde 2SC	3	4.75 fl oz/ac	2 (14 days)	0.0 a	0.0 a	0.0	0.0 a	0.5 ± 0.3 a	0.0 a
Rimon 0.83EC	4	6.0 fl oz/ac	4 (7 days)	0.0 a	1.0 ± 0.7 ab	0.0	0.3 ± 0.3 ab	0.5 ± 0.5 a	1.8 ± 1.1 ab
UTC	5	N/A	--	6.0 ± 1.9 c	1.3 ± 0.8 ab	0.0	1.8 ± 1.0 c	14.8 ± 3.7 c	22.6 ± 9.3 c

[1] Means followed by the same letter are not significantly different ($P > 0.05$; Fisher's Protected LSD; n = 4).

[2] Spray application dates occurred 16 and 30 June for treatment numbers 1, 2 and 3. Application dates for treatment 4 occurred on 16, 23, and 30 June plus 6 July.

Table 2. Mean (± SE) number of small larvae (L1 – L3) of Colorado potato beetles counted on 10 plants in experimental plots located at the Arlington, Agricultural Experiment Station (AES), Arlington, WI.

Treatment	Trt No	Rate	Number of Applications (days)[2]	Mean (± SE) Number of CPB Small Larvae/ 10 plants[1]					
				16 June	25 June	2 July	10 July	17 July	23 July
Rimon 0.83 EC	1	12.0 fl oz/ac	2 (14 days)	0.0	17.0 ± 7.5 c	1.0 ± 1.0 a	0.0 a	0.0	0.0 a
Rimon 0.83 EC Alverde 2SC	2	6.0 fl oz/ac 2.375 fl oz/ac	2 (14 days)	0.0	3.0 ± 1.8 a	0.0 a	0.0 a	0.0	0.0 a
Alverde 2SC	3	4.75 fl oz/ac	2 (14 days)	0.0	1.8 ± 0.8 a	0.0 a	0.0 a	0.0	0.0 a
Rimon 0.83EC	4	6.0 fl oz/ac	4 (7 days)	0.0	8.3 ± 2.4 b	0.0 a	0.0 a	0.0	0.0 a
UTC	5	N/A	--	0.0	55.5 ± 10.2 d	46.3 ± 7.1 b	7.3 ± 3.3 b	0.3 ± 0.3	9.4 ± 3.3 b

[1] Means followed by the same letter are not significantly different ($P > 0.05$; Fisher's Protected LSD; n = 4).

[2] Spray application dates occurred 16 and 30 June for treatment numbers 1, 2 and 3. Application dates for treatment 4 occurred on 16, 23, and 30 June plus 6 July.

Table 3. Mean (± SE) number of large larvae (L4 & L5) of Colorado potato beetles counted on 10 plants in experimental plots located at the Arlington, Agricultural Experiment Station (AES), Arlington, WI.

				Mean (± SE) Number of CPB Large Larvae/ 10 plants[1]					
Treatment	Trt No	Rate	Number of Applications (days)[2]	16 June	25 June	2 July	10 July	17 July	23 July
Rimon 0.83 EC	1	12.0 fl oz/ac	2 (14 days)	0.0	1.8 ± 1.2 b	0.0 a	0.3 ± 0.3 ab	0.0 a	0.0 a
Rimon 0.83 EC Alverde 2SC	2	6.0 fl oz/ac 2.375 fl oz/ac	2 (14 days)	0.0	0.0 a	0.0 a	0.0 a	0.0 a	0.5 ± 0.3 ab
Alverde 2SC	3	4.75 fl oz/ac	2 (14 days)	0.0	0.0 a	0.0 a	0.0 a	0.3 ± 0.3 a	0.0 a
Rimon 0.83EC	4	6.0 fl oz/ac	4 (7 days)	0.0	0.5 ± 0.5 ab	0.5 ± 0.5 a	0.0 a	0.0 a	0.0 a
UTC	5	N/A	--	0.0	8.0 ± 3.3 c	6.0 ± 3.8 b	53.8 ± 8.9 b	5.0 ± 2.5 b	3.3 ± 2.1 b

[1] Means followed by the same letter are not significantly different ($P > 0.05$; Fisher's Protected LSD; n = 4).

[2] Spray application dates occurred 16 and 30 June for treatment numbers 1, 2 and 3. Application dates for treatment 4 occurred on 16, 23, and 30 June plus 6 July.

Table 4. Mean (± SE) number of egg masses of Colorado potato beetles counted on 10 plants in experimental plots located at the Arlington, Agricultural Experiment Station (AES), Arlington, WI.

Treatment	Trt No	Rate	Number of Applications (days)[2]	Mean (± SE) Number of CPB Egg Masses / 10 plants[1]					
				16 June	25 June	2 July	10 July	17 July	23 July
Rimon 0.83 EC	1	12.0 fl oz/ac	2 (14 days)	2.2 ± 0.4 a	3.3 ± 2.0 ab	0.3 ± 0.2 ab	1.0 ± 0.4 b	0.8 ± 0.4 b	0.0 a
Rimon 0.83 EC Alverde 2SC	2	6.0 fl oz/ac 2.375 fl oz/ac	2 (14 days)	2.6 ± 0.5 a	0.3 ± 0.3 ab	0.0 a	0.0 a	0.0 a	0.0 a
Alverde 2SC	3	4.75 fl oz/ac	2 (14 days)	2.9 ± 0.6 a	0.3 ± 0.3 c	0.0 a	0.0 a	0.0 a	0.0 a
Rimon 0.83EC	4	6.0 fl oz/ac	4 (7 days)	2.6 ± 0.6 a	1.0 ± 0.7 a	0.5 ± 0.5 ab	0.3 ± 0.3 ab	0.5 ± 0.3 b	0.0 a
UTC	5	N/A	--	5.8 ± 0.8 b	1.8 ± 0.8 b	8.2 ± 3.9 b	1.3 ± 0.5 b	0.9 ± 0.5 b	2.1 ± 0.6 b

[1] Means followed by the same letter are not significantly different ($P > 0.05$; Fisher's Protected LSD; n = 4).

[2] Spray application dates occurred 16 and 30 June for treatment numbers 1, 2 and 3. Application dates for treatment 4 occurred on 16, 23, and 30 June plus 6 July.

Table 5. Mean (± SE) percent Colorado potato beetle egg mass hatch from egg masses collected in experimental plots located at the Arlington, Agricultural Experiment Station (AES), Arlington, WI.

Treatment	Trt No	Rate	Number of Applications (days)[2]	Mean (± SE) Percent CPB Egg Mass Hatch / 10 Egg Masses[1]					
				16 June	25 June	2 July	10 July	17 July	23 July
Rimon 0.83 EC	1	12.0 fl oz/ac	2 (14 days)	98.5 ± 2.5	37.5 ± 12.5 a	22.5 ± 7.5 a	10.4 ± 6.3 a	28.5 ± 6.3 a	55.0 ± 7.2 a
Rimon 0.83 EC Alverde 2SC	2	6.0 fl oz/ac 2.375 fl oz/ac	2 (14 days)	97.5 ± 2.4	70.0 ± 7.0 b	72.5 ± 6.3 b	46.3 ± 11.8 b	68.3 ± 8.3 b	60.5 ± 8.5 ab
Alverde 2SC	3	4.75 fl oz/ac	2 (14 days)	93.8 ± 3.0	90.0 ± 4.1 b	92.5 ± 2.5 c	89.4 ± 4.1 c	100.0 c	92.5 ± 5.5 bc
Rimon 0.83EC	4	6.0 fl oz/ac	4 (7 days)	97.5 ± 2.5	75.0 ± 11.9 b	22.5 ± 10.3 a	60.0 ± 12.1 b	70.0 ± 12.2 b	82.0 ± 8.1 b
UTC	5	N/A	--	100.0	92.5 ± 4.8 b	90.0 ± 3.0 c	95.0 ± 5.0 c	97.5 ± 2.2 c	100.0 c

[1] Means followed by the same letter are not significantly different ($P > 0.05$; Fisher's Protected LSD; n = 4).

[2] Spray application dates occurred 16 and 30 June for treatment numbers 1, 2 and 3. Application dates for treatment 4 occurred on 16, 23, and 30 June plus 6 July.

Table 6. Mean (± SE) yield and quality parameters collected from experimental treatments located at the Arlington, Agricultural Experiment Station (AES), Arlington, WI.

				Mean Yield and Quality Parameters / Treatment[1]		
Treatment	Trt No	Rate	Number of Applications (days)	Mean Proportion. US #1, Grade A	Mean Proportion. US #1, Grade B	Mean Total Yield (cwt. / ac)
Rimon 0.83 EC	1	12.0 fl oz/ac	2 (14 days)	89.8 ± 1.9 a	10.1 ± 1.9 a	447.8 ± 57.0 a
Rimon 0.83 EC Alverde 2SC	2	6.0 fl oz/ac 2.375 fl oz/ac	2 (14 days)	93.1 ± 1.7 a	6.9 ± 1.7 a	468.9 ± 35.6 a
Alverde 2SC	3	4.75 fl oz/ac	2 (14 days)	92.5 ± 2.2 a	7.5 ± 2.3 a	488.5 ± 78.8 a
Rimon 0.83EC	4	6.0 fl oz/ac	4 (7 days)	92.1 ± 1.7 a	7.9 ± 1.7 a	470.4 ± 60.9 ab
UTC	5	N/A	--	84.2 ± 3.7 a	15.8 ± 4.8 a	206.6 ± 21.7 b

[1] Means followed by the same letter are not significantly different ($P > 0.05$; Fisher's Protected LSD; n = 4).

Part 3. Full Season Insect Control with Systemic and Foliar Insecticides – Hancock 2008.

In a study conducted at the Hancock Agricultural Research Station, Hancock, Wisconsin, experimental and registered systemic and foliar insecticides were evaluated for efficacy on Colorado potato beetles, potato leafhoppers and aphids. Insect management programs were designed to primarily target the Colorado potato beetle (CPB). Insecticides were chosen to target early, mid and late season CPB populations; not necessarily 1st or 2nd generations.

Russet Burbank variety potatoes were planted on 22 April 2008 into twelve 50' row plots, replicated three times in a randomized complete block design. All plots were separated by 15' of cultivated alleyway and replicates were 15' apart. Plot maintenance was per commercial production practices and was completed by HARS personnel.

Nine management programs were evaluated:

Systemic based programs:

1. Cruiser 5FS (0.16 fl. oz./cwt) seed treated followed by; Voliam Xpress 2ZC (7.0 oz./a) 2 apps (14 days)

2. Admire Pro 4.6SC (8.7 oz/a) and Regent 4SC (3.2 oz/a) in furrow followed by; Alverde 2SC (4.5 oz/a) + Penetrator Plus at 0.25% v/v. 2 apps (10-14 days)

3. Platinum 2SC (8.0 oz/a) in furrow followed by Coragen 1.67SC (3.5 oz/a) 2 apps (14 days)

4. Belay 16WSG (16.0 oz/a) in furrow followed by Alverde 2SC (4.5 oz/a) + Penetrator Plus at 0.25% v/v.

5. Belay 2.13SC (0.6 oz/cwt) seed treated followed by; Alverde 2SC (4.5 oz/a) + Penetrator Plus at 0.25% v/v. 2 apps (14 days)

Foliar based programs:

6. Radiant 1SC (4.58.0 fl. oz./a) 2 apps (7 days) Coragen 1.67SC (3.5 oz./a) 2 apps (14 days)

7. Rimon 0.83EC (12 fl. oz./a) 2 apps (7 days) Alverde 2SC (4.5 oz/a) + Penetrator Plus at 0.25% v/v. 2 apps (14 days)

8. Agrimek 0.15EC (12 fl oz/a) 2 apps (7 days) Voliam Xpress (7.0 oz/a) 2 apps (14 days)

9. Alverde 2SC (4.5 oz/a) + Penetrator Plus at 0.25% v/v. 2 apps (7 days) Assail 30SG (4.0 oz/a) 2 apps (14 days)

10. Assail 30SG (4.0 oz/a) 2 apps (10 days)
    Coragen 1.67SC (3.5 oz/a) 2 apps (14 days)

11. Assail 30SG (4.0 oz/a) Bifenture 2EC (2.5 oz/a) 2 apps (10 days)
    Coragen 1.67SC (3.5 oz/a) 2 apps (14 days)

12. Assail 30SG (4.0 oz/a) KFD-47 1ME (3.5 oz/a) 2 apps (10 days)
    Coragen 1.67SC (3.5 oz/a) 2 apps (14 days)

13. Novodor (2.75 L/a) 2 apps (14 days)
    Entrust 80WP (2.0 oz/a) 2 apps (14 days)

14. Actara 25WG (3.0 oz/a) 2 apps (10 days)
    Voliam Xpress (7.0 oz/a) 2 apps (14 days)

15. Agri-Mek 0.15EC (12.0 oz/a) 2 apps (7 days)
    Voliam Flexi (4.0 oz/a) 2 apps (14 days)

Seed spray treatments were applied with a CO_2 pressurized backpack sprayer operating at 30 psi. Preweighed, cut and suberized potato seed was placed in a single layer and sprayed with half of a spray solution. The seed was allowed to dry and then it was flipped over and the remaining spray solution was applied on the other half of the seed pieces. Treated seed was machine planted into solid blocks of potatoes (36' x 50'). In furrow insecticides were applied in a 4-6" band over suberized seed pieces placed into an open furrow using a CO_2 pressurized back pack sprayer with a single hollow cone nozzle (TXVS-6) delivering 5 gpa at 30 psi.

Foliar materials were applied with Hancock Agricultural Research Stations "Spray Coupe".

Colorado potato beetle (CPB) populations were surveyed weekly from 4 June through 19 August by counting CPB life stages (adults, egg masses, small and large larvae) on ten plants randomly selected from the center two rows of each plot. Damage was recorded weekly by estimating percent defoliation of each plot. Potato leafhopper adults were surveyed weekly from 17 June through 19 August with sweep sampling (25 sweeps per plot). Potato leafhopper nymph, green peach aphid and potato aphids were also surveyed weekly from 17 June through 19 August but with leaf sampling (25 leaves per plot).

Plots were overhead irrigated with 0.4-0.6" water every 2-5 days from plant emergence to vine kill for a total of 20.61 inches.

Plots were vine killed on 17 September (Reglone 1 pt./a) and a single row from the center from each plot was harvested and graded for yield on 3 October. Plot maintenance was conducted by Hancock Agriculture Research Station personnel and was per commercial production.

Table 1. Colorado potato beetle adults sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean adults per 10 plants					
	4 June	10 June	17 June	24 June	1 July	8 July
1	0.7 a	6 a	5.7 a	1.3 bcd	1.0 a	0.0 a
2	2.0 a	4.7 a	2.7 a	2.0 bc	0.0 a	0.7 a
3	0.3 a	4.0 a	1.3 a	2.0 bc	2.0 a	0.0 a
4	0.7 a	5.7 a	4.3 a	6.0 a	0.7 a	0.0 a
5	0.7 a	5.3 a	3.7 a	2.7 b	1.0 a	0.0 a
6	2.7 a	5.3 a	3.0 a	0.3 cd	1.3 a	0.7 a
7	---	---	---	1.3 bcd	0.0 a	2.3 a
8	---	---	---	0.0 d	0.0 a	0.0 a
9	---	---	---	0.0 d	1.0 a	0.3 a
10	---	---	---	1.3 bcd	0.7 a	0.0 a
11	---	---	---	0.3 cd	2.7 a	0.0 a
12	---	---	---	0.3 cd	1.3 a	0.0 a
13	---	---	---	0.7 cd	0.0 a	0.0 a
14	---	---	---	1.3 bcd	1.7 a	0.0 a
15	---	---	---	1.0 bcd	0.3 a	1.7 a
LSD	0.58	1.04	0.94	0.64	0.67	0.49
S.D.	0.32	0.57	0.52	0.39	0.40	0.29
C.V.	22.2	23.53	25.74	26.51	30.18	26.17
F	2.816	0.206	1.308	3.548	1.273	1.745
Prob. (F)	0.0769	0.9524	0.3349	0.0021	0.2834	0.1021

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 1. (Continued). Colorado potato beetle adults sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean adults per 10 plants					
	16 July	23 July	29 July	5 August	12 August	19 August
1	0.0 a	19.0 bc	31.3 cde	12.3 bc	19.7 a-d	8.3 a
2	0.3 a	28.7 b	45.7 bc	1.0 d	2.7 fg	9.7 a
3	1.0 a	22.0 bc	69.3 ab	31.3 a	27.3 abc	16.7 a
4	1.3 a	16.0 c	91.3 a	40.0 a	35.0 a	19.0 a
5	0.7 a	20.0 bc	35.7 bcd	1.0 d	5.3 efg	2.0 a
6	1.7 a	4.7 d	22.7 d-g	14.3 bc	17.3 b-f	8.0 a
7	0.7 a	4.7 d	8.3 fg	4.0 cd	17.3 a-e	9.3 a
8	1.0 a	3.7 d	23.0 c-f	23.0 ab	31.7 ab	7.3 a
9	0.0 a	3.0 d	4.3 g	1.7 d	8.3 c-g	2.3 a
10	1.0 a	4.0 d	4.0 g	5.0 cd	16.3 b-g	7.0 a
11	1.7 a	6.0 d	5.3 g	4.7 cd	18.0 a-e	12.3 a
12	2.7 a	7.3 d	4.0 g	1.7 d	11.7 c-g	7.7 a
13	2.7 a	45.3 a	31.7 cde	4.7 cd	2.0 g	1.3 a
14	0.7 a	4.7 d	5.7 fg	6.0 cd	9.3 c-g	13.0 a
15	0.0 a	4.0 d	12.3 efg	0.7 d	8.3 d-g	14.3 a
LSD	0.64	1.21	2.25	1.72	2.05	1.82
S.D.	0.38	0.73	1.35	1.03	1.23	1.09
C.V.	28.08	21.71	29.84	36.25	33.48	37.08
F	1.558	12.858	8.795	7.022	3.434	1.771
Prob. (F)	0.1543	0.0001	0.0001	0.0001	0.0026	0.0962

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 2. Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean egg masses per 10 plants					
	4 June	10 June	17 June	24 June	1 July	8 July
1	0.0 a	0.3 b	1.7 a	4.0 a	1.7 a	0.0 a
2	0.0 a	1.3 b	2.3 a	0.3 a	0.7 a	1.0 a
3	0.0 a	1.0 b	4.3 a	2.0 a	3.7 a	0.3 a
4	0.0 a	0.3 b	2.7 a	2.0 a	0.3 a	0.7 a
5	0.0 a	0.0 b	1.7 a	1.0 a	0.7 a	0.7 a
6	0.3 a	6.0 a	1.7 a	1.3 a	0.7 a	1.0 a
7	---	---	---	2.7 a	0.3 a	1.0 a
8	---	---	---	2.0 a	0.0 a	0.3 a
9	---	---	---	1.0 a	1.0 a	1.0 a
10	---	---	---	1.7 a	1.0 a	0.3 a
11	---	---	---	2.0 a	0.7 a	0 a
12	---	---	---	1.0 a	0.0 a	0.3 a
13	---	---	---	2.0 a	0.3 a	0.7 a
14	---	---	---	0.7 a	1.3 a	0.3 a
15	---	---	---	1.3 a	0.3 a	1.7 a
LSD	0.18	0.45	0.83	0.80	0.62	0.44
S.D.	0.10	0.25	0.45	0.48	0.37	0.26
C.V.	9.54	16.93	25.52	30.94	28.45	21.34
F	1.000	17.661	1.121	0.680	1.616	1.093
Prob. (F)	0.4651	0.0001	0.4086	0.7738	0.1359	0.4044

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 2. (Continued). Colorado potato beetle egg masses sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean egg masses per 10 plants					
	16 July	23 July	29 July	5 August	12 August	19 August
1	0.0 a	0.3 a	1.3 a	0.3 a	0.0 a	0.0 a
2	0.7 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
3	0.0 a	0.3 a	0.3 a	0.0 a	0.0 a	0.0 a
4	0.3 a	0.3 a	0.7 a	0.0 a	0.0 a	0.0 a
5	0.0 a	0.7 a	1.7 a	0.0 a	0.0 a	0.0 a
6	0.0 a	0.0 a	0.3 a	0.0 a	0.0 a	0.0 a
7	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
8	0.3 a	0.7 a	0.7 a	0.3 a	0.0 a	0.0 a
9	0.3 a	0.7 a	0.3 a	0.0 a	0.3 a	0.0 a
10	0.3 a	0.3 a	1.7 a	0.0 a	0.0 a	0.0 a
11	0.3 a	0.7 a	0.3 a	0.0 a	0.3 a	0.0 a
12	0.3 a	0.7 a	0.7 a	0.7 a	0.0 a	0.3 a
13	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
14	0.0 a	0.0 a	0.0 a	0.3 a	0.0 a	0.0 a
15	0.7 a	0.3 a	0.3 a	0.0 a	0.0 a	0.0 a
LSD	0.33	0.45	0.48	0.19	0.15	0.10
S.D.	0.20	0.27	0.29	0.11	0.09	0.06
C.V.	17.91	23.97	23.67	10.82	8.73	6.12
F	0.725	0.463	1.462	1.702	0.897	1.000
Prob. (F)	0.7329	0.9346	0.1901	0.1123	0.5713	0.4794

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 3. Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean larvae per 10 plants					
	4 June	10 June	17 June	24 June	1 July	8 July
1	0.0 a	0.0 a	0.0 b	11.7 a	41.0 a	12.3 ab
2	0.0 a	0.0 a	0.0 b	1.3 a	23.0 abc	8.3 a-d
3	0.0 a	0.0 a	0.0 b	4.3 a	16.3 bcd	8.3 a-d
4	0.0 a	0.0 a	0.0 b	8.3 a	18.7 bcd	8.3 abc
5	0.0 a	0.0 a	0.0 b	5.0 a	10.7 b-e	13.3 a
6	0.0 a	0.0 a	14.0 a	1.0 a	1.3 e-h	2.0 cde
7	---	---	---	9.0 a	6.7 d-h	0.0 e
8	---	---	---	2.3 a	0.0 h	3.7 b-e
9	---	---	---	5.0 a	11.7 b-f	0.0 e
10	---	---	---	1.3 a	9.0 b-g	0.3 e
11	---	---	---	5.0 a	6.3 c-h	0.0 e
12	---	---	---	0.0 a	1.0 fgh	0.0 e
13	---	---	---	8.3 a	24.3 ab	12.7 a
14	---	---	---	0.0 a	12.0 bcd	0.0 e
15	---	---	---	1.7 a	0.3 gh	1.7 de
LSD	0.00	0.00	0.99	1.64	2.02	1.41
S.D.	0.00	0.00	0.59	0.98	1.21	0.84
C.V.	0.00	0.00	51.03	49.52	38.29	42.1
F	0.000	0.000	3.267	1.564	4.936	4.384
Prob. (F)	1.0000	1.0000	0.0037	0.1524	0.0002	0.0004

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 3. (Continued). Colorado potato beetle small larvae sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean larvae per 10 plants					
	16 July	23 July	29 July	5 August	12 August	19 August
1	0.0 a	0.0 c	0.0 a	0.0 a	0.0 a	0.0 a
2	2.0 a	0.0 c	1.7 a	0.0 a	0.0 a	0.0 a
3	6.7 a	1.0 c	0.7 a	0.0 a	0.0 a	0.0 a
4	4.7 a	0.3 c	0.0 a	0.0 a	0.0 a	0.0 a
5	0.0 a	0.0 c	0.0 a	0.0 a	0.0 a	0.3 a
6	50 a	13.3 ab	0.0 a	0.0 a	0.0 a	0.0 a
7	13.0 a	16.7 a	14.7 a	0.0 a	0.0 a	0.0 a
8	1.7 a	0.3 c	7.0 a	0.0 a	0.0 a	0.0 a
9	0.0 a	0.0 c	0.0 a	0.0 a	1.7 a	0.3 a
10	0.3 a	0.3 c	17.0 a	0.0 a	0.3 a	0.0 a
11	1.3 a	0.3 c	12.3 a	1.0 a	0.3 a	0.0 a
12	5.3 a	4.0 bc	11.3 a	1.0 a	0.0 a	0.0 a
13	0.3 a	0.0 c	0.0 a	0.0 a	0.0 a	0.0 a
14	1.7 a	0.0 c	6.0 a	0.0 a	0.3 a	0.0 a
15	2.3 a	6.3 abc	4.0 a	0.0 a	0.0 a	0.0 a
LSD	1.65	1.56	2.26	0.34	0.48	0.15
S.D.	0.99	0.94	1.35	0.20	0.29	0.09
C.V.	58.47	60.28	69.33	19.45	26.43	8.73
F	1.388	2.876	1.838	1.000	0.788	0.897
Prob. (F)	0.2229	0.0084	0.0829	0.4793	0.6732	0.5713

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 4. Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean larvae per 10 plants					
	4 June	10 June	17 June	24 June	1 July	8 July
1	0.0 a	0.0 a	0.0 a	0.0 a	28.7 a	12.7 cd
2	0.0 a	0.0 a	0.0 a	0.0 a	16.0 abc	28.0 b
3	0.0 a	0.0 a	0.0 a	0.0 a	14.3 abc	37.0 ab
4	0.0 a	0.0 a	0.0 a	0.0 a	14.0 abc	35.0 b
5	0.0 a	0.0 a	0.0 a	0.0 a	9.0 b-e	27.7 b
6	0.0 a	0.0 a	0.0 a	0.0 a	1.0 def	9.0 cd
7	---	---	---	0.0 a	3.0 c-f	1.7 de
8	---	---	---	1.3 a	0.0 f	11.3 c
9	---	---	---	0.0 a	14.3 bcd	0.3 e
10	---	---	---	0.0 a	5.0 b-f	0.0 e
11	---	---	---	0.0 a	3.7 b-f	0.0 e
12	---	---	---	0.0 a	0.7 def	0.0 e
13	---	---	---	0.3 a	14.0 ab	60.7 a
14	---	---	---	0.0 a	7.0 b-f	0.0 e
15	---	---	---	0.7 a	0.3 ef	6.7 cde
LSD	0	0	0	0.37	2.00	1.79
S.D.	0	0	0	0.22	1.19	1.07
C.V.	0	0	0	21.23	45.44	32.82
F	0	0	0	0.885	3.209	13.462
Prob. (F)	1	1	1	0.5821	0.0042	0.0001

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 4. (Continued). Colorado potato beetle large larvae sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean larvae per 10 plants					
	16 July	23 July	29 July	5 August	12 August	19 August
1	0.0 d	1.7 cd	0.0 d	0.0 a	0.0 a	0.0 b
2	0.3 d	2.0 cd	0.0 d	0.0 a	0.0 a	0.0 b
3	7.0 ab	2.3 bcd	0.3 d	0.0 a	0.0 a	0.0 b
4	4.3 bc	2.3 cd	1.0 cd	0.3 a	0.0 a	0.0 b
5	0.0 d	1.0 d	3.3 bcd	0.0 a	0.0 a	1.3 b
6	2.0 cd	7.0 abc	7.3 bcd	0.0 a	0.0 a	0.0 b
7	11.0 a	11.3 a	30.0 a	0.0 a	0.0 a	0.7 b
8	2.7 cd	8.7 ab	8.0 bcd	0.0 a	0.0 a	0.0 b
9	0.3 d	1.7 cd	0.0 d	0.0 a	0.0 a	3.7 a
10	2.7 cd	2.7 cd	1.3 bcd	0.3 a	0.0 a	0.3 b
11	1.3 cd	5.3 a-d	7.3 bcd	1.3 a	1.7 a	0.0 b
12	3.0 cd	10.3 a	11.7 bc	2.0 a	0.0 a	0.0 b
13	0.0 d	1.3 d	0.0 d	0.3 a	1.3 a	1.0 b
14	1.0 d	11.7 a	12.0 b	0.3 a	0.0 a	0.0 b
15	1.7 cd	6.0 a-d	7.3 bcd	1.0 a	0.0 a	0.3 b
LSD	0.88	1.36	1.95	0.54	0.41	0.52
S.D.	0.52	0.81	1.17	0.33	0.25	0.31
C.V.	31.34	36.92	54.09	28.93	23.24	26.63
F	5.412	2.664	3.474	0.915	1.439	2.607
Prob. (F)	0.0001	0.0133	0.0024	0.5541	0.1997	0.015

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 5. Percent defoliation ratings from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean defoliation per plot					
	4 June	10 June	17 June	24 June	1 July	8 July
1	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
2	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	1.7 a
3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	1.7 a
4	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	1.7 a
5	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	1.7 a
6	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
7	---	---	---	0.0 a	0.0 a	0.0 a
8	---	---	---	0.0 a	0.0 a	0.0 a
9	---	---	---	0.0 a	0.0 a	0.0 a
10	---	---	---	0.0 a	0.0 a	0.0 a
11	---	---	---	0.0 a	0.0 a	0.0 a
12	---	---	---	0.0 a	0.0 a	0.0 a
13	---	---	---	0.0 a	0.0 a	3.3 a
14	---	---	---	0.0 a	0.0 a	0.0 a
15	---	---	---	0.0 a	0.0 a	0.0 a
LSD	0.00	0.00	0.00	0.00	0.00	2.64
S.D.	0.00	0.00	0.00	0.00	0.00	1.58
C.V.	0.00	0.00	0.00	0.00	0.00	237.17
F	0.000	0.000	0.000	0.000	0.000	1.333
Prob. (F)	1.0000	1.0000	1.0000	1.0000	1.0000	0.2500

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 5. (Continued). Percent defoliation ratings from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean defoliation per plot					
	16 July	23 July	29 July	5 August	12 August	19 August
1	0.0 b	0.0 b	0.0 c	1.7 bc	1.7 c	8.3 d
2	0.0 b	0.0 b	5.0 bc	8.3 bc	3.3 c	8.3 d
3	0.0 b	0.0 b	10.0 b	15.0 bc	16.7 bc	40.0 bc
4	0.0 b	0.0 b	5.0 bc	15.0 bc	15.0 c	26.7 bcd
5	0.0 b	0.0 b	5.0 bc	8.3 bc	5.0 c	18.3 cd
6	0.0 b	0.0 b	1.7 bc	1.7 bc	10.0 c	48.3 b
7	0.0 b	0.0 b	1.7 bc	18.3 b	33.3 b	85.0 a
8	0.0 b	0.0 b	1.7 bc	3.3 bc	3.3 c	28.3 bcd
9	0.0 b	0.0 b	0.0 c	0.0 c	0.0 c	21.7 cd
10	0.0 b	0.0 b	0.0 c	0.0 c	0.0 c	13.3 d
11	0.0 b	0.0 b	0.0 c	0.0 c	0.0 c	8.3 d
12	0.0 b	0.0 b	0.0 c	0.0 c	0.0 c	10.0 d
13	2.3 a	5.0 a	35.0 a	73.3 a	75.0 a	83.3 a
14	0.0 b	0.0 b	0.0 c	0.0 c	0.0 c	8.3 d
15	0.0 b	0.0 b	0.0 c	0.0 c	1.7 c	18.3 cd
LSD	1.09	2.16	8.52	17.47	16.80	23.99
S.D.	0.65	1.29	5.09	10.45	10.05	14.35
C.V.	417.72	387.3	117.56	108.09	91.34	50.43
F	2.579	3.000	9.303	9.653	11.837	9.559
Prob. (F)	0.0159	0.0065	0.0001	0.0001	0.0001	0.0001

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 6. Potato leafhopper adults sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean adults per 25 sweeps				
	17 June	24 June	1 July	8 July	16 July
1	0.7 b	1.3 cde	0.3 a	0.0 c	0.0 a
2	0.0 b	2.0 cde	0.0 a	0.0 c	1.7 a
3	0.3 b	1.3 cde	0.0 a	0.0 c	1.0 a
4	0.7 b	2.3 cde	1.0 a	0.0 c	1.3 a
5	1.3 b	0.3 de	0.0 a	0.3 c	0.7 a
6	11.3 a	8.3 a	1.0 a	0.3 c	6.0 a
7	---	9.0 a	1.0 a	2.3 a	3.3 a
8	---	8.0 ab	1.0 a	0.7 bc	5.0 a
9	---	3.7 bcd	0.0 a	0.3 c	4.0 a
10	---	1.0 cde	0.3 a	0.3 c	1.3 a
11	---	0.0 e	0.0 a	0.0 c	0.0 a
12	---	0.0 e	0.7 a	0.3 c	1.0 a
13	---	1.7 cde	0.0 a	0.3 c	1.0 a
14	---	0.0 e	0.3 a	0.0 c	0.3 a
15	---	3.3 bc	1.0 a	1.3 b	3.3 a
LSD	0.61	0.89	0.45	0.33	0.97
S.D.	0.36	0.53	0.27	0.20	0.58
C.V.	29.57	30.05	23.02	17.02	36.31
F	8.324	5.560	1.164	3.925	1.984
Prob. (F)	0.0001	0.0001	0.3524	0.0010	0.0597

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 6. (Continued). Potato leafhopper adults sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean adults per 25 sweeps				
	23 July	29 July	5 August	12 August	19 August
1	0.0 a	0.0 b	0.3 c	0.0 c	0.0 c
2	0.3 a	0.0 b	0.0 c	0.3 bc	0.0 c
3	1.3 a	0.0 b	0.0 c	0.0 c	0.0 c
4	0.0 a	0.0 b	0.0 c	0.0 c	0.0 c
5	0.0 a	0.0 b	0.3 c	0.3 bc	0.0 c
6	1.7 a	1.7 a	1.3 bc	1.0 abc	1.3 ab
7	2.3 a	0.3 b	2.7 b	2.0 a	2.0 a
8	1.0 a	1.3 a	1.3 bc	0.0 c	0.0 c
9	1.0 a	0.0 b	0.0 c	0.0 c	0.3 bc
10	0.3 a	0.0 b	0.3 c	0.0 c	0.0 c
11	0.3 a	0.0 b	0.7 bc	0.3 bc	0.0 c
12	0.0 a	0.0 b	0.0 c	0.0 c	0.0 c
13	1.3 a	0.7 ab	7.0 a	1.4 ab	2.0 a
14	0.0 a	0.0 b	0.0 c	0.0 c	0.0 c
15	2.7 a	0.3 b	0.0 c	0.3 bc	0.0 c
LSD	0.59	0.34	0.75	0.40	0.40
S.D.	0.35	0.21	0.45	0.24	0.24
C.V.	27.42	18.64	37.71	21.18	22.12
F	2.018	2.532	0.955	2.062	0.905
Prob. (F)	0.0553	0.0177	0.5181	0.0501	0.5638

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 7. Potato leafhopper nymphs sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean nymphs per 25 leaves				
	17 June	24 June	1 July	8 July	16 July
1	0.0 a	0.0 a	0.3 a	0.0 c	0.0 c
2	0.0 a	0.0 a	0.0 a	0.0 c	0.0 c
3	0.0 a	0.0 a	0.3 a	0.0 c	0.0 c
4	0.0 a	0.0 a	0.3 a	0.3 c	1.3 c
5	0.0 a	0.0 a	0.0 a	1.0 bc	0.0 c
6	0.0 a	0.3 a	1.7 a	4.0 b	6.0 b
7		0.0 a	3.3 a	10.0 a	15.7 a
8		0.0 a	0.3 a	2.7 bc	1.0 c
9		0.0 a	0.7 a	1.3 bc	2.7 bc
10		0.3 a	0.0 a	1.0 c	0.0 c
11		0.0 a	0.0 a	2.0 bc	0.0 c
12		0.0 a	0.0 a	0.0 c	0.0 c
13		0.0 a	1.3 a	0.7 c	0.7 c
14		0.0 a	0.0 a	0.0 c	0.0 c
15		0.3 a	1.0 a	1.0 c	1.3 c
LSD	0	0.19	0.66	0.75	0.85
S.D.	0	0.11	0.39	0.45	0.51
C.V.	0	10.77	32.85	31.24	34.84
F	0	0.800	1.348	5.328	7.728
Prob. (F)	1	0.6620	0.2423	0.0001	0.0001

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 7. (Continued). Potato leafhopper nymphs sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean nymphs per 25 leaves				
	23 July	29 July	5 August	12 August	19 August
1	0.0 a	0.0 b	0.3 c	0.0 c	0.0 c
2	0.3 a	0.0 b	0.0 c	0.3 bc	0.0 c
3	1.3 a	0.0 b	0.0 c	0.0 c	0.0 c
4	0.0 a	0.0 b	0.0 c	0.0 c	0.0 c
5	0.0 a	0.0 b	0.3 c	0.3 bc	0.0 c
6	1.7 a	1.7 a	1.3 bc	1.0 abc	1.3 ab
7	2.3 a	0.3 b	2.7 b	2.0 a	2.0 a
8	1.0 a	1.3 a	1.3 bc	0.0 c	0.0 c
9	1.0 a	0.0 b	0.0 c	0.0 c	0.3 bc
10	0.3 a	0.0 b	0.3 c	0.0 c	0.0 c
11	0.3 a	0.0 b	0.7 bc	0.3 bc	0.0 c
12	0.0 a	0.0 b	0.0 c	0.0 c	0.0 c
13	1.3 a	0.7 ab	7.0 a	1.4 ab	2.0 a
14	0.0 a	0.0 b	0.0 c	0.0 c	0.0 c
15	2.7 a	0.3 b	0.0 c	0.3 bc	0.0 c
LSD	0.59	0.34	0.75	0.40	0.40
S.D.	0.35	0.21	0.45	0.24	0.24
C.V.	27.42	18.64	37.71	21.18	22.12
F	2.018	2.532	0.955	2.062	0.905
Prob. (F)	0.0553	0.0177	0.5181	0.0501	0.5638

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 8. Potato leafhopper hopperburn ratings from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean hopperburn per plot				
	17 June	24 June	1 July	8 July	16 July
1	0.0 a	0.3 cd	0.7 bc	0.3 c	0.0 d
2	0.0 a	0.7 cd	0.0 c	0.0 c	0.0 d
3	0.0 a	0.3 cd	0.3 bc	1.0 c	0.0 d
4	0.0 a	0.0 d	0.7 bc	0.3 c	0.0 d
5	0.0 a	0.3 cd	0.0 c	0.7 c	0.0 d
6	1.3 a	6.0 ab	8.7 a	5.3 ab	5.3 ab
7	---	8.0 a	5.3 a	2.0 abc	3.0 a-d
8	---	2.7 bc	1.7 abc	5.3 ab	5.7 a
9	---	5.7 ab	3.7 ab	5.7 ab	4.3 abc
10	---	1.0 cd	0.7 bc	1.7 bc	0.7 cd
11	---	0.0 d	0.0 c	0.7 c	0.0 d
12	---	0.0 d	0.0 c	0.0 c	0.7 cd
13	---	4.0 ab	2.7 abc	0.3 c	1.0 cd
14	---	1.0 cd	0.3 bc	0.3 c	0.3 d
15	---	4.7 ab	2.0 abc	5.7 a	2.0 bcd
LSD	0.53	0.77	1.03	0.92	0.82
S.D.	0.29	0.46	0.62	0.55	0.49
C.V.	27.26	27.77	41.40	35.10	34.34
F	1.000	6.567	2.317	3.364	3.626
Prob. (F)	0.4651	0.0001	0.0284	0.003	0.0018

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 8. (Continued). Potato leafhopper hopperburn ratings from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean hopperburn per plot				
	23 July	29 July	5 August	12 August	19 August
1	0.0 a	0.0 d	0.0 c	0.0 a	0.0 c
2	0.0 a	0.3 cd	0.0 c	0.0 a	0.0 c
3	0.3 a	0.7 bcd	0.0 c	0.0 a	0.0 c
4	0.0 a	0.3 cd	0.0 c	0.0 a	0.0 c
5	0.3 a	0.0 d	0.0 c	0.0 a	0.0 c
6	0.0 a	3.0 ab	0.7 b	0.0 a	1.0 b
7	2.7 a	2.3 a-d	2.3 a	0.3 a	2.0 a
8	2.0 a	3.3 ab	0.0 c	0.0 a	0.3 c
9	3.0 a	5.3 a	0.0 c	0.0 a	0.0 c
10	0.7 a	2.3 abc	0.0 c	0.7 a	0.0 c
11	1.0 a	0.7 bcd	0.0 c	0.0 a	0.3 c
12	0.3 a	0.3 cd	0.0 c	0.0 a	0.0 c
13	1.3 a	2.3 abc	1.0 bc	0.0 a	0.0 c
14	0.0 a	1.7 bcd	0.0 c	0.0 a	0.0 c
15	1.3 a	2.3 abc	0.0 c	0.0 a	0.0 c
LSD	0.70	0.78	0.21	0.21	0.28
S.D.	0.42	0.47	0.13	0.13	0.16
C.V.	32.49	30.36	11.62	12.41	15.54
F	1.655	2.659	8.735	0.911	1.495
Prob. (F)	0.1246	0.0134	0.0001	0.5581	0.1772

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 9. Aphids sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean aphids per 25 leaves				
	17 June	24 June	1 July	8 July	16 July
1	0.0 a	0.0 c	0.3 c	0.0 a	0.0 a
2	0.0 a	0.0 c	0.3 c	0.0 a	0.0 a
3	0.0 a	0.0 c	0.3 c	0.0 a	0.0 a
4	0.0 a	0.0 c	0.0 c	0.0 a	0.0 a
5	0.0 a	0.0 c	0.0 c	0.0 a	0.0 a
6	0.0 a	0.7 bc	1.0 bc	5.3 a	0.0 a
7	---	1.0 bc	2.0 ab	1.3 a	1.3 a
8	---	2.0 ab	1.3 bc	2.7 a	0.7 a
9	---	4.0 a	4.0 a	0.0 a	2.7 a
10	---	0.0 c	1.0 bc	0.7 a	0.3 a
11	---	0.0 c	0.0 c	0.0 a	0.0 a
12	---	0.0 c	0.0 c	0.0 a	0.0 a
13	---	2.0 bc	0.7 bc	0.7 a	0.7 a
14	---	0.0 c	0.0 c	0.0 a	0.0 a
15	---	0.3 bc	0.3 c	0.7 a	1.3 a
LSD	0.00	0.57	0.57	0.81	0.56
S.D.	0.00	0.34	0.34	0.48	0.33
C.V.	0.00	28.06	27.42	40.06	29.09
F	0.000	3.164	2.504	1.432	1.377
Prob. (F)	1.0000	0.0046	0.0188	0.2028	0.2281

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 9. (Continued). Aphids sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean aphids per 25 leaves				
	23 July	29 July	5 August	12 August	19 August
1	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
2	0.0 a	0.0 a	0.3 a	0.0 a	0.0 a
3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
4	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
5	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
6	0.3 a	0.0 a	0.3 a	0.0 a	0.0 a
7	0.0 a	0.0 a	0.3 a	0.0 a	0.0 a
8	0.3 a	0.0 a	0.0 a	0.0 a	0.0 a
9	0.3 a	0.3 a	0.0 a	0.0 a	0.0 a
10	0.0 a	0.3 a	0.0 a	0.0 a	0.0 a
11	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
12	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
13	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
14	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
15	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
LSD	0.18	0.15	0.18	0.00	0.00
S.D.	0.11	0.09	0.11	0.00	0.00
C.V.	10.41	8.73	10.41	0.00	0.00
F	0.857	0.897	0.857	0.000	0.000
Prob. (F)	0.6080	0.5713	0.6080	1.0000	1.0000

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 10. Green peach aphids sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean aphids per 25 leaves				
	17 June	24 June	1 July	8 July	16 July
1	0.0 a	0.0 b	0.0 a	0.0 d	0.0 b
2	0.0 a	0.0 b	0.0 a	0.3 cd	0.0 b
3	0.0 a	0.0 b	0.0 a	0.0 d	0.0 b
4	0.0 a	0.0 b	0.0 a	0.0 d	0.0 b
5	0.0 a	0.0 b	0.0 a	0.3 cd	0.0 b
6	0.0 a	0.0 b	0.0 a	2.7 a	0.3 b
7	---	0.0 b	0.7 a	1.7 ab	6.3 a
8	---	2.3 a	1.0 a	2.3 ab	1.3 b
9	---	0.0 b	0.7 a	1.3 abc	4.0 a
10	---	0.0 b	0.0 a	0.3 cd	0.3 b
11	---	0.0 b	0.0 a	0.0 d	0.0 b
12	---	0.0 b	0.0 a	0.0 d	0.3 b
13	---	0.0 b	0.7 a	1.0 bcd	0.7 b
14	---	0.0 b	0.0 a	0.0 d	0.0 b
15	---	0.0 b	0.7 a	1.0 bcd	0.7 b
LSD	0	0.28	0.34	0.44	0.64
S.D.	0	0.17	0.20	0.27	0.38
C.V.	0	16.14	18.5	21.04	30.04
F	0	3.871	1.426	3.989	4.312
Prob. (F)	1	0.0011	0.2056	0.0009	0.0005

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 10. (Continued). Green peach aphids sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean aphids per 25 leaves				
	23 July	29 July	5 August	12 August	19 August
1	0.0 b	0.0 a	0.0 a	0.0 a	0.0 a
2	0.0 b	0.0 a	0.0 a	0.0 a	0.0 a
3	0.0 b	0.0 a	0.0 a	0.0 a	0.0 a
4	0.0 b	0.0 a	0.0 a	0.0 a	0.0 a
5	0.0 b	0.3 a	0.0 a	0.0 a	0.3 a
6	0.0 b	0.7 a	0.0 a	0.0 a	0.3 a
7	0.7 a	1.3 a	0.0 a	0.3 a	0.0 a
8	0.0 b	1.0 a	0.0 a	0.0 a	0.3 a
9	0.0 b	0.0 a	0.3 a	1.3 a	0.0 a
10	0.0 b	0.3 a	0.0 a	0.0 a	0.0 a
11	0.0 b	0.0 a	0.0 a	0.0 a	0.0 a
12	0.0 b	0.0 a	0.3 a	0.0 a	0.7 a
13	0.0 b	0.7 a	0.0 a	0.1 a	0.0 a
14	0.0 b	0.0 a	0.0 a	0.0 a	0.0 a
15	0.3 ab	0.3 a	0.0 a	0.0 a	0.0 a
LSD	0.15	0.42	0.14	0.33	0.26
S.D.	0.09	0.25	0.08	0.20	0.16
C.V.	8.80	22.68	8.26	18.95	15.08
F	2.200	1.036	1.000	0.937	0.759
Prob. (F)	0.0368	0.4490	0.4794	0.5347	0.7005

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 11. Potato aphids sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean aphids per 25 leaves				
	17 June	24 June	1 July	8 July	16 July
1	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
2	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
4	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
5	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
6	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
7	---	0.0 a	0.0 a	0.0 a	0.0 a
8	---	0.0 a	0.0 a	0.0 a	0.0 a
9	---	0.0 a	0.0 a	0.0 a	0.0 a
10	---	0.0 a	0.0 a	0.0 a	0.0 a
11	---	0.0 a	0.0 a	0.0 a	0.0 a
12	---	0.0 a	0.0 a	0.0 a	0.0 a
13	---	0.0 a	0.0 a	0.0 a	0.0 a
14	---	0.0 a	0.0 a	0.0 a	0.0 a
15	---	0.0 a	0.0 a	0.0 a	0.0 a
LSD	0.00	0.00	0.00	0.00	0.00
S.D.	0.00	0.00	0.00	0.00	0.00
C.V.	0.00	0.00	0.00	0.00	0.00
F	0.000	0.000	0.000	0.000	0.000
Prob. (F)	1.0000	1.0000	1.0000	1.0000	1.0000

(Continued)

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 11. (Continued). Potato aphids sampled from Russet Burbank variety potatoes managed with various insecticide programs. Hancock Ag Research Station, Hancock, WI 2008.

Management Program	Mean aphids per 25 leaves				
	23 July	29 July	5 August	12 August	19 August
1	0.0 a	0.0 c	0.0 b	0.0 b	0.0 b
2	0.0 a	0.0 c	0.0 b	0.0 b	0.0 b
3	0.0 a	0.0 c	0.0 b	0.0 b	0.0 b
4	0.0 a	0.0 c	0.0 b	0.0 b	0.0 b
5	0.0 a	0.0 c	0.0 b	0.0 b	0.0 b
6	0.0 a	0.7 ab	0.3 b	1.0 a	1.0 a
7	0.3 a	1.0 a	1.0 a	1.0 a	1.0 a
8	0.0 a	0.3 bc	0.3 b	0.3 b	0.0 b
9	0.0 a	0.0 c	0.0 b	0.0 b	0.3 b
10	0.0 a	0.0 c	0.0 b	0.0 b	0.0 b
11	0.0 a	0.0 c	0.0 b	0.0 b	0.0 b
12	0.0 a	0.0 c	0.0 b	0.0 b	0.0 b
13	0.3 a	0.7 ab	1.0 a	0.5 ab	0.0 b
14	0.0 a	0.0 c	0.0 b	0.0 b	0.0 b
15	0.0 a	0.0 c	0.0 b	0.3 b	0.3 b
LSD	0.36	0.43	0.35	0.55	0.39
S.D.	0.21	0.26	0.21	0.33	0.23
C.V.	482.74	143.50	118.59	157.82	130.35
F	0.897	5.024	8.429	3.509	6.975
Prob. (F)	0.5713	0.0001	0.0001	0.0025	0.0001

Means in a column followed by the same letter are not significantly different, LSD (P=0.05).

Table 12. Yields from Russet Burbank variety potatoes treated with systemic insecticides. Hancock Agricultural Research Station, Hancock, WI 2008.

Management program	Proportion Grade			Yield (cwt/A)
	A	B	Culls	
1	0.78 b	0.18 a	0.04 a	506.17 a
2	0.82 ab	0.13 a	0.05 a	489.55 a
3	0.77 b	0.16 a	0.07 a	482.68 a
4	0.76 b	0.18 a	0.05 a	438.57 a
5	0.83 ab	0.13 a	0.04 a	464.93 a
6	0.66 c	0.21 a	0.14 a	358.01 a
7	0.75 bc	0.19 a	0.06 a	408.03 a
8	0.81 ab	0.14 a	0.05 a	448.66 a
9	0.81 ab	0.13 a	0.05 a	467.97 a
10	0.81 ab	0.11 a	0.08 a	534.53 a
11	0.81 ab	0.15 a	0.04 a	572.72 a
12	0.77 b	0.19 a	0.04 a	419.34 a
13	0.80 ab	0.14 a	0.05 a	451.01 a
14	0.85 ab	0.10 a	0.05 a	535.40 a
15	0.88 a	0.11 a	0.01 a	500.08 a
LSD	0.10	0.085	0.06	119.175
S.D.	0.06	0.051	0.036	70.992
C.V.	7.49	33.57	66.90	15.05
F	2.219	1.312	1.683	1.806
Prob. (F)	0.0382	0.2657	0.1219	0.0933

Means in a column followed by the same letter are not significantly different LSD (P = 0.05).

SECTION I. PART 4.

2008 WISCONSIN SURVEYS OF COLORADO POTATO BEETLE INSENSITIVITY TO NEONICOTINOIDS

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Abstract. This project continues to be directed at further enhancing our present integrated pest management strategies for key insect pests in potato with a focus on the development of integrated chemical, biological, and cultural management practices. A primary focus of the proposed work has been to accurately identify pest management strategies that reduce the total number of insecticide applications, limit the onset or development of insecticide resistance, and provide novel or refined management tactics for the sequence of insect control measures implemented. An emphasis of this project continues to focus on documenting the occurrence and increase(s) in neonicotinyl resistance among populations of Colorado potato beetle while also providing practical guidance towards implementing an appropriate insecticide resistance management program. Objectives of this project have been designed to address knowledge gaps that must be filled if we are to devise both short and long-term, sustainable management plans to address the key insect pests in potato. Proposed objectives will include: 1) the continued assessment of Colorado potato beetle insensitivity to neonicotinyl insecticides among several populations in Wisconsin, 2) determining if insensitive populations (resistant) possess modified behavior(s) including delayed or even extended diapause, 3) determine if insensitivity, or resistance, to new products (spinosad, abamectin , spinetoram, novaluron, and rynaxypyr), may be developing faster in neonicotinoid resistant populations already present in Wisconsin, 4)

continue to develop and refine full-season, IPM-based management programs for control of the Colorado potato beetle, 5) evaluate the relationship between long term storage of tubers and infestations of phytophagous insects, and 6) delivery and implementation of novel pest management recommendations and practices to producers, growers, pest management practitioners, and other stakeholders.

Project History. This is a project that has been supported for 2 growing seasons by the Wisconsin Potato and Vegetable Growers Association and was initiated at the outset of the 2007 growing season. Objectives outlined in this research are directly related to the recent and widespread occurrence of neonicotinoid insensitivity among populations of the Colorado potato beetle. Integrated pest management practices combined with effective resistance management planning will extend the functional life of this very important class of chemicals which remains the backbone in a sequence of reduced risk insecticides.

Background and Rationale. The Colorado potato beetle is truly one on a short list of "super" pests in commercial agriculture that includes, among others, the diamondback moth. The CPB has developed resistance to most insecticides and great care must be used when targeting this insect and making choices to select an appropriate material, or sequence of materials for its control. It is important to recognize that once you begin to observe reductions in the time interval over which a particular material works effectively against CPB or you must increase the rate to get adequate control, insensitivity (resistance) to that insecticide is likely present in the population. Because of the difficulty faced in controlling populations of CPB, future production and revenue increases in Wisconsin will remain challenged by these persist insect pest populations. Recurrent populations of these insect pests demand the development of efficient and effective integrated pest management (IPM) and insecticide resistance management (IRM) strategies which out of necessity need to not only enhance environmental quality but also reduce risks in potato production systems.

Wisconsin potato growers rely heavily on neonicotinoid insecticides for the control of damaging populations of the Colorado potato beetle. Reported at-plant applications of soil-applied neonicotinoid insecticides have occurred on greater than 80% of all acres planted. The potential for resistance due to the frequent and now widespread use of these compounds has recently been investigated by our laboratory as well as cooperating scientists at Michigan State University, East Lansing, Michigan.

The development of insecticide resistance is one of the key factors which limit the range of available products for controlling insect pests in potato. In Wisconsin, localized resistance by Colorado potato beetle to some organophosphates, carbamates, pyrethroids, and organochlorines has resulted in sporadic control failures. Although this resistance is very discrete in its distribution, it stresses the need for continued vigilance in the management of insecticide resistance and strict adherence to IRM strategies which reduce the likelihood and onset of resistance development.

Objectives.

1) Continue to assess the potential of Colorado potato beetle insensitivity to neonicotinyl insecticides among several populations in Wisconsin.

2) Develop and refine full-season, reduced-risk, IPM-based management programs for control of the Colorado potato beetle.

Experimental Approach and Results: 2008 Resistance Assays. In 2007 and 2008, the Wisconsin Potato and Vegetable Growers Association supported our laboratory to conduct a comprehensive, statewide survey of potential insensitivity to the neonicotinoids. Correspondence was maintained in both years to request University and Extension personnel, consultants, agrichemical representatives, and growers to identify and send in suspect populations for testing representing 1) potato seed production, 2) commercial potato production, 3) Certified Healthy Grown production, and 4) sites where CPB populations were showing some level of insensitivity. In both years, adult CPB were collected from a select number of sites (N=5) representing successive, within-season generations to compare changes in insensitivity between overwintered beetles and summer adults.

In the coming 2009 season, we will again continue this type of resistance monitoring on a very specific select number of fields where measured insensitivity has been documented over 2 successive seasons. Adult bioassays are performed by treatments with a topical application of technical grade insecticide dissolved in acetone, 30 beetles/dose, 5 doses causing between 0 and 100% mortality, plus 30 beetles treated only with acetone. Measured responses are assessed for selected, in-state populations and compared directly to a highly susceptible, reference control strain of CPB obtained from a laboratory colony in New Jersey. Mortality is assessed after 7 days and data analyzed using log-probit regression analysis. A highly susceptible CPB strain obtained from a New Jersey is used as a reference control. In 2007, a total of 32 overwintered, CPB populations were assayed for imidacloprid sensitivity and an additional 3 populations of summer adult CPB populations were re-sampled for a total of 35 site/season samples. These samples were distributed among 6 potato growing Counties in Wisconsin including Adams, Columbia, Langlade, Oconto, Portage, and Waushara Counties. It is important to note that sites were not selected at random across these areas. A portion of candidate populations evaluated in this survey were selected with the prior knowledge that some were difficult to control with neonicotinoid tools. A total of four populations were observed with estimated resistance ratios (LD_{50} test population / LD_{50} New Jersey reference population) exceeding 20-fold. Of these, a single population resulted in an estimated resistance ratio exceeding 40-fold.

Again in 2008, we reinstituted this survey to determine what, if any changes, have taken place to measure annual increases in neonicotinoid insensitivity on a per site basis. Among the 37 individual populations sampled for imidacloprid insensitivity in 2008, 10 CPB populations were collected from sites previously certified as grown under 'Healthy Grown' standards (Table 1). In general, the mean LD_{50}'s of populations collected from these locales averaged 0.187 µg imidacloprid / beetle compared to populations collected from conventionally grown fields, predominantly in the Central Sands production area, which averaged 0.387 µg imidacloprid / beetle resulting in a 2-fold reduction in measured insensitivity (Figure 1).

Table 1. Estimated LD_{50} values (µg/beetle), 95% fiducial limits, and calculated resistance ratios for adult Colorado potato beetle populations collected and assayed in Wisconsin, 2008.

County	Site ID	CPB Managment[1]	(*P*<0.0001) (α=0.05)	Estimated slope (± SE)	LD_{50} (± 95% CL)	Resistance Ratio[2]
Adams	A	CV	(P=0.0124)	6.1% ± 3.9	0.339 (0.160 – 0.479)	0.339 / 0.031 (**10.9**)
	B	CV	(P=0.0338)	5.8% ± 4.6	0.430 (0.348 – 0.532)	0.430 / 0.031 (**13.9**)
	C	CV	(P=0.0085)	8.2% ± 2.8	0.256 (0.123 – 0.367)	0.256 / 0.031 (**8.3**)
	D	CV	(P=0.0631)	4.9% ± 3.2	0.260 (0.181 – 0.326)	0.260 / 0.031 (**8.4**)
	E	HG	(P=0.0832)	9.9% ± 4.2	0.035 (0.029 – 0.041)	0.035 / 0.031 (**1.1**)
	F	CV	(P=0.0763)	3.9% ± 2.7	0.291 (0.222 – 0.355)	0.291 / 0.031 (**9.4**)
	G	CV	(P=0.0112)	11.9% ± 4.1	0.631 (0.479 – 0.786)	0.631 / 0.031 (**20.4**)
Columbia	H	CV	(P=0.0422)	11.1% ± 3.7	0.035 (0.019 – 0.053)	0.035 / 0.031 (**0.9**)
Langlade	I	CV	(P=0.0481)	12.4% ± 3.9	0.050 (0.044 – 0.056)	0.050 / 0.031 (**1.6**)
	J	CV	(P=0.0058)	8.8% ± 2.6	0.025 (0.020 – 0.031)	0.025 / 0.031 (**0.8**)
	K	CV	(P=0.0175)	10.2% ± 3.3	0.075 (0.062 – 0.100)	0.075 / 0.031 (**2.4**)
	L	CV	(P=0.0809)	6.2% ± 4.9	0.550 (0.363 – 0.908)	0.550 / 0.031 (**17.8**)
	M	CV	(P=0.0533)	8.2% ± 3.3	0.543 (0.449 – 0.656)	0.543 / 0.031 (**17.5**)
	N	CV	(P=0.0092)	13.7% ± 5.2	0.015 (0.010 – 0.019)	0.015 / 0.031 (**0.5**)
	O	CV	(P=0.0066)	10.2% ± 2.9	0.049 (0.041 – 0.057)	0.049 / 0.031 (**1.6**)
	P	CV	(P=0.0238)	9.9% ± 3.5	0.050 (0.041 – 0.060)	0.050 / 0.031 (**1.6**)
Oconto	Q	CV	(P=0.7902)	12.7% ± 6.2	0.027 (0.039 – 0.022)	0.027 / 0.031 (**0.9**)
Portage	R	HG	(P=0.0143)	9.0% ± 2.4	0.041 (0.019 – 0.103)	0.041 / 0.031 (**1.3**)
	S	HG	(P=0.0077)	12.2% ± 4.2	0.293 (0.217 – 0.360)	0.293 / 0.031 (**9.5**)
	T	HG	(P=0.0517)	7.1% ± 3.9	0.072 (0.020 – 0.116)	0.072 / 0.031 (**2.3**)
	U	HG	(P=0.0789)	4.9% ± 2.1	0.250 (0.089 – 0.418)	0.250 / 0.031 (**8.1**)
	V	HG	(P=0.0336)	11.6% ± 4.3	0.323 (0.191 – 0.445)	0.323 / 0.031 (**10.4**)
	W	HG	(P=0.0098)	10.7% ± 3.9	0.179 (0.134 – 0.222)	0.179 / 0.031 (**5.8**)
	X	HG	(P=0.0237)	9.9% ± 2.1	0.661 (0.412 – 0.890)	0.661 / 0.031 (**21.3**)
Waushara	Y	CV	(P=0.0085)	9.2% ± 2.8	0.504 (0.345 – 0.655)	0.504 / 0.031 (**16.3**)
	Z	CV	(P=0.0231)	11.9% ± 3.2	0.735 (0.433 – 0.988)	0.735 / 0.031 (**23.7**)
	AA	CV	(P=0.0069)	6.9% ± 4.3	0.455 (0.159 – 0.644)	0.455 / 0.031 (**14.7**)
	AB	HG	(P=0.0109)	8.2% ± 3.3	0.455 (0.271 – 0.608)	0.455 / 0.031 (**14.7**)
	AC	CV	(P=0.0045)	12.2% ± 4.0	0.448 (0.328 – 0.594)	0.448 / 0.031 (**14.5**)
	AD	CV	(P=0.0109)	8.2% ± 3.3	0.280 (0.191 – 0.360)	0.280 / 0.031 (**9.0**)
	AE	CV	(P=0.0482)	5.2% ± 3.9	0.454 (0.104 – 0.889)	0.454 / 0.031 (**14.6**)
	AF	CV	(P=0.0749)	8.2% ± 3.3	0.380 (0.059 – 0.719)	0.380 / 0.031 (**12.3**)
	AG	CV	(P=0.1013)	7.3% ± 2.9	0.184 (0.130 – 0.307)	0.184 / 0.031 (**5.9**)
	AH	HG	(P=0.0278)	10.2% ± 3.3	1.331 (0.902 – 3.190)	1.331 / 0.031 (**42.9**)
	AI	CV	(P=0.0341)	7.7% ± 2.9	0.521 (0.407 – 0.667)	0.521 / 0.031 (**16.8**)

[1] Potato management categorized as either conventionally grown (CV) or qualifying as certified under 'Healthy Grown' (HG) standards.
[2] Resistance ratio estimates calculated against a New Jersey reference control strain of Colorado potato beetle adults (LD_{50} = 0.031).

Finally, the rates of insensitivity or developing resistance, measured among the 37 populations examined in this study were, again, not equal in the 2008 surveys. Estimated slopes of transformed probit-lines vary considerably among test populations of CPB suggesting that the allelic frequencies for resistance are in transition and not fixed in all populations at a consistent rate. Resistance develops over time in a pest population as a result of successive external population stressors (e.g. insecticide application(s)) resulting in a physiological or behavioral adaptation that can be passed to subsequent generations. Pest management practitioners then continue to select for these individuals in the population when they fail to discontinue the use same insecticide or materials with very similar modes of action.

Develop and Refine Full-Season Management Practices for CPB: Here again, the reliance that Wisconsin potato growers place on the at-plant use of soil-applied neonicotinoid insecticides has steadily increased over the last 7 to 9 years. The goal of this portion of our research has been to re-evaluate existing and novel insecticide control products for their use and integration into full-season control programs targeting the key insect pests of potato including Colorado potato beetle, potato leafhoppers, and colonizing aphid species. Broad screening research of this type in minor crops is often not justified by the agrichemical industry given the limited market potential. This research has been aimed at the integration of novel, pest control products that can be used in combination with neonicotinoids in a reduced risk and resistance management context similar to the projects we performed in 2006 & 2007. Experimental plots are located at the Hancock Agricultural Research Station where significant annual CPB populations are present and also on cooperating WPVGA grower fields as warranted. Reduced risk materials for consideration in these trials include, but are not limited to, spinosad (Spintor®), spinetoram (Radiant®) abamectin (Agri-Mek®), novaluron (Rimon®), rynaxypyr (Coragen™), metaflumizone (Alverde™), as well as the biorational *Bacillus thuringiensis*, subsp. *tenebrionis* (Novodor®). To our knowledge, none of the reduced-risk, foliar materials selected for these experiments (should) have the potential for cross-resistance development with an EPA Group 4A mode of action. Additional foliar product evaluations include several of the pre-pack insecticide offerings currently registered including, but not limited to, Brigadiere® (FMC), Volium Xpress (Syngenta), and Volium Flexi (Syngenta). This research directly complements our insecticide research trials conducted by Dr. Scott Chapman, where potential new insect control products are evaluated among varieties, application timings, and rates in an effort to secure new registrations in potatoes. A primary goal of this objective is to provide leadership in the development of biologically-based, pest management strategies that produce a safer food supply for consumers, reduce the risk to agricultural producers, and enhance environmental quality; an approach embraced by the Wisconsin Eco-Potato Collaboration. Results of this project will be presented by Dr. Scott Chapman and summarized in his proceedings write-up.

Insecticide Resistance Management Guidelines.

I. Problem Identification: If you suspect resistance, first eliminate other possible causes. In many instances, lack of control can be attributed to application error, equipment failure, or less-than-optimal environmental conditions. If these possibilities have been ruled out, work with local agricultural advisors and the manufacturer to confirm actual resistance to the compound applied. In the event of a control failure due to resistance, do not repeat the application with an insecticide of the same chemical class and consult a pest control advisor or area extension specialist for up-to-date recommendations and advice on IPM and IRM options.

II. Product Rotation: Avoid the consecutive use of a single product, or multiple products with similar modes of action. To assist farmers, growers, advisors, extension staff, consultants and crop protection professionals, the Insecticide Resistance Action Committee (IRAC) has developed and updates a Mode of Action (MoA) classification system with a guide to the selection of insecticides or acaricides in an effective and sustainable insecticide or acaricide resistance management (IRM) strategy (Table 1). This program was the direct result of the EPA's voluntary pesticide labeling proposal (2001) for all registered insecticides to include the MoA in a particular numbered group. To implement an effective IRM program, growers can

consult this information and select a sequence of insecticides that represent different groups wit unique MoA's.

III. Cultural Control(s): Where possible, consider selecting early-maturing or pest-tolerant varieties of crop plants. Adopt all non-chemical techniques known to control or suppress pest populations, including crop rotation in particular for managing resistance with the Colorado potato beetle. Specifically, potato crops should be rotated > 400 m (¼ mile) away from a previous potato crop. It has been well documented that overwintering adult Colorado potato beetles disperse only short distances after emergence from the soil.

IV. Preserve Natural Control(s): Where possible, select insecticides and other pest management tools which preserve beneficial insects. Natural mortality factors other than insecticides can significantly delay the onset and development of resistance. The use of selective insecticides (e.g. spinosad, *Bacillus thuringiensis*) and the selective, well-timed use of low-dose strategies are feasible for specific pest targets.

V. Pest Surveillance and Scouting: Monitor the pest population during the growing season. Regularly monitor fields to identify pests and natural enemies, estimate insect populations and track stage of development. Insecticides and acaricides generally should be used only if insect counts exceed action thresholds or the point where economic losses exceed the costs of insecticide plus application. Time applications against the most susceptible life stages to gain maximum benefit from the product. Where larval stages are being controlled, target younger larval instars where possible because these are usually much more susceptible and therefore much more effectively controlled by insecticides than older stages

VI. Rates and Spray Intervals: Use insecticides at labeled rates and follow prescribed spray intervals. Do not reduce or increase rates from manufacturer recommendations as this can hasten resistance development. Use products at their full, recommended doses. Reduced (sub-lethal) doses quickly select populations with average levels of tolerance, whereas doses that are too high may impose excessive selection pressures.

VII. Product Application: Appropriate, well-maintained equipment should be used to apply insecticides. Recommended water volumes, spray pressures and optimal temperatures should be used to obtain optimal coverage. Sprayer nozzles should be checked for blockage and wear, and be able to handle pressure adequate for good coverage. Spray equipment should be properly calibrated and checked on a regular basis. Use application volumes and techniques recommended by the manufacturers and local advisors.

VIII. Tank Mixes: Mixtures may offer a short-term solution to resistance problems, but it is essential to ensure that each component of a mixture belongs to a different insecticide mode of action class, and that each component is used at its full rate. Under certain circumstances, tank mix different chemicals for improved or broader spectrum pest control. It is equally crucial that compounds should persist on the crop or surface for similar periods in order to expose insects to both modes of action for the same length of time. Use of multiple products of the same mode of action in the spray tank will do little more than using an increased rate of a single compound of the same chemical class.

SECTION I. PART 5-A

Mineral Oil Application Experiments: Reducing Current Season PVY

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Abstract. In recent years, *Potato Virus Y* has reemerged as a serious disease problem in many potato production areas in the northern United States and eastern Canada. Asymptomatic cultivars which express mild or no symptoms when infected with PVY combined with an

increase in recombinant strains of this virus prevent accurate field identification and rouging of infected plants. There is a lack of effective strategies to reduce the incidence of PVY infected plants and tubers, and there is a need to improve cost-effective methods of determining PVY levels in seed lots and further understanding the impact of current season virus infection on tuber storage and quality attributes. Limited information currently exists to document the optimal oil application conditions to limit infection of PVY during the current season. In the first year of preliminary research, we have documented significant reductions in PVY incidence using different foliar oil protectants at varying concentrations and application frequencies. This area of investigation seems extremely important towards limiting continued losses associated with asymptomatic potato cultivars in which PVY remains a challenge.

Foliar Mineral Oil Treatments
Antigo, Wisconsin 2008. Langlade County Airport.

I. Oil Applications(s).

Foliar Treatments (N=12): 12 treatments X 4 reps = **48 plots**

Treat No.	Product	Application Frequency (days)	Rate [conc]	Nozzle Tip	Plot Number	Flag Color
1)	UTC	--	--	--	(101, 201, 301, 401)	red
2)	Aphoil	7	0.02	D3-DC25	(102, 202, 302, 402)	white
3)		7	0.04	D3-DC25	(103, 203, 303, 403)	blue
4)		7	0.04	XR-11003	(104, 204, 304, 404)	yellow
5)		4	0.02	D3-DC25	(105, 205, 305, 405)	orange
6)		4	0.04	D3-DC25	(106, 206, 306, 406)	pink
7)	JMS	7	0.0075	D3-DC25	(107, 207, 307, 407)	green
8)	Stylet Oil	7	0.015	D3-DC25	(108, 208, 308, 408)	brown
9)		7	0.015	XR-11003	(109, 209, 309, 409)	silver
10)		4	0.0075	D3-DC25	(110, 210, 310, 410)	lime
11)		4	0.015	D3-DC25	(111, 211, 311, 411)	violet
12)	QRD 416 (OMRI-Approved Formulation)	4	0.01	D3-DC25	(112, 212, 312, 412)	2 red

II. Plot Size.

Dimensions:

- 24 ft rows X 36" row (4 rows/ plot) = 540 ft^2 / plot
- 540 ft^2 / plot X 48 plots
- experimental replicates separated by 3, 20' alleys
- total experiment size = 0.6 acres

Cultivars:

- treatment rows will consist of 4, 20 plant rows of virus-free *S. tuberosum*, cv. 'Silverton' ( ) flanked on all sides by guard rows of the PVY-resistant cv. 'Villetta Rose' ( ) (Figure 1). Drive rows for foliar applications ( ) will be arranged to cover Villetta rose border rows and provide access for foliar applications to 4 row experimental plots.

III. PVY Inoculum.

Inoculum of Potato virus Y will be established by sap-inoculating 2, plants centrally in the 2nd and 3rd rows of each experimental plot. Infected sap was generated from *Nicotiana tabacum* plants mechanically, sap-inoculated with PVY^{O} and $PVY^{N:O}$ from isolates collected in Wisconsin 2004-06. Plants were inoculated 26 June 2008.

IV. Treatment Evaluations:

Foliar oil applications will be applied beginning 1 July 2008 using a CO_2 pressurized, tractor-mounted sprayer with a 12' boom operating at either 80 and 40 psi delivering total volumes of 21.1 and 37.5 gpa through 13 nozzles bodies equipped with either 1) a D3-DC25 Disc-Core type cone spray tip, or 2) a XR 110 03VS Flat Fan spray tip spaced 12" apart, respectively. Incidence of PVY will be surveyed monthly by counting all symptomatic plants, and their relative position in each experimental plot. Total plot yield will be determined at the conclusion of the experiment from each plot.

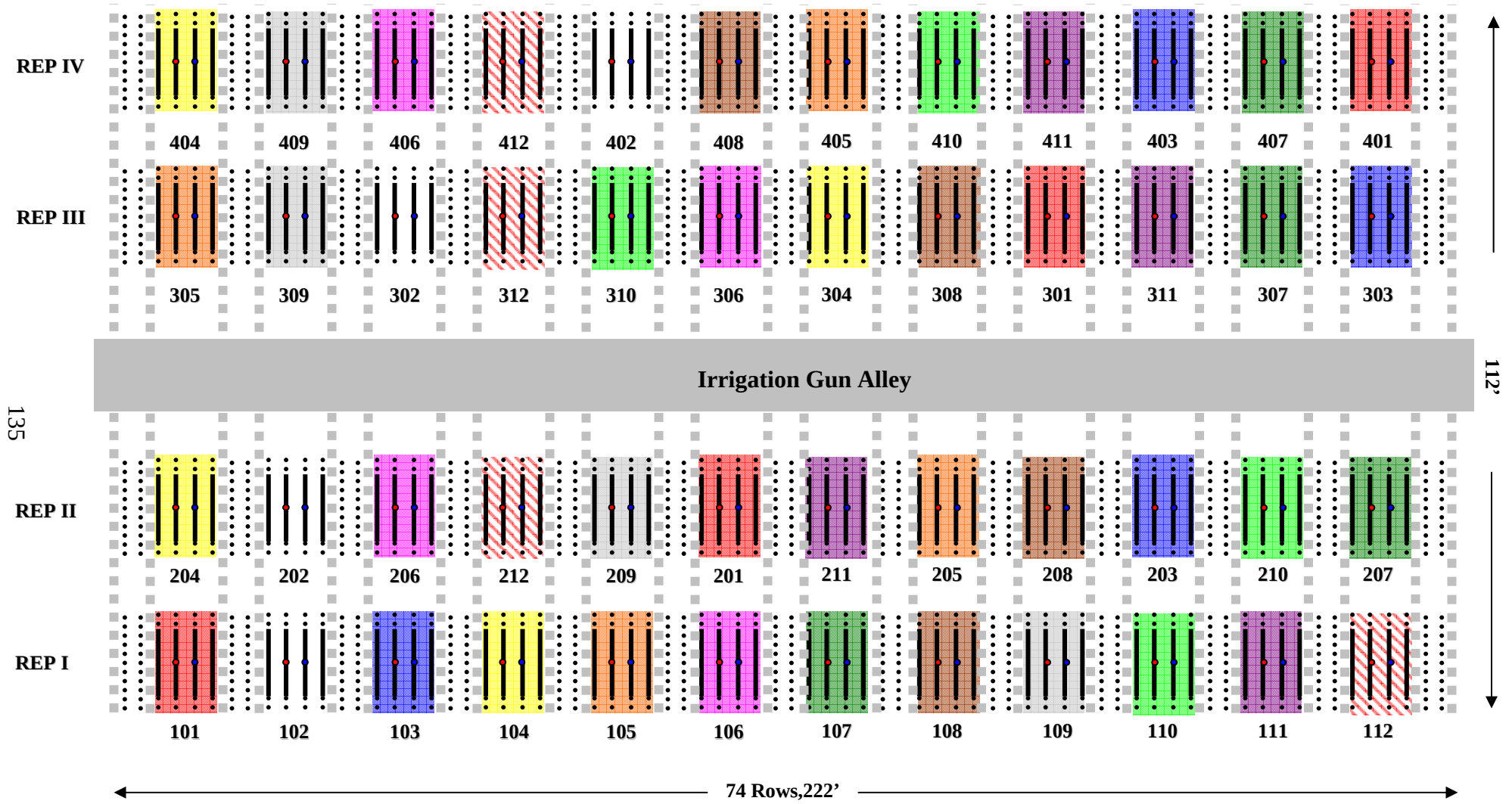

Figure 1. Experimental plot layout for evaluation of foliar-applied, mineral oil treatments at the Langlade County Airport, Antigo, Wisconsin 2008. Experimental plot size 4, row (36" bed) X 24' with 4 replicates resulting in an experiment size (222' X 112'), (0.6 acres). Two, PVY-infected plants, PVY^{O} (●) and $PVY^{N:O}$ (●) were inoculated 26 June 2008 in the center 2 rows of each plot to serve as an inoculum source for spread.

University of Wisconsin-Madison

Protocol ID: Study Director:
Location: Investigator: Dr. Russ Groves

Reps: 4 Plots: 12 by 20 feet
Spray vol: 21.1 gal/ac (37.5 gal/ac for treatments 4 and 9) Mix size: 16 liters

Trt No.	Type	Treatment Name	Form Conc	Form Unit	Form Type	Rate	Rate Unit	Other Rate	Other Rate Unit	Growth Stage	Appl Code	Amt Product to Measure
1	CHK	UTC										
2	ADJ	Aphoil	100	%	SL	2	% v/v					320.0 ml/mx
3	ADJ	Aphoil	100	%	SL	4	% v/v					639.9 ml/mx
4	ADJ	Aphoil	100	%	SL	4	% v/v					639.9 ml/mx
5	ADJ	Aphoil	100	%	SL	2	% v/v					320.0 ml/mx
6	ADJ	Aphoil	100	%	SL	4	% v/v					639.9 ml/mx
7	ADJ	JMS Stylet Oil	100	%	SL	0.75	% v/v					120.0 ml/mx
8	ADJ	JMS Stylet Oil	100	%	SL	1.5	% v/v					240.0 ml/mx
9	ADJ	JMS Stylet Oil	100	%	SL	1.5	% v/v					240.0 ml/mx
10	ADJ	JMS Stylet Oil	100	%	SL	0.75	% v/v					120.0 ml/mx
11	ADJ	JMS Stylet Oil	100	%	SL	1.5	% v/v					240.0 ml/mx
12	INSE	QRD 416	100	%	SL	1	% v/v					160.0 ml/mx

Material Applied	Application Date	Rate	Treatment (flag colors)	Amount Product	Amount Water
Aphoil	Monday	2%	(2=white, 5=orange)	640 ml	32 L (= 4.0 gal)
		4%	(3=blue, 4=yellow, 6=pink)	1.9L	32 L (= 8.4 gal)
	Thursday	2%	(5=orange)	320 ml	16 L
		4%	(6=pink)	640 ml	16 L
				3.5 L (0.92 gal)	
JMS Stylet Oil	Monday	0.75%	(7=green, 10=lime)	240 ml	16 L
		1.5%	(8=brown, 9=silver, 11=violet)	480 ml	16 L
	Thursday	0.75%	(10=lime)	120 ml	16 L
		1.5%	(11=violet)	240 ml	16 L
				1.3 L (0.34 gal)	
QRD 416	Monday	1.0%	(12=2 red)	160 ml	16 L
	Thursday	1.0%	(12=2 red)	160 ml	16 L
				320 ml	

Product quantities required for listed treatments and applications over 12 successive weeks of treatment:

Amount*	**Unit**	**Treatment Name**	**12 week total**
3.5	L	Aphoil 100 SL	42 L (11.1 gal)
1.3	L	JMS Stylet Oil 100 SL	15.6 L (4.1 gal)
320	ml	QRD 416 100 SL	3.8 L (1.0 gal)

* 'Per area' calculations based on spray volume= 40 gal/ac, mix size= 5 liters (mix size basis).
* Product amount calculations increased 25 % for overage adjustment.
* 'Per volume' calculations use spray volume= 40 gal/ac, mix size= 5 liters.

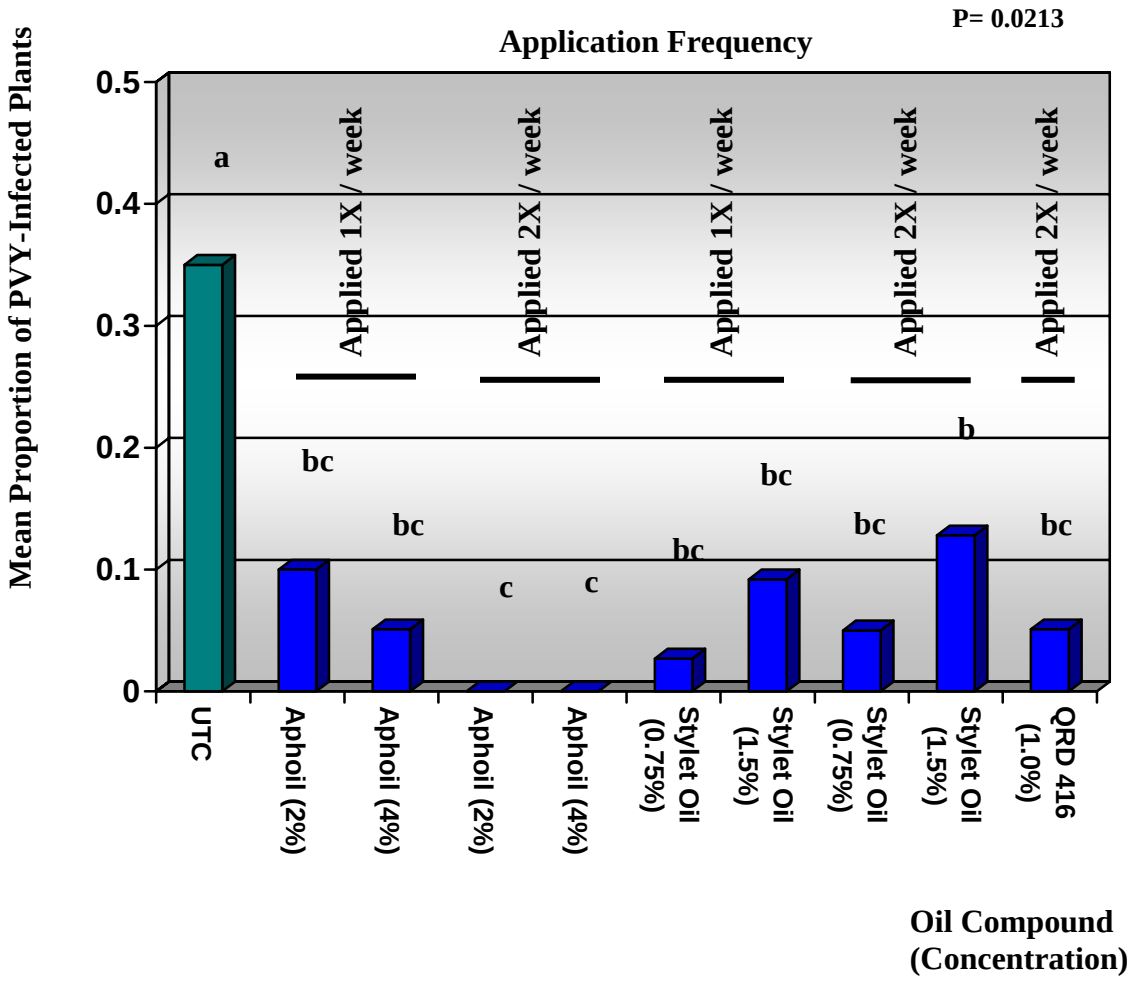

Figure 1. Mean proportion of PVY-infected plants collected from the experimental plots receiving different mineral oil compounds, application frequencies, and application rates. Probability of a difference in mean cumulative proportion of PVY-infected plants is provided (α=0.05) with a Least Squared Difference, means separation procedure. Means not followed by the same letter among columns are significantly different.

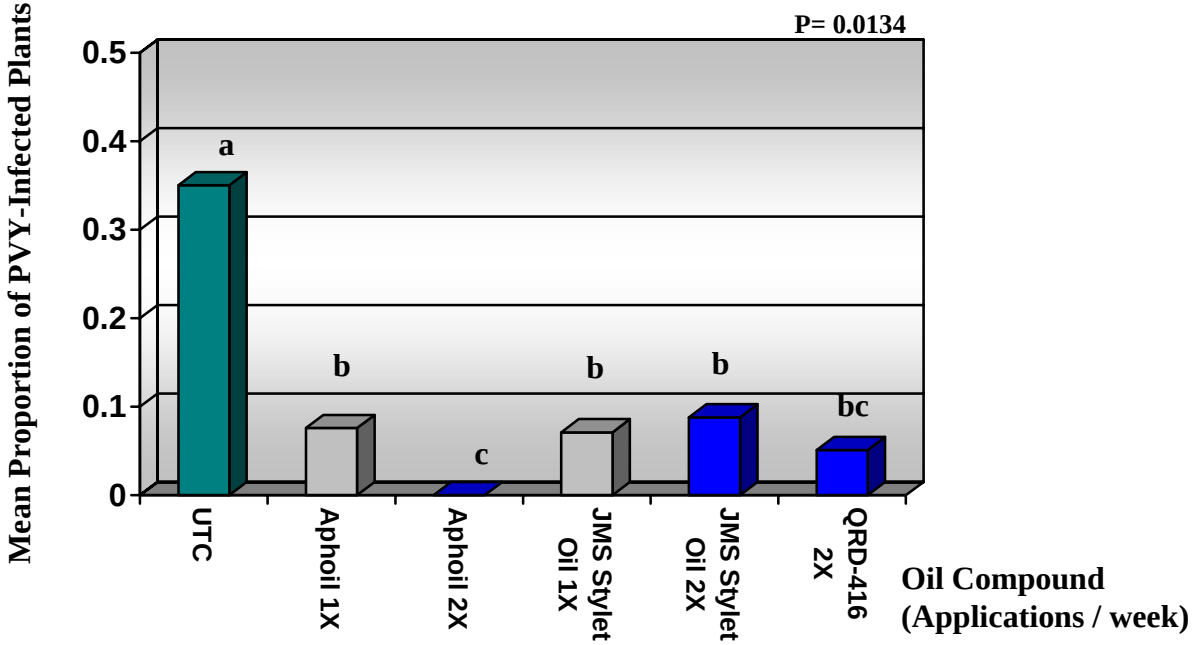

Figure 2. Mean proportion of PVY-infected plants among oil compounds applied. Probability of a difference in mean cumulative proportion of PVY-infected plants is provided (α=0.05).

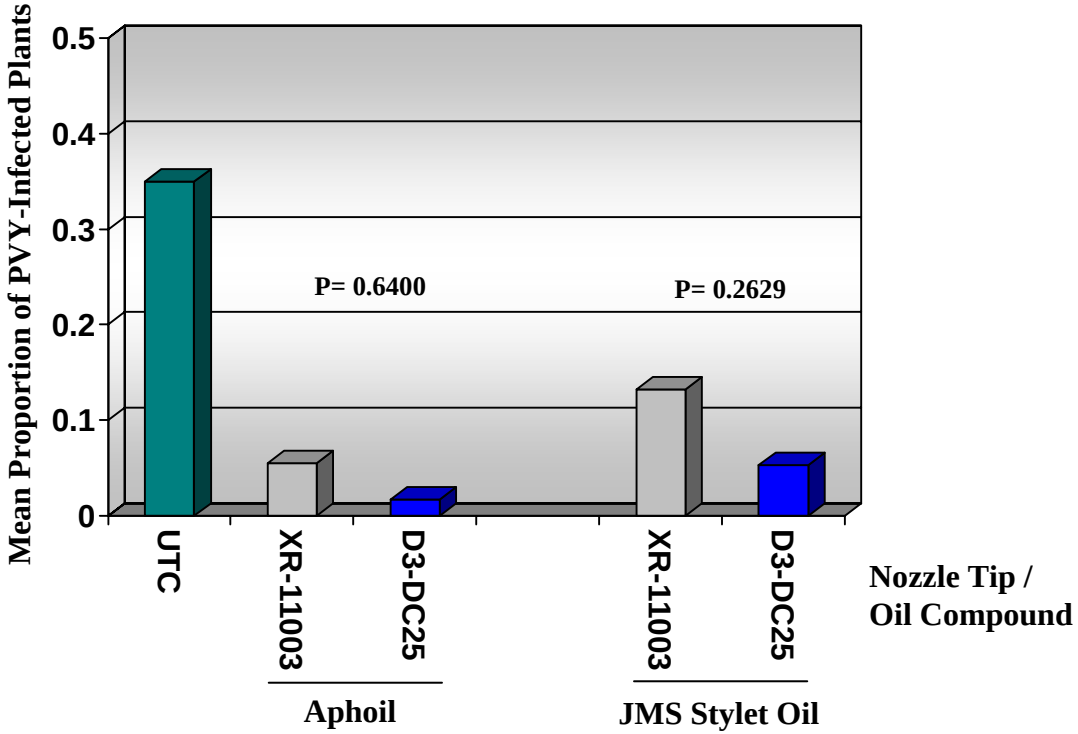

Figure 3. Mean proportion of PVY-infected plants comparing the extender range, flat fan nozzle tips (XR-11003) with the disc-core, hollow cone nozzle tips (D3-DC25). Probability of a difference in mean cumulative proportion of PVY-infected plants between tips is provided (α=0.05) for each oil compound evaluated, Aphoil and JMS Stylet Oil, respectively.

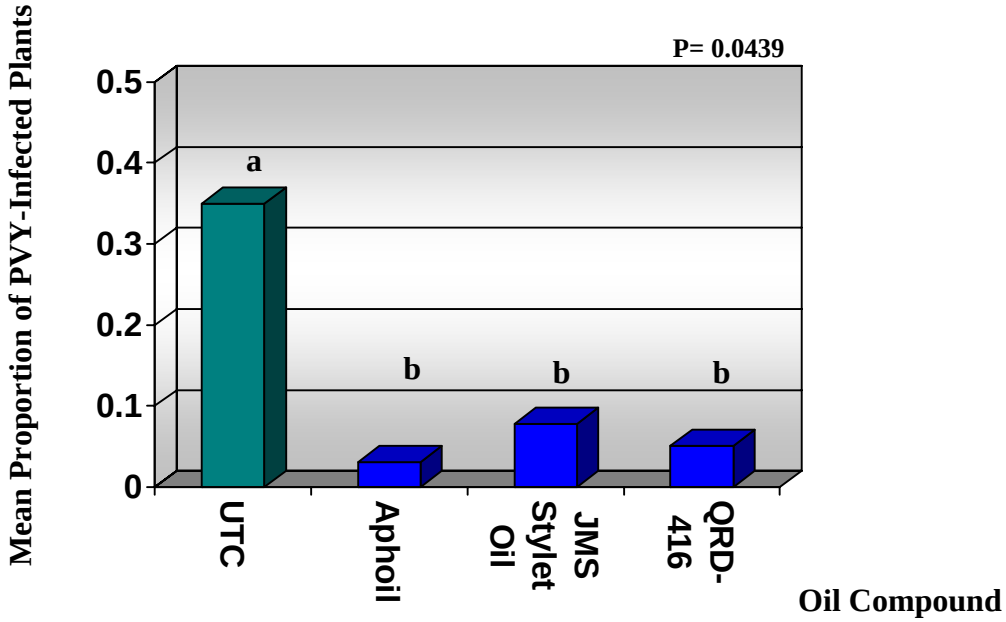

Figure 4. Mean proportion of PVY-infected plants comparing the mineral oil compounds Aphoil, JMS Stylet Oil, and QRD-416. Probability of a difference in mean cumulative proportion of PVY-infected plants among compounds is provided (α=0.05).

Table 1. Mean (± SE) yield and quality parameters collected from experimental treatments located at the Langlade County Regional Airport, Experimental Research Facility, Antigo, WI.

					Mean Yield and Quality Parameters / Treatment[1]		
Compound Applied	Trt No.	Appl Freq[2]	Concentration (%)	Nozzle Tip[3]	Mean Proportion. US #1, Grade A	Mean Proportion. US #1, Grade B	Mean Total Yield (cwt. / ac)
Untreated	1	--	--	--	96.5 ± 0.6 a	3.5 ± 0.6 a	358.4 ± 20.0 a
Aphoil	2	7	2.0	D3-DC25	96.2 ± 0.7 a	3.8 ± 0.7 a	366.2 ± 40.9 a
	3	7	4.0	D3-DC25	96.6 ± 0.3 a	3.4 ± 0.3 a	343.7 ± 15.8 a
	4	7	4.0	XR-11003	96.0 ± 0.5 a	4.0 ± 0.5 a	344.8 ± 10.6 a
	5	4	2.0	D3-DC25	96.1 ± 0.3 a	3.9 ± 0.3 a	341.0 ± 12.2 a
	6	4	4.0	D3-DC25	96.4 ± 0.4 a	3.6 ± 0.4 a	325.0 ± 29.4 a
JMS Stylet Oil	7	7	0.75	D3-DC25	96.1 ± 0.6 a	3.9 ± 0.6 a	320.5 ± 30.5 a
	8	7	1.5	D3-DC25	96.0 ± 0.8 a	4.0 ± 0.8 a	335.5 ± 19.9 a
	9	7	1.5	XR-11003	95.9 ± 0.9 a	4.1 ± 0.9 a	318.8 ± 24.8 a
	10	4	0.75	D3-DC25	97.2 ± 0.1 a	2.8 ± 0.1 a	367.0 ± 46.1 a
	11	4	1.5	D3-DC25	95.7 ± 0.1 a	4.3 ± 0.1 a	313.3 ± 14.7 a
QRD-416	12	4	1.0	D3-DC25	97.1 ± 0.3 a	2.9 ± 0.3 a	397.2 ± 27.4 a

[1] Means followed by the same letter are not significantly different ($P > 0.05$; Fisher's Protected LSD; n = 4).

[2] Application frequency of mineral oil compounds occurred on either a weekly (once / 7 days) or bi-weekly (once / 4 days) basis.

[3] Mineral oils were applied through a CO_2 pressurized, tractor-mounted sprayer with a 12' boom operating at either 80 and 40 psi delivering total volumes of 21.1 and 37.5 gpa through 13 nozzles bodies equipped with either 1) a D3-DC25 Disc-Core type cone spray tip, or 2) a XR 110 03VS Flat Fan spray tip spaced 12" apart, respectively.

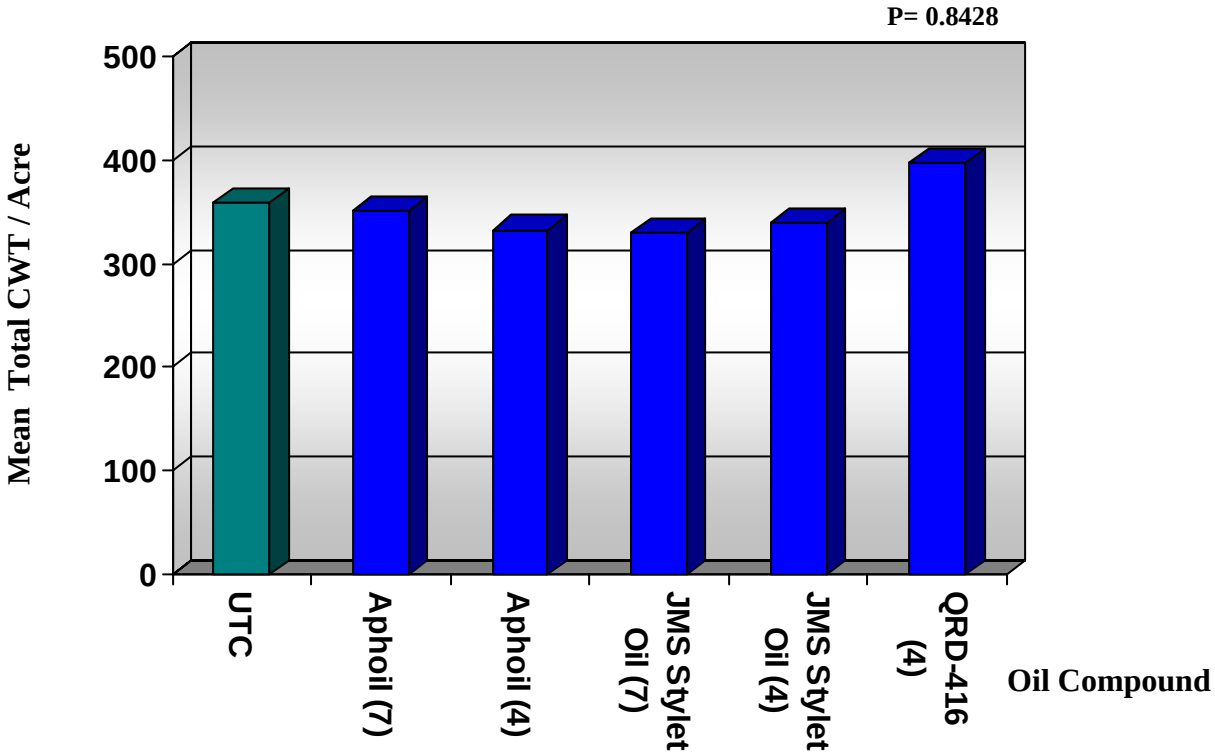

Figure 5. Mean estimated total hundred weight (CWT) / acre comparing the mineral oil compounds Aphoil, JMS Stylet Oil, and QRD-416 applied at weekly (every 7 days) and bi-weekly (every 4 days). Probability of a difference in mean estimated total hundred weight among compounds and application intervals are provided (α=0.05).

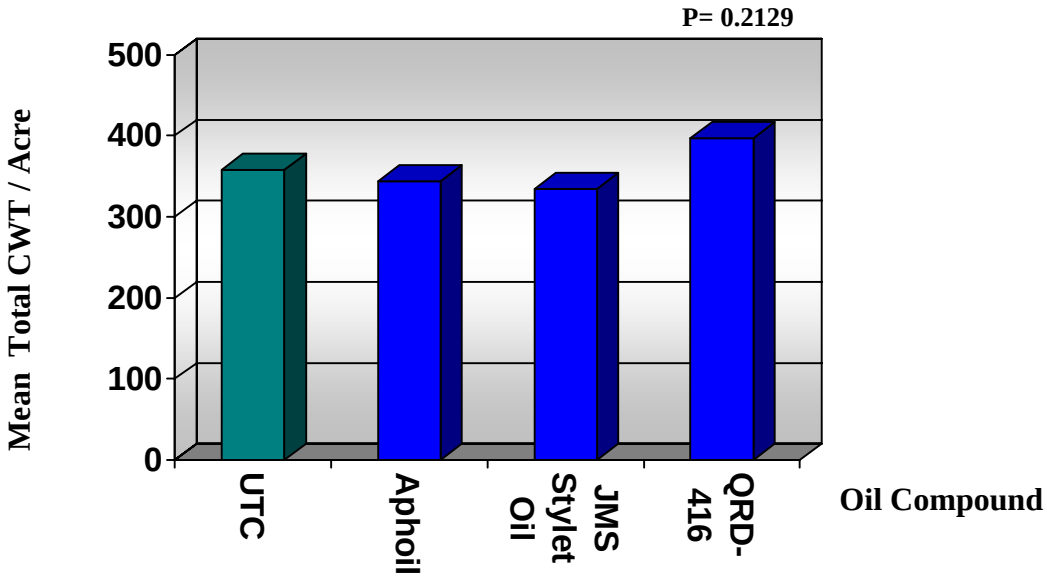

Figure 6. Mean estimated total hundred weight (CWT) / acre comparing the mineral oil compounds Aphoil, JMS Stylet Oil, and QRD-416. Probability of a difference in mean estimated total hundred weight among compounds are provided (α=0.05).

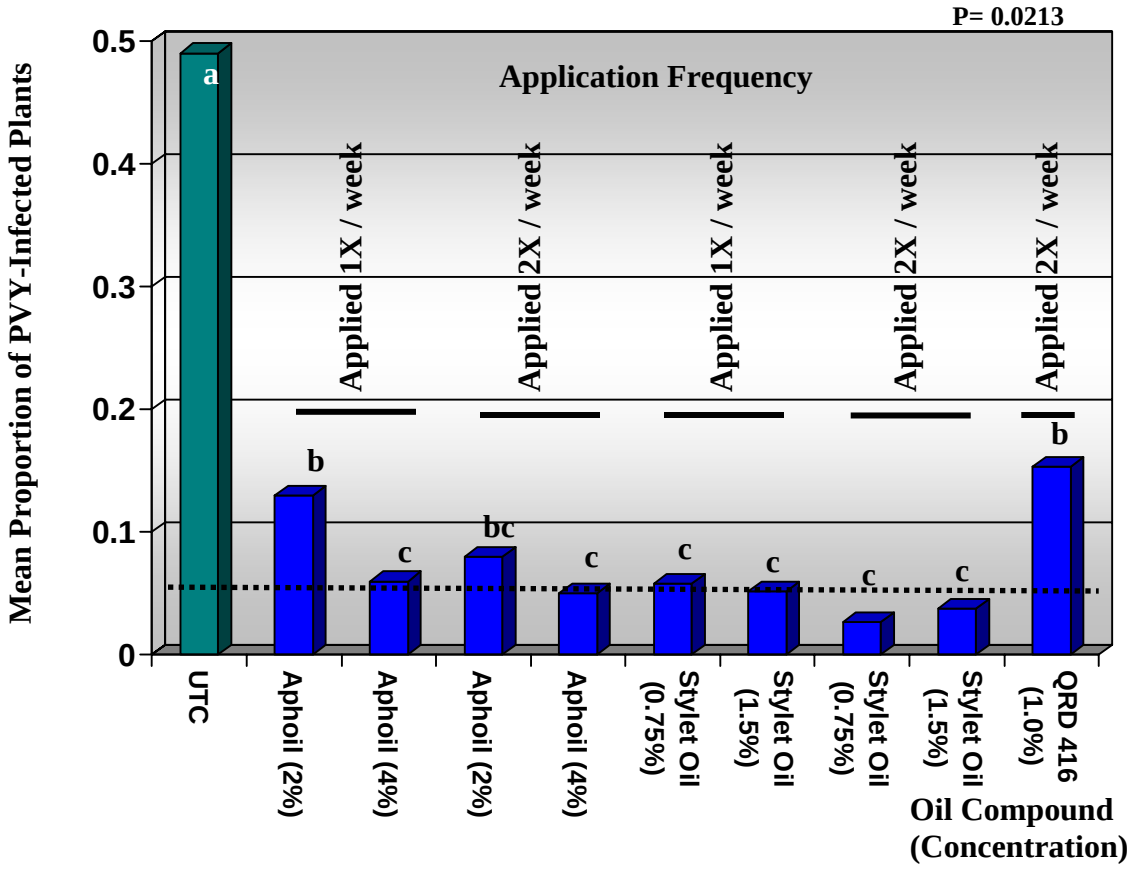

Figure 7. Mean proportion of PVY-infected plants resulting from winter grow-out tests conducted in Homestead, FL 2008-09. Symptoms recorded from plants grown from tubers receiving different mineral oil compounds, application frequencies, and application rates. Probability of a difference in mean cumulative proportion of PVY-infected plants is provided (α=0.05) with a Least Squared Difference, means separation procedure. Means not followed by the same letter

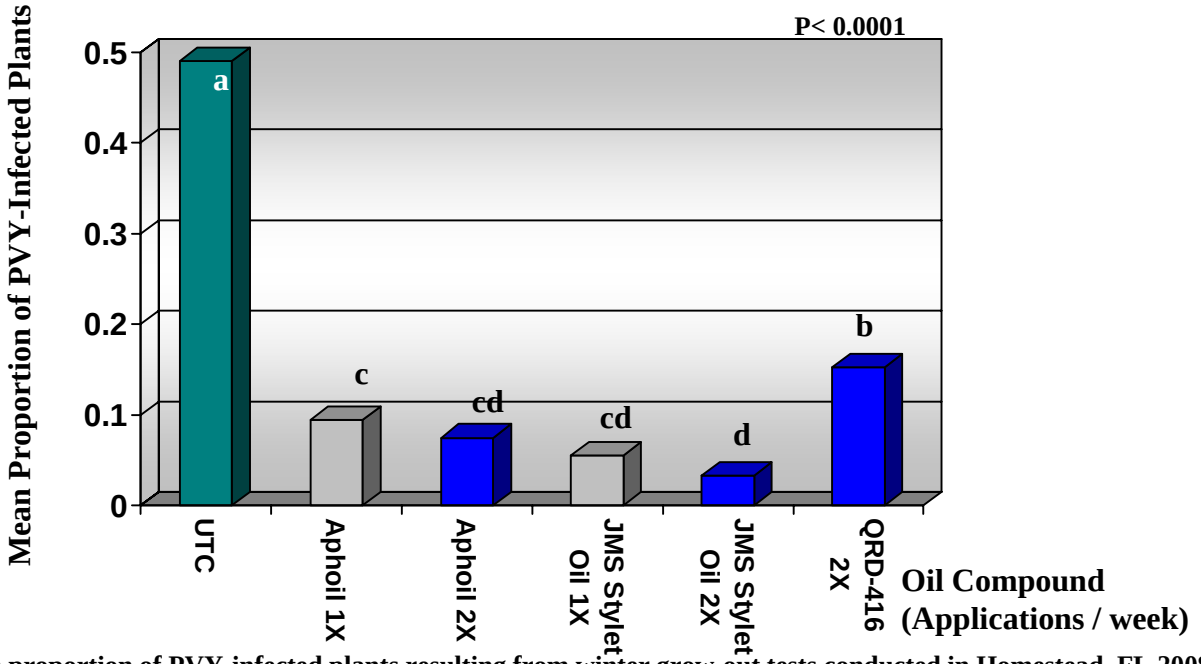

Figure 8. Mean proportion of PVY-infected plants resulting from winter grow-out tests conducted in Homestead, FL 2008-09. Symptoms recorded from plants grown from tubers receiving different oil compounds applied. Probability of a difference in mean cumulative proportion of PVY-infected plants is provided (α=0.05).

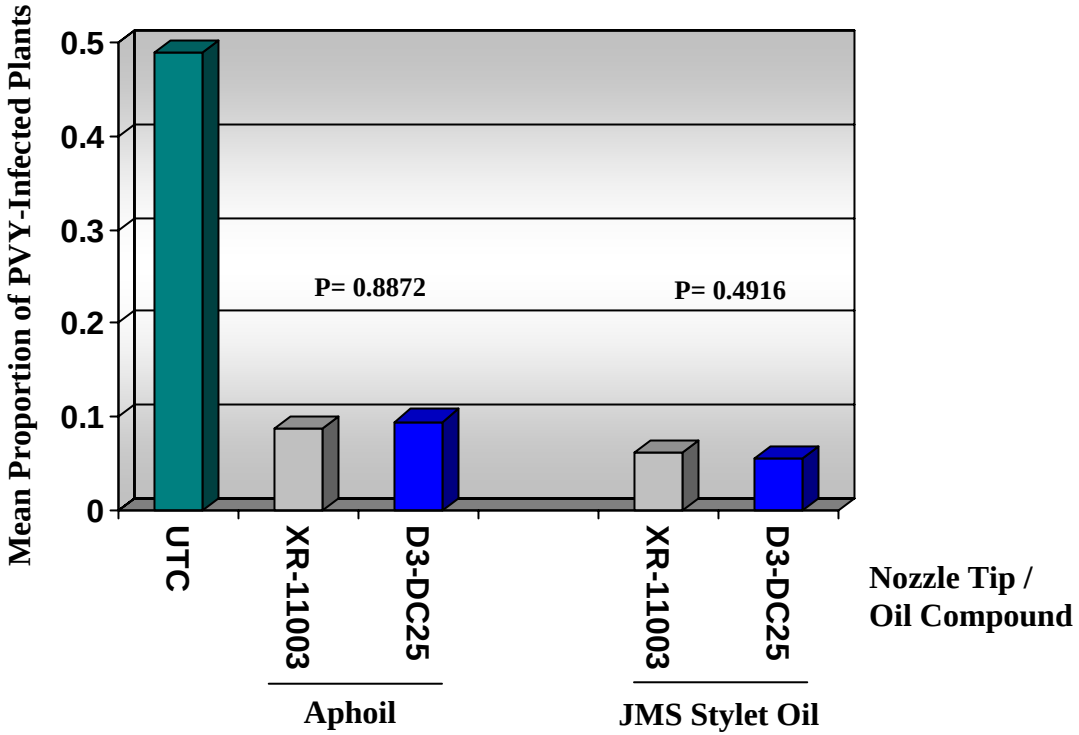

Figure 9. Mean proportion of PVY-infected plants resulting from winter grow-out tests conducted in Homestead, FL 2008-09. Symptoms recorded from plants grown from tubers comparing the extender range, flat fan nozzle tips (XR-11003) with the disc-core, hollow cone nozzle tips (D3-DC25). Probability of a difference in mean cumulative proportion of PVY-infected plants between tips is provided (α=0.05) for each oil compound evaluated, Aphoil and JMS Stylet Oil, respectively.

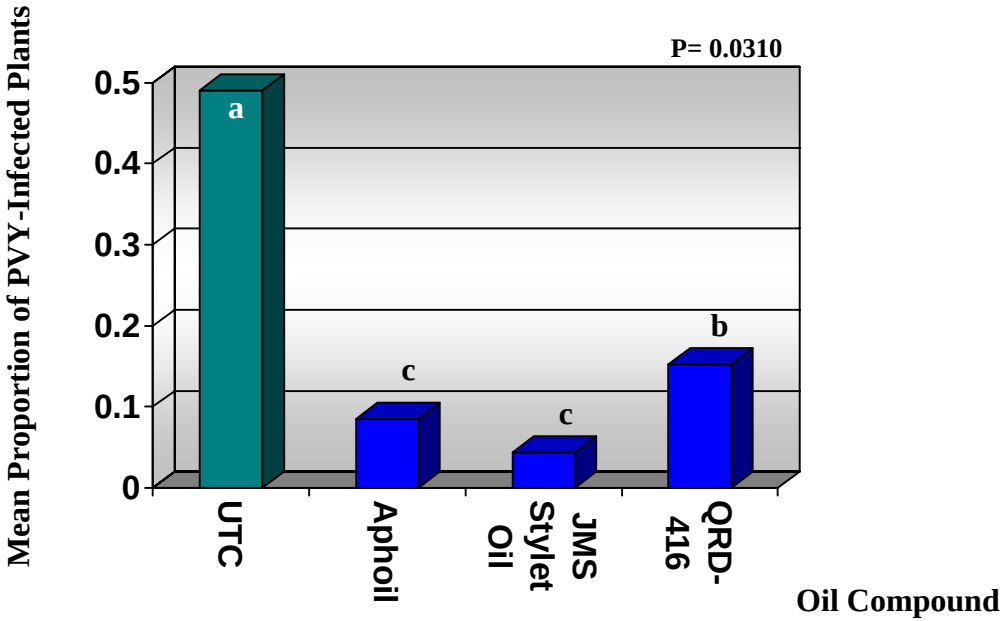

Figure 10. Mean proportion of PVY-infected plants resulting from winter grow-out tests conducted in Homestead, FL 2008-09. Symptoms recorded from plants grown from tubers comparing the mineral oil compounds Aphoil, JMS Stylet Oil, and QRD-416. Probability of a difference in mean cumulative proportion of PVY-infected plants among compounds is provided (α=0.05).

Research Summary:

2008 Field Season Results:

1) A significant difference in PVY (foliar) detection was observed among the different mineral oil compounds examined, the application frequencies, and rate (or concentration). This resulted from a significant Compound X Application X Rate interaction ($F=7.12$, $df=3,9$, $P=0.0213$). All oil applications reduced PVY foliar detection when compared with the untreated control. Among application frequencies and product concentrations, Aphoil applied twice weekly, at both the 2 and 4% concentrations, resulted in the lowest overall foliar detection of PVY. The remaining treatment combinations were not significantly different (**Figure 1**).

2) Averaging over mineral oil concentrations, Aphoil applied twice weekly again provided the greatest amount of protection from infection by PVY when compared to other treatment combinations (**Figure 2**). Here again, the remaining treatment combinations were not significantly different to each other, however all were significant improvements over untreated control plots where as much as 35% PVY infection was detected.

3) Comparing nozzle types for mineral oil application, no significant differences were detected between nozzle tips with either the Aphoil or the JMS Stylet Oil products under the conditions of our test (**Figure 3**). Recall, we conducted this comparison with only Aphoil and JMS Stylet Oil applied weekly at the higher, prescribed concentrations (4 and 1.5%) for each compound, respectively.

4) Averaging over application frequency, concentration, and nozzle type, no significant differences were observed among the 3 mineral oil compounds tested in this experiment with respect to foliar detection of PVY infection (**Figure 4**). Numerically, Aphoil had the least infection (3.1%) followed by QRD-416 (5.1%), and then JMS Stylet Oil (7.8%). Again, all compounds performed better than untreated control plots which reached 35% infection by the end of the experiment.

5) No significant impacts on tuber yield and quality were observed among any of the treatment combinations in the experiment (**Table 1**). Specifically, the mean proportion of US #1 'A' and 'B' grade potatoes, as well as total hundred weight / acre, did not differ among the interaction or main effect treatments in the experiment.

6) Closer examination of treatment effects with respect to total hundred weight per acre, did not reveal any significant differences among application frequency and the mineral oil treatment applied (**Figure 5**). Averaging over all application frequencies and concentrations, no differences in tuber yield and quality were noted among the mineral oil compounds examined (**Figure 6**). Numerically, applications of QRD-416 (2X week at 1%) resulted in the highest total yields (397.3 cwt/ac), followed by the untreated control plots (358.4 cwt/ac), Aphoil (applied once and twice weekly at 2 and 4%) (343.9 cwt/ac), and JMS Stylet Oil (applied once and twice weekly at 0.75 and 1.5%).

2008-09 Winter Grow-Out Test Results:

1) The most important set of observations for this experiment must be interpreted from the Wisconsin Seed Certification, Winter Grow-Out Test located in Homestead, FL. As is often the case with asymptomatic varieties (e.g. 'Silverton Russet'), the infection frequencies in the above-ground portion of plants do not often accurately reflect the incidence of infection among daughter tubers. Similar to the field-based assays at the end of the growing season, some significant differences in PVY were observed among the different mineral oil treatments examined. Here again, all oil applications reduced PVY detection when compared with the untreated control (49.5%). Following the untreated control, the QRD-416 compound averaged 15.3% PVY incidence. Among remaining application frequencies and product concentrations, Aphoil applied at the 2% concentrations, both once and twice a week, resulted in the next highest overall PVY infection. Finally, all remaining treatment combinations were not significantly different (**Figure 7**).

2) Averaging over mineral oil concentrations, JMS Stylet Oil and Aphoil applied twice weekly provided the greatest amount of protection from infection by PVY when compared to other treatment combinations (**Figure 8**). Here again, treatment combinations other than QRD-416, were significant improvements over untreated control plots where as much as 49.5% PVY infection was detected.

3) Comparing nozzle types for mineral oil application, no significant differences were again detected between nozzle tips with either the Aphoil or the JMS Stylet Oil products during the Winter Grow-Out Test (**Figure 9**).

4) Averaging over application frequency, concentration, and nozzle type, no significant differences were observed between the JMS Stylet Oil and the Aphoil tested in this experiment (**Figure 10**). Numerically, JMS Stylet Oil had the least infection (4.4%) followed by Aphoil (8.5%), and then QRD-416 (15.3%). Again, all compounds performed better than untreated control plots which reached 49.5% infection during the Winter Grow-Out Test.

SECTION I. PART 5-B

LONG-TERM STORABILITY OF POTATO VIRUS Y INFECTED TUBERS

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Abstract. In recent years, *Potato Virus Y* has reemerged as a serious disease problem in many potato production areas in the northern United States and eastern Canada. Asymptomatic cultivars which express mild or no symptoms when infected with PVY combined with an increase in recombinant strains of this virus prevent accurate field identification and rouging of infected plants. There is a lack of effective strategies to reduce the incidence of PVY infected plants and tubers, and there is a need to improve cost-effective methods of determining PVY levels in seed lots and further understanding the impact of current season virus infection on tuber

storage and quality attributes. Limited information currently exists to document the impact of PVY infection on quality aspects tuber storage performance. In the first year of preliminary research, we have documented significant reductions in storage quality parameters including percent solids and shrinkage. This area of investigation seems extremely important towards limiting continued storage losses and further assessing the impact of plant disease (PVY infection) on seed tuber physiological age.

Project Description: This is the second year of a project that was initiated in the 2007 growing season. Objectives outlined in this research are directly related to the recent and problematic re-emergence of *Potato Virus Y* (PVY) in potato seed production in Wisconsin. The proposed project will continue to generate new information regarding the relative responses of selected potato varieties to infection by novel, recombinant PVY strains in Wisconsin while also providing practical guidance towards documenting the impact of virus infection on long-term tuber storage. Knowledge of how PVY strains move and distribute within developing potato tubers of these commercially important cultivars has not been described.

Infection with PVY is the main reason that seed potato lots are rejected from certification and this virus has resulted in rejection of up to 4% of seed lots in the past decade, which is a significant loss to the seed industry. In addition, PVY is the main cause of downgrading lots from foundation class to certified class, which can be costly to seed growers if they had planned on increasing a particular lot for another year on their seed farm. The return on investment to growers will be 1) an improved understanding of the potential impact(s) virus infection may have upon storage losses; successful storage is dependent upon growers having a through understanding of the factors that can influence tuber health and quality. And 2) increasing the Wisconsin Seed Potato Certification Program's ability to accurately identify novel, problematic strains of PVY and ensure seed quality for participating growers. For commercial growers, beginning with clean seed greatly facilitates the incorporation of reduced risk pest management into the arsenal of pest control; an approach which is central to achievement of the WPVGA / WWF / UW collaboration goals.

Background and Rationale. In recent years, PVY has reemerged as a serious disease problem in many potato production areas in the northern United States and eastern Canada (5). Three recently introduced cultivars, 'Russet Norkotah', 'Shepody', and 'Silverton' are widely grown and express mild or no symptoms when infected with PVY. Furthermore, recent investigations into the diversity of PVY isolates prevalent in these production areas have revealed a significant increase in the proportion of PVY_N and PVY_O recombinants ($PVY_{N:O}$) (3). The lack of symptoms often associated with these cultivars and recombinant viruses prevents accurate field identification and rouging of infected plants resulting in higher levels of virus inoculum and greater disease pressure. There is a lack of effective strategies to reduce the incidence of PVY infected plants and tubers, and there is a need to improve cost-effective methods of determining PVY levels in seed lots of these two important varieties.

Briefly, PVY occurs as a population of strains or pathotypes, many of which have overlapping characteristics. These strains have been described as the ordinary strain (PVY^O), a tobacco necrotic strain (PVY^N), a tuber necrotic strain (PVY^{NTN}), and a common, or stipple-streak strain (PVY^C) (2, 3). The PVY^N strains were first detected in North America in the early 1990's when

an outbreak occurred in the Canadian maritime region. Shortly thereafter, reports of the tobacco necrotic strains began occurring in the Western US and by 2005 this strain was becoming fairly prevalent across several potato production areas in the US. Sequence analyses of several strains from across the country have now identified strains which contain elements from both the PVY^{N} and PVY^{O} strain types; and these are now referred to as PVY recombinant strains ($PVY^{N:O}$). Historically in Wisconsin, the most prevalent strain of PVY has been the ordinary strain, PVY^{O}. Recent molecular analyses performed by Dr. Stewart M. Gray at Cornell University have revealed a subtle shift in the composition of PVY strains present in Wisconsin. Since 2004, the proportion of recombinant strains has increased and these may become a more frequent component of the population of PVY strains in the state.

Specifically, we continue to expand on the previous year's research by, 1) investigating the efficiency of tuber infection in plants inoculated with different strains of PVY (PVYO, and PVYN:O) at different plant developmental stages, and 2) documenting the quality losses associated with inoculations of each PVY strain prior to and during long-term storage. This area of investigation seems extremely important as there have been no studies to quantify or define the consequences of long-term storage of tubers infected with PVY. To address these questions, this project has begun to document and quantify the potential of current-season, PVY infections to impact the long-term storage of selected cultivars with respect. This information will ultimately provide basic information needed to emphasize the importance of seed certification management efforts to reduce viral inoculum in foundation and certified seed stocks.

Objective.

Investigate how the timing of PVY infection within the growing season and PVY strain (PVY_{O}, and $PVY_{N:O}$) can affect the efficiency of tuber infection and the resulting long-term storability of harvested tubers.

Objectives and Experimental Approach.

Replicated field plots of four cultivars including 'R. Norkotah', 'Silverton', 'Shepody' and 'Atlantic' were established at the Hancock, Agricultural Research Station in 2008. Replicated plots were arranged in a randomized complete block design and consisted of 20 plants arranged in 4, 20-plant rows. A double guard row of PVY-resistant, 'Villetta Rose' was planted between varieties and surrounding the experimental plot to minimize interplot interference. Twenty plants in each experimental plot were mechanically, sap-inoculated using an artists airbrush with the three following PVY treatment combinations (PVY_{O}, $PVY_{N:O}$, and untreated control) at the 3-5 true-leaf developmental stage after emergence from the soil (early inoculation) and again on different replicates following the flowering stage (late inoculation). At the conclusion of the experiment, all plants in the experiment were subjected to double antibody sandwich, enzyme-linked, immunosorbant assay for confirmation of infection. A subset of inoculated plants determined to be infected with PVY strains were individually hand harvested from each experimental replicate and all tubers placed in harvest bags labeled according to variety, inoculation time, PVY strain, replicate, and plant number within row. A subset of non-inoculated, healthy plants from each variety / replicate combination was hand harvested and tubers placed in individually labeled bags.

Following harvest, tubers collected under individual plants were thoroughly washed, and tuber fresh weight (g) recorded. Washed tubers will then be air-dried and specific gravity determined. All tubers collected under plants serologically determined to be infected with PVY were then individually bagged and placed in storage. Quality parameters (tuber fresh weight, specific gravity, and percent sprouting) were assessed on stored tubers at regular intervals post-harvest throughout the cold storage period extending up to 36 weeks. Fresh market cultivars (e.g. 'Russet Norkotah' and 'Silverton') were maintained in storage at a constant 40° F and 95% RH while processing cultivars ('Russet Burbank' and 'Atlantic') were held at 48° F and 95% RH.

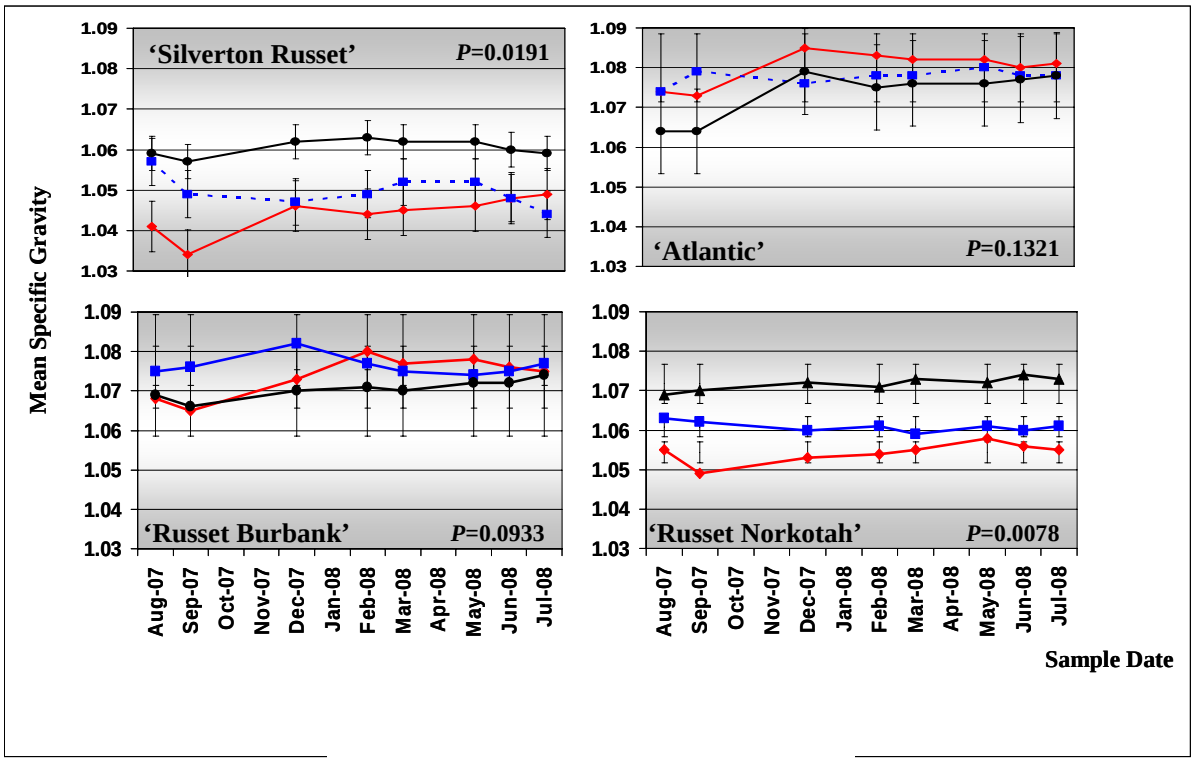

Figure 1. Mean specific gravity of fresh market (e.g. 'Russet Norkotah' and 'Silverton Russet') and processing cultivars ('Russet Burbank' and 'Atlantic') held in storage over 40 weeks comparing non-inoculated, control plants (●—●) to PVYO (◆—◆) and PVYN:O (■—■) inoculations.

To date, replicated field experiments have resulted in some interesting overall differences in tuber quality estimates among the varieties tested. Differences in percent solids (specific gravity), (Fig. 1) and mean weight loss (shrinkage) were detected in both 'Russet Norkotah' and 'Silverton' (Fig. 2). The efficiency of tuber infection in the 2007-08 field experiment did vary among cultivars when plants were infected at different developmental stages (e.g. preflower & postflower). With increasing plant age at the time of infection, reductions in the mean proportion of PVY-infected shoots resulted in the cultivars 'Atlantic' and 'R. Burbank'. This pattern of reduced tuber infection with increasing age of infection is consistent with the previously described phenomenon of mature plant resistance. However, the asymptomatic cultivars 'Silverton' and 'R. Norkotah' possessed daughter tuber mean infection rates that did not vary between infection times. Finally, no differences in the frequency of tuber infection were

observed between the two PVY strains used in the experiment, PVY_O and $PVY_{N:O}$ between the two asymptomatic cultivars.

In the coming season (2009), we propose to continue this area of investigation to determine if infection by PVY can influence the tuber physiological age and resulting emergence, stem number and tuber set. During development, the potato tuber passes through very definite stages which relate to the accumulation of physiological age. Furthermore, tuber production is directly related to physiological age of the seed piece which results from the combination of stresses imposed upon the plant. Plants with multiple stems, high tuber numbers and early plant maturity are highly desirable for the production of a seed potato crop. This type of plant arises from a seed tuber which has accumulated sufficient physiological age to have multiple sprouts. If seed physiological aging progresses too far, however, the sprouts will become progressively weaker and form branches. The resulting plant will be weak and will mature before maximum yield is attained. Potato seed grown with infection by PVY, which can stress the crop considerable, would be expected to be physiologically older at harvest than tubers from an un-infected plant. This area of investigation also seems extremely important as there have been no studies to quantify or define the consequences of long-term storage of tubers infected with PVY or the impact of this virus upon physiological age of tubers.

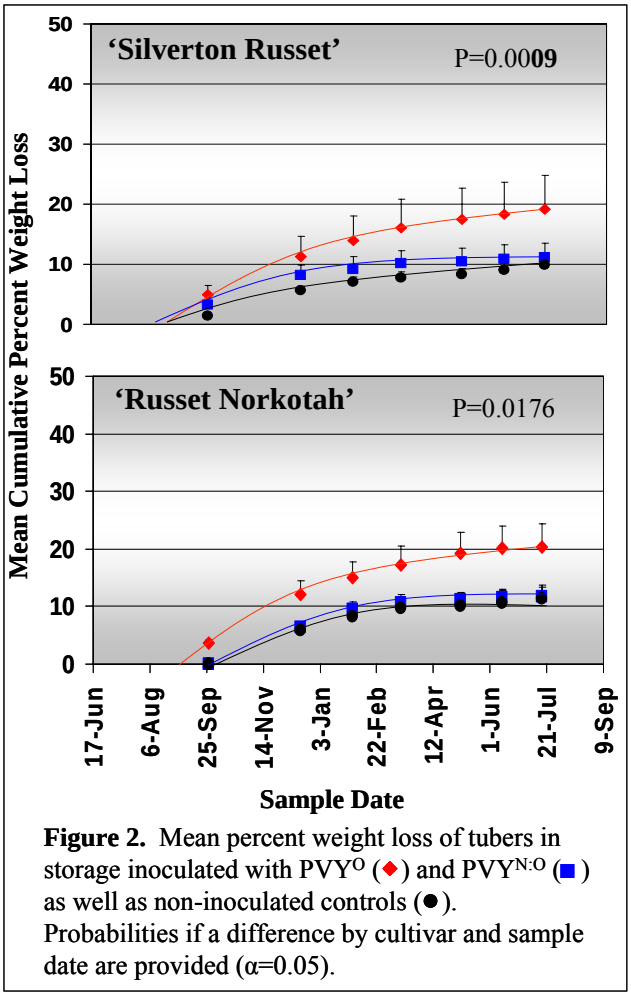

Figure 2. Mean percent weight loss of tubers in storage inoculated with PVY^O (◆) and $PVY^{N:O}$ (■) as well as non-inoculated controls (●). Probabilities if a difference by cultivar and sample date are provided (α=0.05).

References.

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SECTION I. PART6

Overwintering habitats of the Colorado potato beetle in Wisconsin's Central Sands Production Area

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Project History. Determination of Colorado potato beetle's (CPB), *Leptinotarsa decemlineata* (Say), relationship to previous potato crops has provided significant information aiding in development of area wide pest management and accurate recommendations, especially crop rotation. Documenting localized CPB movement improves our understanding of how this pest interacts with landscapes beyond the crop. Identification of preferred overwintering sites will provide fundamental research-based information needed to more feasibly and economically apply various cultural management tools (e.g. rotation, trap crops, perimeter sprays, etc).

Background and Rationale. Significant information has been generated regarding infield population dynamics, dispersal, and movement patterns of the CPB. Accurate characterization of CPB dispersal tendencies and overwintering site selection would benefit Wisconsin's commercial growing region. In temperate potato production regions, preferred CPB overwintering, or diapause, sites, are thought to be outside production fields and along field margins (Weber & Ferro 1994). Late season movement of CPB towards prominent dark, vertical landscape features, such as windbreaks and adjacent forested edges, is hypothesized to occur in many systems (Follett et al. 1996). Field studies by Weber and Ferro supporting this observation were conducted at several sites throughout Massachusetts. Understanding pre-diapause behavior in Wisconsin would greatly assist our interpretation of season to season pest management.

Density-dependent emigration was proposed by Weber and Ferro (1994) as the single greatest factor influencing edge habitat dispersal. These findings have been met with some disagreement regarding the relative importance of dispersal mechanisms to field edges. Specifically, Sandeson

et al. (2002) described the emigration patterns of CPB to be density-independent, influenced more so by short day length and forage quality than by population size or aggregations of populations. Regardless of the dominant dispersal mechanism that triggers movement, Weber and Ferro (1994) have shown overwintering beetles proceeding to non-crop areas exhibit consistent behavioral tendencies. Long range flight seems to be the primary method for late season CPB dispersal from cropping systems. Observation of long range flights to field edges have been documented where individuals will fly approximately five meters or less from the ground to overwintering sites. Striking vegetation induces the beetles to drop to the earth and burrow into the soil (Weber and Ferro 1994). This behavioral response to vegetation may result in 'apparent' aggregation of diapausing adults along field edges.

Investigation of this phenomenon is extremely important as there has been little work to quantify or spatially define the influence of specific, non-crop habitat types in Wisconsin. Understanding behavioral tendencies of adult CPB dispersion from the field will make management practices such as large scale, focused trap crops, trenches, and specific applications of adulticides more efficient and effective. To address these questions, this project has documented and quantified differing bordering landscape elements, consistent with the Natural Resource Initiatives, Managed Ecosystems Project, serving as potential overwintering habitats and has attempted to document the movement and dispersal patterns of overwintered, adult CPB from these areas.

A realization of what, if any, specific non-crop community is preferentially selected by CPB in the Central Sands would be advantageous for several reasons. 1) Unmanaged fallow areas may not provide services and additionally create quality overwintering conditions for beetles. 2) Important native plant communities of particular interest have been identified in the potato growing region through the efforts by the USDA's Natural Resource Initiatives program. These communities may provide positive ecosystem services such as biological control of pests. 3) Characterization of landscapes which are consistently associated with CPB will promote more effective management solutions.

Objectives:

Do influential landscape characteristics (or features) exist for CPB and can colonization be modeled for potato production area?

- Colonization magnitude is influenced by distance to previous potato.
- Colonization is associated with composition of landscapes surrounding the field.
- Statistical modeling may characterize influential habitats through robust sampling and advanced analysis.

Will pest colonization magnitude be similar over time for the Central Sands?

- Infield CPB colonization and relative population magnitude for the 2008 growing season will be similar to 1998.
- Results from pest populations of 2008 will validate the statistical model indicating landscape influence upon CPB colonization.

Experimental Site: A total of 13 potato fields dispersed throughout the I-39 corridor were sampled in the Central Sands in 2008. Among these 13 experimental fields, 4 sites used systemic neonicotinoid insecticides as early season pest control while the remained of the field

sites selected used a combination of neonicotinoid as well as other modes of action as foliar based control programs to reduce CPB.

Materials and Methods: Historical CPB count data from 1998 were provided by Drs. Deana Knutson and Jeffrey Wyman through the Area Wide Management Project and creation of a 2008 set was similar to the data collected in 1998. The experimental design and data collection protocol was replicated in 1998 similar to that in 2008, with respect to CPB counts.

Data compiled in 1998 by the Wyman lab at UW-Madison provides significant information about pest colonization from 39 commercial potato fields. Each sample field possessed sixteen specific geo-referenced systematic data points. Points were placed at approximately equal intervals surrounding the field. Points were positioned ten feet from the field edge within the crop. CPB populations were counted at each point by recording numbers of adults, eggs, small larvae (1^{st} and 2^{nd} instars), large larvae (3^{rd} and 4^{th} instars) per ten plants. Sample collection dates were May 26^{th} to June 5^{th}, 1998.

Field studies were duplicated in the 2008 growing season. Six growers were contacted and identified as cooperators in the study. Growers were asked to identify potato acreages from both 2007 and 2008. Sample fields were selected from their composite of acreages throughout the I-39 corridor from Stevens Point to Coloma. Thirteen fields were selected from the complete acreages to generally represent a range of distances from previous year's potato. Field boundaries were identified and digitized into a GIS (ArcGIS 9.2). Field edges were buffered 10 feet inward. The buffer edge was split into 16 equidistant sample points based on edge length. CPB colonization was documented in an identical manner to the 1998 study. The large spatial distribution of sample fields made sampling peak colonization exceptionally difficult. We felt several sampling dates per field would better represent peak colonization over time. Sampling occurred between the first and fourth week in June, 2008.

Spatial Analysis: 1998 & 2008 count data was loaded into a geographic information system (ArcGIS 9.2). Sampling points had a field location designation attached. These appended together based on sampling field. Each sample point was then incrementally buffered at 50 meter radii to 450 meters (Figure 1).

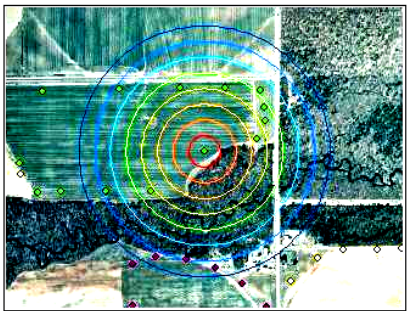

Figure 1: 50 – 450 meter radii to quantify acreages of non-crop habitat contributing to CPB colonization

Sample fields were given a specific landuse classification indicating the year of potato production. These locations were merged with an improved landuse data layer derived from the Portage, Waushara, and Adams County landuse layers. Information was standardized into a 24 class scheme. Habitat classifications were consistent with those established by the NRI-Managed Ecosystems Project. Land classes were visually validated with the assistance of NAIP ortho-rectified aerial photography (National Agriculture Imagery Program 2000 & 2005). All sample points and buffers were projected upon the updated landuse data. A layer intersect process was conducted

for each buffer zone to determine aerial extent of all land classes within its boundary. The resulting data set produced information quantifying non-crop land surrounding sampled growing fields.

Tabular outputs of were then exported for statistical analysis. SAS Software (SAS Institute 2008) was used for initial stepwise, multivariate regression analysis. Development of a model describing pest colonization and interaction with the landscape is a good first step in understanding how this insect interacts with individual landscape components.

Preliminary Results: Model development over a region-wide landscape has proven to be a difficult task. Considerable differences in the range and identity of habitats and ecosystems from the southern Sands to Stevens Point were present in our study. Initial development of a 2008 model to describe colonization for all 13 fields led to a relatively low predictive ability (R^2 = 0.22). Reduced predictability may be attributed to the wide or large separation of samples in space. Factors such as variation in degree days, non-crop landscapes, soil characteristics, or management style may contribute to the general nature of the among location variability observed. The comprehensive 2008 model does however highlight interesting trends in landscape influence. By building this model we have observed that certain landscapes consistently contribute either in a positive or negative manner to CPB colonization (Figure 2). Specifically, the model indicates that the mixed urban and herbaceous scrub classes are negatively associated with beetle colonization. Conversely, high beetle numbers are generally positively associated to non-irrigated cropland and water bodies; or more specifically the riparian habitats surrounding the water bodies.

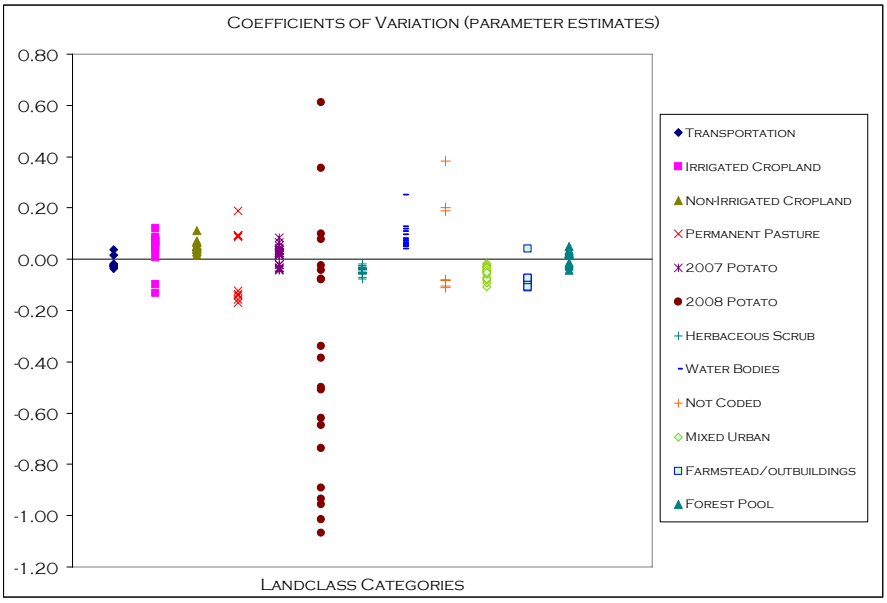

Figure 2: Landscape model output for the entire 15 field sample. Points above and below the line are related to high or low beetle colonization.

Discussion: Though this is a general understanding of the information produced in the summer of 2008, it does provide a quality start. The next step in analysis will focus upon documenting relationships over time (1998 & 2008). Additionally, use of geostatistics will assist in determining an optimal spatial extent to model fields by region. Accomplishing a general interpretable understanding of landscape contribution may very well complement both management strategies and ecosystem enhancement.

Detection of preferential diapause locations would also greatly increase the accurate deployment of cultural control methods for emerging adults in the spring. Accurate deployment of large scale focused trap crops, trenches, and specific applications of adulticides may result from an improved understanding of CPB behavioral tendencies. Focused and well-timed deployment of selected cultural practices may benefit the potato growing industry by providing another set of sustainable management practices to limit an insect with a tremendous potential for resistance development. With the potential for increases in insensitivity to industry control standards such as the neonicotinyl class of insecticides, adequate control may be achieved through a combination of practices. Successful implementation of cultural control tactics would directly assist in CPB management. The perpetuation of this valuable chemical family would clearly be advantageous due to their minimal effects on non-target organisms and their flexibility in use through in-furrow, lay-by, and seed treatment applications. Continued use of these important chemistries, however, can only occur with responsible stewardship in managing the CPB which should embrace alternate control methods where possible. Thus there are significant intrinsic merits to researching and discovering the over wintering habitat preferences of Colorado potato beetles.

Acknowledgements: We wish to extend a sincere thanks to participating growers and producers who have hosted our research including Coloma Farms, Coloma, WI, Heartland Farms, Hancock, WI, Bacon Farms, Hancock, WI, Okray Family Farms, Plover, WI, Hamerski Farms, Plover, WI, Plover River Farms, Stevens Point, WI.

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Section II. Insect Control on Other Crops.

In the Midwestern United States snap beans are grown primarily for processing with production areas in Wisconsin, Illinois, Minnesota, and Michigan. Wisconsin ranks first nationally with 35% of national production on over 80,000 acres valued at $36 million annually.

The most damaging insect pests are those that attack the pods which result in either pod damage or contamination of the processed product. The European corn borer (ECB) and to a lesser extent the corn earworm (CEW) are the major pod feeding pests with damage primarily from 2nd generation ECB and late flights of CEW in August/September. Damage from both species occurs from flowering to harvest, creating a treatment window of 30-7 days before harvest. Pods are protected during this window with a 2-4 spray program when crop maturity coincides with moth flights. A typical spray program in Wisconsin includes a pyrethroid (Capture, Warrior, or Mustang) frequently used in rotation with an organophosphate (Orthene).

Although many of the insecticides used on snap beans are targeted at bloom/pod pests, there is never the less a complex of insects which frequently attacks snap beans prior to bloom. These insect pests in Wisconsin have traditionally been the seed corn maggot (SCM) and potato leafhopper (PLH). SCM adults lay eggs in the soil over freshly planted bean seeds and larvae (maggots) tunnel in germinating seeds and plants causing seedling distortion and stand loss. Control of SCM has been achieved with a seed treatment using the organophosphate (OP) insecticide Lorsban with most of the snap bean acreage being treated. PLH adults migrate into emerged beans and feed by extracting sap and causing leaf chlorosis, necrosis and yield loss. Control of PLH is achieved with foliar sprays at threshold using low rates of pyrethroids (Capture, Warrior, Asana, and Mustang), organophosphates (Dimethoate) or carbamates (Sevin, Lannate).

Part 1. Insect Control on Snap Beans, Arlington, WI 2008.

A. European Corn Borer Control on Snap Bean with Foliar Insecticides. Arlington.

In 2008, an experiment was established at the Arlington Entomology Research Farm to evaluate efficacy of registered and experimental insecticides on European corn borer larvae (ECB) on snap bean.

Plots of Hystyle variety snap beans were planted on 30 May and consisted of two rows by 30', planted on 30" centers. Plots were separated by two untreated border rows and 12' alleyways separated four replications arranged in a randomized complete block experimental design. Metolachlor (Dual II Magnum) at 2.0 pint product per acre was applied on 30 May for weed control. Plots were also mechanically cultivated and hand weeded as necessary to maintain weed control.

All materials were applied at 26.5 gpa with a CO2 pressurized backpack sprayer with a 6' boom operating at 30 psi.

The following insecticides were evaluated for ECB efficacy on snap bean:

Cyazapyr 10SE (0.088, 0.11, and 0.134 lb. a.i./a)
Cyazapyr 10OD (0.11 lb. a.i./a)
Coragen 1.67SC (0.044 and 0.066 lb. a.i./a)
Avaunt 30WG (0.0656 and 0.112 lb. a.i./a)
Tesoro 4E (0.2 lb. a.i./a)
Capture 2EC (0.07 lb. a.i./a)
Spintor 2SC (0.094 lb. a.i./a)
Entrust 80WP (0.125 lb. a.i./a)
Lannate 29E (0.91 lb. a.i./a)
Radiant 1SC (0.047 and 0.0625 lb. a.i./a)
Hero 1.24EC (0.058 and 0.082 lb. a.i./a)
Alverde 2SC (0.214 lb. a.i./a)
Orthene 97SP (1.0 lb. a.i./a)
Rimon 0.83EC (0.078 lb. a.i./a)
Dipel 54DF (0.27 and 0.54 lb. a.i./a)
Aza-Direct (0.0123 and 0.0247 lb. a.i./a)
Warrior 1CS (0.03 lb. a.i./a)
Mustang Max 0.8EC (0.025 lb. a.i./a)

Insecticide applications were made on 23 July, which was three days after the first ECB infestation (20 July) and two days prior to the second infestation (25 July).

Five consecutive plants in each plot were pinned with wax paper strips, each containing 10 blackhead stage ECB egg masses. Egg masses were placed on the plants during optimal environmental conditions (early evening hours) to increase larval survival.

Plots were harvested and evaluated on 6 August (early pinning) and 14 August (late pinning) and included the inspection of the pods and stems of the five infested plants from each infestation, recording damage and presence of live larvae.

RESULTS

The early artificial infestations in 2008 (20 July) at first pin pod resulted in an average of 4.0 larvae in 10.8 damaged pods from the untreated plots while an average of 2.3 larvae were found in 5.3 damaged stems (Table 1). The experimental compound Cyazapyr at all three rates and both formulations did not appear to have much efficacy on ECB larvae. Larval numbers from both the stems and the pods were similar to the untreated plots. Coragen and at both rates significantly reduced larval numbers in both the stems and in the pods. Avaunt also significantly reduced larval numbers in the stems but pod larval numbers were similar to the untreated plots. Tesoro provided little efficacy against ECB larvae in both the stems and pods. The pyrethroids (Capture, Mustang Max, Warrior, and Hero) performed well and all had fewer damaged pods and stems than the untreated plots. Spintor, Radiant, Entrust and Orthene performed very well, limiting pod and stem damage with few larvae found.

Rimon, Dipel, and Aza-Direct reduced larval numbers in the stems while larval numbers were higher in the damaged pods.

The late artificial infestations on 25 July resulted in an average of 3.0 larvae in 6.0 damaged pods while an average of 1.8 larvae were found in 5.3 damaged stems from the untreated plots (Table 2). Overall larval numbers were lower among all the treatments in comparison to the earlier infested plots, indicating a less successful artificial infestation. Similar efficacy trends were observed in the later pinning as seen in the early pinning.

Table 1. European corn borer larvae and damage on Hystyle variety snap beans infested on 20 July. Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean data from 5 plants					Mean data from pods					
		Plants	Stems	Larvae from stems			Pods			Larvae from pods		
				Small	Large	Total	Total	Dam.	% Dam.	Small	Large	Total
Untreated	---	3.3 ab	5.3 ab	1.8 a	0.5 ab	2.3 a	49.8 bc	10.8 b-g	22.0 b-g	2.3 abc	1.8 a-d	4.0 abc
Cyazapyr 10SE[1]	0.088	2.5 a-e	3.5 b-f	0.5 bcd	0.3 ab	0.8 b-e	54.8 bc	11.8 a-f	21.9 b-g	2.3 abc	1.5 a-e	3.8 abc
Cyazapyr 10SE[1]	0.11	2.5 a-e	4.8 abc	0.5 bcd	0.8 a	1.3 a-d	48.8 bc	12.0 a-e	23.1 a-f	1.3 b-e	1.8 a-d	3.0 b-f
Cyazapyr 10SE[1]	0.134	3.0 abc	5.3 ab	1.3 ab	0.5 ab	1.8 ab	59.5 bc	14.3 ab	36.0 a	1.8 b-e	2.5 a	4.3 abc
Cyazapyr 10OD[1]	0.11	1.3 ef	1.3 ef	0.3 cd	0.0 b	0.3 de	72.0 ab	5.8 f-i	7.1 h	1.3 b-e	0.3 de	1.5 c-f
Coragen 1.67SC[1]	0.044	1.5 def	2.0 def	0.0 d	0.0 b	0.0 e	59.3 bc	5.0 ghi	8.4 h	0.3 de	0.3 de	0.5 ef
Coragen 1.67SC[1]	0.066	2.0 b-f	3.5 b-f	0.5 bcd	0.5 ab	1.0 b-e	57.5 bc	5.8 f-i	9.3 gh	0.0 e	0.3 de	0.3 f
Avaunt 30WG[1]	0.0656	2.3 b-f	2.8 b-f	0.3 cd	0.5 ab	0.8 b-e	56.5 bc	7.3 d-i	13.3 d-h	1.8 b-e	2.5 a	4.3 abc
Avaunt 30WG[1]	0.11	2.0 b-f	2.3 c-f	0.3 cd	0.3 ab	0.5 cde	90.5 a	9.5 b-h	13.6 c-h	1.5 b-e	1.3 a-e	2.8 b-f
Tesoro 4EC	0.20	3.8 a	6.5 a	1.3 ab	0.5 ab	1.8 ab	57.0 bc	17.5 a	31.9 ab	3.8 a	2.3 ab	6.0 a
Capture 2EC	0.07	1.0 f	2.0 def	0.0 d	0.0 b	0.0 e	52.0 bc	5.5 ghi	10.0 fgh	1.3 b-e	0.8 b-e	2.0 b-f
Spintor 2SC	0.094	1.3 ef	1.5 ef	0.0 d	0.0 b	0.0 e	57.0 bc	4.3 hi	8.0 h	0.0 e	0.3 de	0.3 f
Entrust 80WP	0.125	1.5 def	1.8 def	0.3 cd	0.0 b	0.3 de	58.3 bc	2.8 i	4.8 h	0.3 de	0.0 e	0.3 f
LSD		1.40	2.56	0.94	0.7	1.2	29.14	6.03	13.40	1.94	1.68	2.98
S.D.		0.99	1.81	0.67	0.49	0.85	20.60	4.27	9.48	1.37	1.19	2.11
C.V.		52.68	69.65	154.11	218.49	128.74	36.43	50.83	59.06	98.65	120.57	88.72
F		2.360	2.422	2.046	0.952	2.100	0.751	2.808	3.141	1.845	1.692	2.259
Prob. (F)		0.0012	0.0009	0.0058	0.5432	0.0044	0.8072	0.0001	0.0001	0.0156	0.0324	0.0020

(continued)

Means in a column followed by the same letter do not significantly differ (Least Significant Difference Test, P=0.05).
[1]MSO was added at 0.5% v/v. [2]Penetrator Plus was added at 0.25% v/v.

Table 1. (Continued). European corn borer larvae and damage on Hystyle variety snap beans infested on 20 July. Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean data from 5 plants					Mean data from pods					
				Larvae from stems			Pods			Larvae from pods		
		Plants	Stems	Small	Large	Total	Total	Dam.	% Dam.	Small	Large	Total
Untreated	---	1.3 ef	1.5 ef	0.0 d	0.3 ab	0.3 de	46.8 bc	6.8 d-i	14.1 c-h	1.5 b-e	0.5 cde	2.0 b-f
Lannate 29E	0.90	2.8 a-d	3.3 b-f	1.3 ab	0.0 b	1.3 a-d	49.8 bc	13.8 abc	26.9 abc	3.0 ab	1.8 a-d	4.8 ab
Radiant 1SC	0.035	1.0 f	1.3 ef	0.3 cd	0.0 b	0.3 de	57.8 bc	6.0 e-i	11.0 e-h	2.0 a-d	0.8 b-e	2.8 b-f
Radiant 1SC	0.047	1.3 ef	1.3 ef	0.5 bcd	0.0 b	0.5 cde	58.3 bc	3.8 hi	6.7 h	0.3 de	0.5 cde	0.8 def
Hero 1.24EC	0.058	1.5 def	2.0 def	0.8 bcd	0.0 b	0.8 b-e	57.0 bc	8.0 c-i	13.6 c-h	1.5 b-e	1.8 a-d	3.3 a-e
Hero 1.24EC	0.082	1.0 f	1.0 f	0.0 d	0.0 b	0.0 e	54.3 bc	3.8 hi	6.7 h	0.3 de	0.3 de	0.5 ef
Alverde 2SC[2]	0.214	1.5 def	1.8 def	0.0 d	0.3 ab	0.3 de	61.8 abc	8.3 b-i	13.8 c-h	1.5 b-e	0.5 cde	2.0 b-f
Orthene 97SP	1.0	1.3 ef	1.3 ef	0.0 d	0.0 b	0.0 e	58.0 bc	6.3 d-i	10.5 fgh	0.3 de	0.3 de	0.5 ef
Rimon 0.83EC	0.078	1.3 ef	2.5 c-f	0.5 bcd	0.0 b	0.5 cde	55.3 bc	9.5 b-h	17.1 c-h	1.5 b-e	0.8 b-e	2.3 b-f
Dipel 54DF	0.54	1.5 def	2.3 c-f	0.0 d	0.5 ab	0.5 cde	41.3 c	9.3 b-h	24.2 a-e	2.0 a-d	1.5 a-e	3.5 a-d
Dipel 54DF	1.08	1.5 def	1.8 def	0.0 d	0.5 ab	0.5 cde	53.8 bc	8.8 b-i	17.5 c-h	0.5 cde	0.3 de	0.8 def
Aza-Direct 0.1EC	0.0123	1.8 c-f	2.3 c-f	0.3 cd	0.0 b	0.3 de	47.5 bc	12.3 a-d	25.4 a-d	2.0 a-d	2.0 abc	4.0 abc
Aza-Direct 0.1EC	0.0247	3.0 abc	3.8 b-e	1.0 abc	0.5 ab	1.5 abc	45.3 bc	13.5 abc	32.0 ab	2.8 ab	1.3 a-e	4.0 abc
Warrior 1CS	0.03	1.5 def	2.0 def	0.3 cd	0.3 ab	0.5 cde	63.8 abc	6.3 d-i	10.2 fgh	1.8 b-e	0.5 cde	2.3 b-f
Mustang Max 0.8EC	0.156	3.0 abc	4.3 a-d	1.0 abc	0.5 ab	1.5 abc	58.8 bc	9.3 b-h	15.4 c-h	1.8 b-e	1.3 a-e	3.0 b-f
LSD		1.40	2.56	0.94	0.7	1.2	29.14	6.03	13.40	1.94	1.68	2.98
S.D.		0.99	1.81	0.67	0.49	0.85	20.60	4.27	9.48	1.37	1.19	2.11
C.V.		52.68	69.65	154.11	218.49	128.74	36.43	50.83	59.06	98.65	120.57	88.72
F		2.360	2.422	2.046	0.952	2.100	0.751	2.808	3.141	1.845	1.692	2.259
Prob. (F)		0.0012	0.0009	0.0058	0.5432	0.0044	0.8072	0.0001	0.0001	0.0156	0.0324	0.0020

Means in a column followed by the same letter do not significantly differ (Least Significant Difference Test, P=0.05).
[1]MSO was added at 0.5% v/v. [2]Penetrator Plus was added at 0.25% v/v.

Table 2. European corn borer larvae and damage on Hystyle variety snap beans infested on 23 July. Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean data from 5 plants					Mean data from pods					
		Plants	Stems	Larvae from stems			Pods			Larvae from pods		
				Small	Large	Total	Total	Dam.	% Dam.	Small	Large	Total
Untreated	---	3.0 abc	5.3 a	1.3 abc	0.5 a	1.8 abc	55.8 ab	6.0 b-e	11.7 b-f	2.5 a	0.5 bc	3.0 a
Cyazapyr 10SE[1]	0.088	2.8 a-d	3.8 a-d	0.5 cd	0.3 a	0.8 bcd	45.0 b	7.0 bcd	16.3 abc	1.0 b-e	1.0 ab	2.0 a-d
Cyazapyr 10SE[1]	0.11	3.3 ab	5.3 a	2.0 a	0.0 a	2.0 ab	52.0 ab	5.5 c-g	10.3 c-g	1.0 b-e	0.3 bc	1.3 c-f
Cyazapyr 10SE[1]	0.134	3.5 a	5.5 a	0.3 d	0.0 a	0.3 d	60.5 ab	8.0 bc	13.8 a-e	0.8 c-f	0.5 bc	1.3 c-f
Cyazapyr 10OD[1]	0.11	2.0 b-g	2.5 b-g	0.3 d	0.0 a	0.3 d	55.3 ab	0.0 j	0.0 k	0.0 f	0.0 c	0.0 g
Coragen 1.67SC[1]	0.044	1.0 fgh	1.0 fg	0.0 d	0.0 a	0.0 d	57.3 ab	0.8 hij	1.1 jk	0.0 f	0.0 c	0.0 g
Coragen 1.67SC[1]	0.066	1.3 e-h	1.5 d-g	0.0 d	0.3 a	0.3 d	64.0 ab	0.3 ij	0.7 k	0.0 f	0.0 c	0.0 g
Avaunt 30WG[1]	0.0656	1.5 d-h	2.0 c-g	0.0 d	0.0 a	0.0 d	66.5 ab	3.8 d-i	6.3 f-k	0.3 ef	0.5 bc	0.8 efg
Avaunt 30WG[1]	0.11	1.3 e-h	1.5 d-g	0.5 cd	0.0 a	0.5 cd	66.8 ab	2.0 g-j	2.8 h-k	0.0 f	0.5 bc	0.5 fg
Tesoro 4EC	0.20	1.5 d-h	2.0 c-g	0.3 d	0.0 a	0.3 d	68.8 ab	0.8 hij	0.7 k	0.0 f	0.0 c	0.0 g
Capture 2EC	0.07	1.3 e-h	1.8 c-g	0.3 d	0.0 a	0.3 d	55.5 ab	0.3 ij	0.3 k	0.0 f	0.3 bc	0.3 fg
Spintor 2SC	0.094	1.5 d-h	2.0 c-g	0.0 d	0.3 a	0.3 d	63.0 ab	2.5 e-j	4.0 g-k	0.0 f	0.3 bc	0.3 fg
Entrust 80WP	0.125	1.0 fgh	1.3 efg	0.0 d	0.0 a	0.0 d	58.0 ab	0.5 hij	0.9 jk	0.0 f	0.0 c	0.0 g
LSD		1.47	2.32	1.00	0.56	1.28	24.88	3.67	6.66	0.88	0.80	1.21
S.D.		1.04	1.64	0.71	0.40	0.90	17.60	2.59	4.70	0.62	0.57	0.86
C.V.		59.85	68.59	153.85	317.75	155.01	29.59	83.19	83.83	140.55	174.11	111.76
F		50.497	60.132	36.621	6.713	34.477	21.931	83.547	83.532	44.247	23.369	54.800
Prob. (F)		0.0002	0.0001	0.0001	0.8216	0.0015	0.9172	0.0001	0.0001	0.0001	0.0209	0.0001

(continued)

Means in a column followed by the same letter do not significantly differ (Least Significant Difference Test, P=0.05).
[1]MSO was added at 0.5% v/v. [2]Penetrator Plus was added at 0.25% v/v.

Table 2. (Continued). European corn borer larvae and damage on Hystyle variety snap beans infested on 25 July. Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean data from 5 plants					Mean data from pods					
				Larvae from stems			Pods			Larvae from pods		
		Plants	Stems	Small	Large	Total	Total	Dam.	% Dam.	Small	Large	Total
Untreated	---	2.3 a-f	3.5 a-e	1.8 a	0.5 a	2.3 a	64.3 ab	5.8 b-f	9.3 d-h	1.3 bcd	0.5 bc	1.8 b-e
Lannate 29E	0.90	2.8 a-d	5.0 a	1.5 ab	0.5 a	2.0 ab	50.5 ab	8.8 abc	17.9 ab	1.3 bcd	1.5 a	2.8 ab
Radiant 1SC	0.035	1.3 e-h	2.0 c-g	0.8 bcd	0.3 a	1.0 a-d	60.5 ab	1.5 hij	2.5 ijk	0.0 f	0.5 bc	0.5 fg
Radiant 1SC	0.047	1.0 fgh	1.3 efg	0.3 d	0.0 a	0.3 d	48.8 ab	1.5 hij	3.1 h-k	0.0 f	0.0 c	0.0 g
Hero 1.24EC	0.058	1.0 fgh	1.0 fg	0.0 d	0.0 a	0.0 d	64.3 ab	0.3 ij	0.3 k	0.0 f	0.0 c	0.0 g
Hero 1.24EC	0.082	1.0 fgh	1.0 fg	0.0 d	0.3 a	0.3 d	62.3 ab	0.5 hij	0.8 jk	0.0 f	0.0 c	0.0 g
Alverde 2SC[2]	0.214	1.8 c-g	2.0 c-g	0.3 d	0.3 a	0.5 cd	60.3 ab	3.0 e-j	4.6 g-k	0.5 def	0.3 bc	0.8 efg
Orthene 97SP	1.0	0.3 h	0.3 g	0.0 d	0.0 a	0.0 d	61.5 ab	0.0 j	0.0 k	0.0 f	0.0 c	0.0 g
Rimon 0.83EC	0.078	2.3 a-f	2.5 b-g	0.3 d	0.0 a	0.3 d	52.3 ab	4 d-h	7.4 e-j	0.8 c-f	0.5 bc	1.3 c-f
Dipel 54DF	0.54	2.5 a-e	4.0 abc	0.3 d	0.0 a	0.3 d	58.5 ab	1.8 hij	3.3 h-k	0.0 f	0.5 bc	0.5 fg
Dipel 54DF	1.08	1.8 c-g	2.3 b-g	0.0 d	0.3 a	0.3 d	58.5 ab	2.3 f-j	4.1 g-k	0.3 ef	0.0 c	0.3 fg
Aza-Direct 0.1EC	0.0123	2.3 a-f	3.3 a-f	1.3 abc	0.0 a	1.3 a-d	54.8 ab	9.3 ab	15.5 a-d	1.5 bc	1.0 ab	2.5 ab
Aza-Direct 0.1EC	0.0247	3.3 ab	4.5 ab	1.5 ab	0.3 a	1.8 abc	72.5 a	12.0 a	19.0 a	1.8 ab	0.5 bc	2.3 abc
Warrior 1CS	0.03	1.3 e-h	1.5 d-g	0.3 d	0.0 a	0.3 d	51.8 ab	0.0 j	0.0 k	0.0 f	0.0 c	0.0 g
Mustang Max 0.8EC	0.156	0.8 gh	0.8 g	0.5 cd	0.0 a	0.5 cd	69.3 ab	0.8 hij	0.9 jk	0.3 ef	0.0 c	0.3 fg
LSD		1.47	2.32	1.00	0.56	1.28	24.88	3.67	6.66	0.88	0.80	1.21
S.D.		1.04	1.64	0.71	0.40	0.90	17.60	2.59	4.70	0.62	0.57	0.86
C.V.		59.85	68.59	153.85	317.75	155.01	29.59	83.19	83.83	140.55	174.11	111.76
F		50.497	60.132	36.621	6.713	34.477	21.931	83.547	83.532	44.247	23.369	54.800
Prob. (F)		0.0002	0.0001	0.0001	0.8216	0.0015	0.9172	0.0001	0.0001	0.0001	0.0209	0.0001

Means in a column followed by the same letter do not significantly differ (Least Significant Difference Test, P=0.05).
[1]MSO was added at 0.5% v/v. [2]Penetrator Plus was added at 0.25% v/v.

SECTION II PART 1-B

Title. Systemic and foliar insecticide options for the control of European corn borer in succulent snap bean production, Arlington Agricultural Experiment Station, 2008.

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Project History. This is first year of a project partially supported by DuPont Crop Protection to investigate the pest management options for the control of late-season insect pests in succulent snap bean production, including European corn borer (ECB), *Ostrinia nubilalis.*

Background and Rationale. Effective, economical, and efficient season-long management of key insect pest species in commercial, succulent snap bean continues to be a challenge for many locales in the Midwest. Much of the processing snap bean crop in the upper Midwest is now treated with an at-plant, seed treatment including thiamethoxam, (Cruiser® 5FS). This prophylactic approach is designed to mitigate risk of damage by both seed corn maggot (SCM), *Delia platura*, and the potato leafhopper (PLH), *Empoasca fabae*. Cruiser applied at the labeled rates of 1.28 fl oz / 100 lb of seed, has been demonstrated to protect the crop from the early season seed maggot pressure as well as the damage resulting from immigrant potato leafhopper populations for nearly 50 days. Unfortunately, the Cruiser seed treatments will not protect the crop against infestation by the European corn borer. As a result, if degree day accumulations are favorable for a flight of European corn borer at a vulnerable stage of snap bean development (e.g. flowering to pin bean stage), a foliar spray of insecticide continues to be warranted.

Experimental Site: Arlington Agricultural Experiment Station, Arlington, Wisconsin 2008.

Project Objective: To evaluate and compare an experimental and a commercially registered anthrilic diamide, cyazypyr (HGW86 20SC), and rynaxypyr (Coragen® 1.67SC), respectively, as in-furrow applied compounds for the control of European corn borer in succulent snap beans. Moreover, to make direct comparisons with the current foliar registration of a bifenthrin and zeta-cypermethrin tank mix (Hero™ 1.24EC) and the unregistered indoxacarb (Avaunt® 30WG) as control standards.

Experimental Design: A total of 10 treatments were arranged in a randomized, complete-block design with 2 ECB egg mass pinning times (1st and 2nd pinning) which were placed 3 days in advance of and 3 days following the application of foliar insecticides (**Table 1**). This approach was taken to measure the residual and direct contact activity of each foliar applied compound, respectively. All experimental plots, including at-plant and foliar applied insecticides, were replicated 4 times on *Phaseolus vulgaris* cv. 'Hystyle'. All seeds received an application of Captan® 4000 at a rate of 2.5 fl oz / 100 lb of seed to reduce early season disease pressure. In-furrow insecticide applications consisted of single row experimental plots measuring 25' and were flanked by three, machine planted rows on 30" row centers. Foliar insecticide treated plots also consisted of single, 25' rows again flanked by three, untreated guard rows.

Table 1. Spray table estimates for systemic and foliar insecticide applications targeting European corn borer populations, AAES 2008.

Trt No.	Type	Treatment Name	Form Conc	Form Unit	Form Type	Rate	Rate Unit	Amt Product to Measure
1	CHK	Untreated						
2	INSE	HGW 86	200	GA/L	SC	0.066	lb ai/a	1.747 ml/mx
3	INSE	HGW 86	200	GA/L	SC	0.134	lb ai/a	3.547 ml/mx
4	INSE	HGW 86	200	GA/L	SC	0.176	lb ai/a	4.658 ml/mx
5	INSE	Coragen	1.67	LB/GAL	SC	0.066	lb ai/a	1.743 ml/mx
	ADJ	MSO	100	%AW/W	L	0.5	% v/v	1.5 ml/mx
6	INSE	Coragen	1.67	LB/GAL	SC	0.176	lb ai/a	4.649 ml/mx
	ADJ	MSO	100	%AW/W	L	0.5	% v/v	1.5 ml/mx
7	INSE	Avaunt	30	%AW/W	WG	3.5	oz wt/a	1.156 g/mx
8	INSE	Avaunt	30	%AW/W	WG	6.0	oz wt/a	1.982 g/mx
9	INSE	Hero	1.24	LB/GAL	EC	4.0	fl oz/a	1.379 ml/mx
10	INSE	Hero	1.24	LB/GAL	EC	5.0	fl oz/a	1.723 ml/mx

* 'Per area' calculations based on spray volume= 6.8 gal/ac, mix size= 0.3 liters (mix size basis).
* Product amount calculations increased 25 % for overage adjustment.
* 'Per volume' calculations use spray volume= 6.8 gal/ac, mix size= 0.3 liters.

Treatment Evaluations: Foliar insecticides were applied on 19 July 2008 using a CO_2 pressurized, backpack sprayer with a 3' boom operating at 30 psi delivering 25 gpa through 2 flat-fan nozzles (8004VS-XR) spaced 18" apart. A pair of ECB egg masses was pinned to the stems of 5 replicate plants per plot on each of 2 dates, 16 and 23 July 2008 flanking the single foliar application of insecticide as described previously. Pinning dates represent 1st and 2nd pinning throughout the remainder of the research report and represent a direct contact treatment and a residual (ingested) treatment, respectively. At-plant insecticides were applied in the planting furrow on 27 June, 2008 when the stand was established. In-furrow insecticides were applied using a CO_2 pressurized, backpack sprayer with a single outlet operating at 30 psi delivering 4.5 gpa through a single, disc-core type hollow-cone nozzle tip (D3-DC25). Approximately 12 days after planting, stand counts were conducted in each experimental plot to determine the potential for any unanticipated phytotoxicity.

Populations of ECB in all plots were surveyed on 2 dates following application of foliar insecticides. Infesting ECB populations in the at-plant and the 1st pinning foliar treatments were conducted 7 August and populations in the 2nd pinning treatments were counted one week later on 14 August 2008. All statistical comparisons among treatments were conducted on separate pinning dates to minimize error variance. Plots were assessed by initially counting the number of infested plants in each plot in addition to counting all mobile lifestages (e.g. small and large larvae) among the 5 plants on which egg masses were initially pinned. After counting the number of infested plants and stems per plant, all pods were removed from the 5 plants and the number of infested pods recorded. Here again, the number of immature lifestages (e.g. small and large larvae) among the 5 plants on which egg masses were initially pinned was recorded. Efficacy of treatments was evaluated by recording and comparing 1) the number of infested plants, and 2) the number of infested pods from the 5 plants per plot. Data were analyzed using ANOVA, with mean separation by Fisher's protected LSD at $P < 0.05$. ECB count data were transformed using a $\log_{10}(x + 1)$ function before analysis and proportion data transformed using an Arc-Sine, square root transformation, but untransformed means are presented.

European corn borer control:

Stand establishment and emergence of seeds from the soil was not influenced by the application of at-plant, potentially systemic insecticides when compared to emerging plant stands in either the untreated control plots or the foliar treated plots (**Table 2**). Populations of European corn borer established in the untreated control plots following pinning of egg masses resulted in a significant infestation in both plant stems as well as bean pods. The number of entrance holes, or infestation sites, as well as the

percentage of damaged stems in the developing bean plants was reduced by the applications of the at-plant insecticide treatments when compared to the UTC plots. One consistent exception, however, was the inconsistent level of control obtained with the HGW86 20SC compound applied at the lower, 3.5 fl oz / A rate. When comparing the level of ECB control between the at-plant versus foliar applied insecticides, however, both the Avaunt and Hero outperformed the at-plant, anthrilic diamides, with the greatest level of control observed in the Hero treated plots. Interestingly, the total pod counts were significantly higher in the at-plant insecticide treated plots averaging 125 pods / 5 plants versus a mean of 65 pods / 5 plants in the foliar treated plots. Unfortunately, pod size or quality data were not collected in this experiment to determine whether mean pod size was significantly greater in one set of experiment treatments versus another. Finally, the percentage of damaged pods was not significantly different among the insecticide treatments when compared across the 1st pinning data collection interval. Recall here that egg masses are pinned approximately 3 days in advance of the foliar insecticide application. In this way, we are attempting to measure the residual activity of foliar applied insecticides upon emerging neonate larvae. However, when we directly compare 1st and 2nd pinning data among the foliar applied treatments, we observe that direct contact of both Avaunt and Hero significantly reduced the number of infested pods when compared with 1st pinning data.

Table 1. Efficacy of soil-applied and foliar insecticide treatments applied for the control of European corn borer in succulent snap bean, *Phaseolus vulgaris*, cv. 'Hystyle' located at the Arlington Agricultural Experiment Station, Arlington, WI 2008. ***Denotes either products not labeled for ECB in WI snap beans or for a proposed use pattern (e.g. in-furrow)**.

Treatment	Active Ingredient	Application Rate	Application Delivery	Egg Mass Pinning	Stand Count	Total Infestation Sites[1]	Percent Damaged Stems[1]	Pod Count[1]	Percent Damaged Pods[1]
Untreated	--	--	--		27 (77.1%) a	7.4 ± 1.7 ab	84.0 ± 7.0 a	106.0 ± 17.6 ab	12.9 ± 3.9 a
Cyazapyr 20SC*	3.5	fl oz / A	In-furrow	1st	29 (82.9%) a	8.8 ± 1.3 a	80.0 ± 12.0 a	164.8 ± 23.8 a	7.5 ± 1.4 ab
	5.0	fl oz / A	In-furrow	1st	30 (85.7%) a	4.8 ± 1.1 b	56.0 ± 11.7 ab	133.4 ± 12.8 a	6.5 ± 1.5 ab
	9.5	fl oz / A	In-furrow	1st	31 (88.6%) a	4.6 ± 1.2 b	44.0 ± 8.5 b	104.2 ± 12.9 ab	6.7 ± 1.9 ab
Coragen 1.67SC*	3.5	fl oz / A	In-furrow	1st	30 (85.7%) a	4.0 ± 1.4 bc	52.0 ± 13.5 ab	80.2 ± 9.2 b	7.2 ± 2.0 ab
	9.5	fl oz / A	In-furrow	1st	24 (68.6%) a	4.6 ± 2.5 b	48.0 ± 16.2 b	142.0 ± 24.5 a	4.4 ± 2.3 b
Avaunt 30WG*	3.5	oz / A	Foliar	1st	33 (94.3%) a	2.8 ± 0.6 bc-A	40.0 ± 9.5 b-A	56.5 ± 3.0 b-A	7.3 ± 2.5 ab-A
			Foliar	2nd	30 (85.7%) a	2.0 ± 0.9 A	30.0 ± 1.7 AB	66.5 ± 11.0 A	3.8 ± 1.1 B
	6.0	fl oz / A	Foliar	1st	29 (82.9%) a	2.3 ± 0.6 c-A	40.0 ± 8.2 b-A	90.5 ± 36.4 ab-A	9.5 ± 2.5 ab-A
			Foliar	2nd	31 (88.6%) a	1.5 ± 0.5 AB	25.0 ± 9.6 AB	66.8 ± 11.7 A	2.0 ± 0.9 B
Hero 1.24EC	4.0	oz / A	Foliar	1st	30 (85.7%) a	2.0 ± 0.9 c-A	30.0 ± 12.9 c-AB	57.0 ± 3.9 b-A	8.0 ± 1.2 ab-A
			Foliar	2nd	29 (82.9%) a	1.0 ± 0.4 B	20.0 ± 8.1 AB	64.3 ± 6.5 A	0.3 ± 0.1 C
	5.0	fl oz / A	Foliar	1st	30 (85.7%) a	1.0 ± 0.3 d-B	22.1 ± 7.1 cd-AB	54.3 ± 5.4 b-A	6.7 ± 0.7 ab-A
			Foliar	2nd	28 (80.0%) a	0.8 ± 0.1 B	10.5 ± 4.4 B	62.3 ± 4.9 A	0.8 ± 0.5 BC
Prob > F[2]					**P=0.6501**	**P=0.0116** **P=0.0397**	**P<0.0001** **P=0.0082**	**P=0.0368** **P=0.2849**	**P=0.0207** **P=0.0104**

[1] Means within a column followed by the same, small-case letter are not significantly different among the treatments evaluated on the 1st pinning date (7 August 2008) (P>0.05; Fisher's Protected LSD; n = 4). Means not followed by the same, capital letter are not significantly different among treatments evaluated on the 2nd pinning date (14 August 2008) (P>0.05; Fisher's Protected LSD; n = 4).

[2] Paired probability values for F-tests comparing treatments evaluated on the 1st pinning date (7 August 2008) and the second pinning date (14 August 2008).

SECTION II. PART 2

SEASONAL INFECTIVITY OF ASTER LEAFHOPPERS IN CARROT

Kenneth E. Frost[1] and Russell L. Groves[2]

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Collaborators
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Problem Defined:

Each year, Wisconsin growers produce carrots on an average of 4200 acres grossing over $6 million dollars in revenues (USDA-NASS, 2007 annual bulletin). Unfortunately, carrot fields are threatened annually by the occurrence of aster yellows phytoplasma (AYp), which is obligately transmitted by the aster leafhopper (*Macrosteles quadrilineatus* Forbes). Current control practices strictly utilize insecticide sprays that target the aster leafhopper. Spray timing is guided by an aster yellows index that is based on the proportion of infective leafhoppers present in a field at a given point in time. Crop scouting and molecular diagnostic tools have decreased the inherent lag between finding inoculative leafhoppers and prescribed sprays. However, yield losses of 5-20% resulting from AYp are still commonplace (1). A more comprehensive and sustainable, multi-tactic control strategy is warranted to lower inoculum pressure in the areas surrounding susceptible crops. The management of off-crop habitats in ways that minimize the persistence and decrease the accumulation of AYp inoculum in the local environment has the potential to contribute to the sustainability of carrot production primarily through reductions in pesticide.

Research Objectives:

The primary focus of this research is to improve our knowledge of where leafhoppers acquire the pathogen, when they move into susceptible fields, and when they spread the pathogen to crops. Specifically, our focus has been to 1) accurately identify primary inoculum sources of AYp of greatest epidemiological significance in non-crop habitats surrounding carrot fields and 2) to compare the genetic structure of the population of AYp from reservoir hosts to that within carrot and to determine if genotype variability relates to either prevalence or infectivity potential of the pathogen. Ultimately, this project will provide accurate, new information about the relative importance of AYp sources in the habitat surrounding carrot fields. This information can then be used to evaluate the local AYp risk and, in turn, management practices can be developed to decrease the accumulation and local persistence of the pathogen.

Background Information:

The spring migration of leafhoppers from the Gulf-states to Wisconsin has been documented to influence the potential for aster yellows epidemics in carrot (2, 3). However, it has been suggested that the dispersal of migrant leafhoppers (after arrival) and locally produced leafhoppers influence the likelihood of an AYp epidemic in a given year. The mixed age-structure of developing leafhopper populations acquire the pathogen from local plant sources, and subsequently transmit AYp to carrot. In severe years, local AYp sources are thought to greatly contribute to epidemic development in Wisconsin carrot fields (4). Additional data that supports the proposition that AYp is acquired local plant sources and is subsequently spread to carrot comes from a 14-year survey of aster leafhopper infectivity conducted by Pest Pros, Inc. of Plainfield, Wisconsin. These data show that the period of highest leafhopper AYp infectivity coincides with the emergence of the locally produced aster leafhoppers (Figure 1).

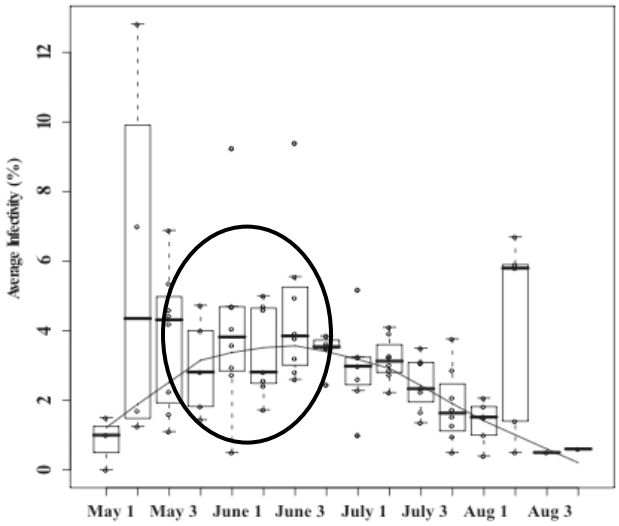

Figure 1. Seasonal infectivity of aster leafhoppers. Data are average leafhopper infectivity at 8 Wisconsin locations from 1994 – 2007. The occurrence of higher AYp infectivity coincides with the emergence of locally produced aster leafhoppers (circled data).

Other recent studies have shown that the spatial arrangement of host and non-host plant species influence epidemic severity (5, 6). Zhou's (2002) modeling demonstrated that AYp acquisition and transmission and AYp latent period within host plant and leafhopper are important factors that influence epidemic development. There is evidence that all of these factors are influenced by strain variability. For example, different AYp strains are transmitted by the leafhopper at different rates (7, 8). To our knowledge there have been no studies to characterize the genetic diversity of AYp in Wisconsin susceptible crops. In addition, the genetic relationships associated with ability to cause disease on carrot and to survive within reservoir hosts has not been examined. This area of study is very important considering the long history of carrot cultivation in Wisconsin.

Our ongoing research is designed to generate significant, new information about the factors that influence geographic movement and spread of aster yellows in carrot fields, which can be used to develop a multidisciplinary approach for the management of AYp in the carrot producing regions of Wisconsin.

Preliminary Data Collected:

Fall 2007

Methods: Our research plan relies on our ability to differentiate AYp strains that exist in the environment and preliminary studies were conducted to determine if multiple AYp strains were present in the Wisconsin carrot crop. In the fall of 2007, we sampled carrot plants displaying symptoms typical of aster yellows (i.e. stunting, yellowing and reddening, twisting, distortion of flowers, bushy or broom-like growth, stunted and malformed roots) from 8 fields in the central

sands of Wisconsin. Molecular methods originally developed to distinguish different AYp strains in lettuce (9) were used to differentiate AYp strains in carrot. In lettuce, different strain types produce different symptoms and we are current evaluating symptoms produced by the different strain types in carrot.

Results: Ninety-four percent of the symptomatic carrot plants tested positive for AYp. Six of the seven AYp strain types previously described in Ohio were present in Wisconsin. The predominant strain types that were found in carrot were AY-WB (32%), a previously uncharacterized AY strain (27%) and AY-BD2 (15%). In leafhoppers, the predominant strain types were AY-WB (44%), a previously uncharacterized strain (28%) and AY-S (15%). The proportions of strain types found in carrot fields were significantly correlated to the proportion of strain types found in aster leafhoppers collected throughout the summer of 2007.

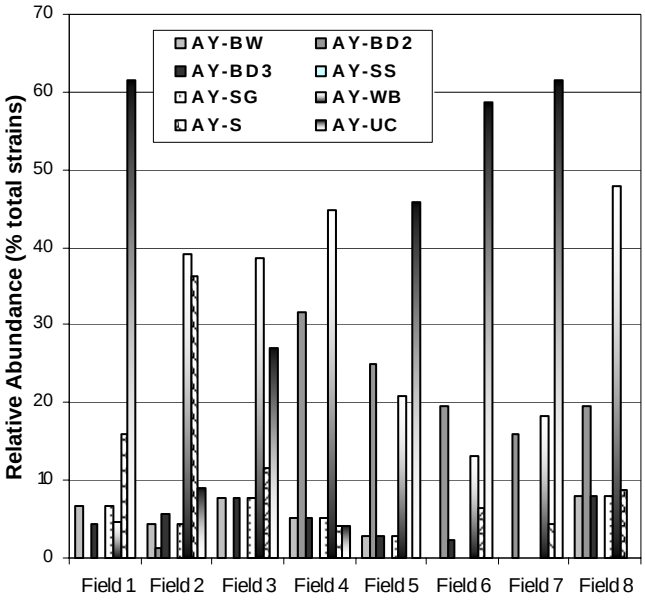

Figure 2. Relative abundance of 7 previously characterized AYp strain types extracted from carrot at 8 field locations in central Wisconsin.

Discussion: Our survey revealed a great degree of variability in the populations of aster yellows phytoplasma present in Wisconsin carrot fields (Figure 2). The relative abundance of AYp strain types extracted from carrot varied by location. In half of the carrot fields sampled, a previously uncharacterized AYp strain represented $\geq$ 40% of the strain types present. The proportion of strain types found at one carrot field did not always correspond to strain types found at other locations. However, some locations had strain type profiles that were highly correlated with the profiles of other locations. These results suggest the possibility that local factors may influence the distribution and spread of aster yellows. The implications of these data suggest that a better characterization of the strain differences is warranted to improve our understanding of the epidemiology of aster yellows in Wisconsin and the relative importance of in-bound inoculum in migratory insects.

Summer 2008

Methods: In 2008, we again sampled carrot plants displaying symptoms typical of aster yellows from 8 fields in the central sands of Wisconsin. Plants from each field were sampled on 4 different dates beginning in June and ending in late August. Aster leafhoppers were also sampled from each of the fields throughout the summer 2008. AYp was extracted from all of the samples and, once again, molecular methods were used to differentiate AYp strains in carrot. We also collected several AYp isolates that are being maintained in the greenhouse for insect transmission studies.

Expected Results: Primer-typing of AYp isolates and data analysis from our 2008 sampling again indicated varied AYp genotypes present in carrot fields associated with specific symptoms present in those fields. New in 2008, we are attempting to determine if the AYp genotype profile changes throughout the growing season which could be indicative that the aster leafhopper is

selectively transmitting predominant AYp strains. It might also indicate that the sources of AYp or inhabiting leafhopper populations change throughout the growing season.

Studies Planned for 2009 and 2010: Over the next 2 summers we plan to tackle 2 objectives:

Objective 1: Accurately identify of the primary reservoir hosts of AYp in habitats surrounding carrot fields and determine which have the greatest epidemiological importance as potential inoculum sources.

We plan to select several fields for more comprehensive studies and at each of the study sites we would like to measure: 1) *plant species abundance in non-crop areas*, 2) *AYp prevalence in non-crop plant species*, 3) *vector phenology in crop and in non-crop areas*, and 4) *aster yellows incidence in Carrot.*

Expected outcomes: Results from these studies will indicate the species that are present in the field margins and the likelihood that a plant species will be infected with AYp. We will initially focus efforts on plant species that have previously be implicated as AYp reservoirs (Table 1). From these data we will calculate an index for each field edge by multiplying the relative abundance of a weed species times the estimated prevalence of AYp within that species. This index will be used to assess a field's AYp risk in terms of inoculum potential. Leafhopper population size data will be used to estimate vector visitation on the non-crop species at the field edge scale providing an accurate estimate of a field's AYp risk.

Family	Genus (species)	Common Name
Asteraceae	*Ambrosia* (sp.)	ragweed
	Cichorium intybus	chicory
	Conyza canadensis	marestail
	Erigeron strigosus	daisy fleabane
	Lactuca serriola	prickly lettuce
	Matricaria matricarioides	pineapple weed
	Taraxacum officianale	dandelion
	Tragopogon dubius	yellow goatsbeard
Plantaginaceae	*Plantago major*	common plantain
Apiaceae	*Daucus carota*	wild carrot, Queen Anne's Lace

Table 1. Common weed species implicated by Schultz (1979) as reservoirs of the AYp in Wisconsin.

Objective 2: I) Compare the genetic structure of the population of AYp isolates collected from reservoir hosts and within affected carrot, and **II)** determine if AYp variability relates to either disease prevalence or infectivity (virulence) of the pathogen.

From our sampling at each of the study sites we will characterize *AYp variability* in non-crop hosts and within affected carrot. We have also started a collection of primer-typed AYp isolates that are maintained *in planta* and will be used to measure leafhopper t*ransmission efficiency*.

Expected outcomes: **I)** Results from these studies will indicate if AYp genotypes present in carrot fields correspond with the predominant genotpyes present in off-crop habitats. In addition, we will determine if AYp genotypes are associated with specific non-crop hosts. **II)** Results will indicate if differences in leafhopper transmission efficiency correspond with particular AYp genetic variants. In particular, we will find out if the aster leafhopper is selectively transmitting AYp genotypes, or predominant strains. This data will provide a better understanding of the importance of AYp variability in relation to the distribution and spread of AYp in the carrot agroecosystem and will aid in the development of management strategies to mitigate AYp risk.

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Endeavor, WI, Miller Family Farms, Hancock, WI, Guth Farms, Almond, WI, Patrykus Farms, Bancroft, WI, and Crystal Farms, Montello, WI.

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SECTION II. PART 3

VINE CROP PEST MANAGEMENT: NEW TOOLS AND TECHNIQUES

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Abstract: Wisconsin has a history in the production of fresh market and processing fruits and vegetables including cucurbit crops such as melons, cucumber, squash, and pumpkins. While acreages and crops have changed over the years, growers have adapted and remained leaders in several crops. Additionally, small-acreage fresh market production, particularly organic, continues to expand in Wisconsin. The demographics of these growers are also in transition in the state. Increasingly, a growing proportion of Amish growers are resettling in Wisconsin from Eastern states. These growers are contributing to an expanding fresh market produce industry through establishment of regional produce markets, multi-farm cooperatives and produce auctions. The geographic and social isolation of Amish communities creates a unique extension challenge in providing integrated pest management training for key pests. A key limiting factor for all cucurbit farmers includes cucumber beetles (e.g. cucumber beetles, *Acalymma vittatum*) and subsequent transmission of the bacterial wilt pathogen, *Erwinia tracheiphila*. This project focuses on the development of enhanced IPM practices for cucurbit production employing a combination of novel cultural and pest management practices. A special focus has been to emphasize practices that limit impacts on domestic and native pollinators. To date, we have documented significant reductions in both populations of cucumber beetles and the bacterial pathogen they transmit in susceptible vine crops using these tactics. Specifically, mean incidence of bacterial wilt was 2-3 X less prevalent among grower cooperators who implemented a combination of IPM-based practices when compared to both commercial and organic farm operators. The seasonal abundance and species composition of insect pollinators did vary among farms locations with *Apis* and *Bombus* spp occurring most frequently. We have demonstrated the ability to significantly reduce the reliance on broad spectrum insecticides by incorporating IPB-based, cultural practices that prevent damaging beetle feeding.

Introduction

Wisconsin Agricultural Statistics report vegetable production on over 112,000 acres in Wisconsin with a total of 2,850 reported processed and fresh market growers. Fresh market vegetables are grown and packaged for direct market sales (road-side stands & farmers markets), produce auctions throughout the state, and for large emerging produce cooperatives emphasizing locally sourced, value-added products (Organic Valley, LaFarge, WI). While acreages and crops continue to evolve in response to market demands and production limitations, growers have adapted and remained leaders in several crops. Although no “official” statistics are collected on fresh market production, the WI Fresh Market grower association estimates nearly 1,500 small-acreage producers rowing over 50 crop cultivars in the state. Recent increases in locally grown food has fostered the growth of local produce auctions, expansion of farmers’ markets, and roadside stands in many locations in western Wisconsin. This has provided Amish and some small acreage, non-Amish farmers in the area an opportunity to diversify their farms and enhance farm income by adding vegetable enterprises. Several farms use a significant portion of their land for raising fresh market vegetables. This has presented two primary challenges; first, they have limited experience in growing vegetables commercially, creating the need for training on cultural

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for raising fresh market vegetables. This has presented two primary challenges; first, they have limited experience in growing vegetables commercially, creating the need for training on cultural and pest management practices on a variety of vegetable crops. Secondly, they need to make sure they have enough quality production from their field crops to meet the needs of rapidly emerging markets driven by the regional food sourcing initiatives. These farmers have been seeking information to help with these two concerns from several sources including Agribusinesses, Wisconsin Cooperative Extension, and other producers.

Among the range of production issues faced by this clientele group, cucumber beetles and the bacterial pathogen *Erwinia tracheiphila*, continue to rank high among limiting factors annually recurring in many areas. The overwintering adult insect causes feeding damage on young, emerging plants as well as blossoms and fruit. In addition to direct damage on plants, cucumber beetles are vectors of the bacterial wilt pathogen. The transmission of bacterial wilt disease is even more serious than direct damage because the disease will kill the plant. Because grower access to IPM strategies for management of this insidious pest complex has been limited, insecticides have been commonly used in conventional cucurbit production for control of cucumber beetles especially in melons and summer squash. Very often, the insecticide options used have been inappropriate formulations applied at inappropriate times leading to direct impacts on native and domestic pollinators and ultimately poor fruit set. IPM practices crucial for successfully improving our management of these beetles and the bacterial wilt pathogen they transmit are the focus of this project.

Research Objectives

To develop a comprehensive set of IPM-based tools to manage the cucumber beetle – bacterial wilt pathosystem and document reductions in total pesticide use and avoidance of risk associated with adoption of IPM.

Results and Discussion

Site Selection(s): A total of 5 experimental farms were identified on which the proposed research was conducted in 2008. Field locations 1-3 were located approximately 8.8 km southwest of Cashton, WI in both Monroe and Vernon Counties. Field Site 1 is operated by Mr. Joseph Kauffman and located at S805 Irish Ridge Road, Cashton, WI. The principal agricultural outputs of the operation include manufactured wood products, greenhouse bedding plants, and field grown fruiting vegetables and cucurbit vine crops occupying approximately 8.5 acres. Both greenhouse and field grown vegetable produce are sold locally at the Cashton, WI produce auction. Field Site 2 is operated by Mr. Christ Hershberger, S2185 County Highway D, Westby, WI. Here again, agricultural outputs of the farm operation include cucurbit vine crops, fruiting vegetables, and greenhouse bedding plants and hanging baskets produced on approximately 4.5 acres and also retail sold at the Cashton WI produce auction. Field Site 3 is operated by Mr. James Yoder, S3718 County Highway D, Westby, WI and is operated as a certified organic produce operation occupying approximately 12.5 acres. Similar to the other local farm operations, the range of vegetable offerings are similar in kind but sold as wholesale raw product to Organic Valley's, Organic Produce Pool, LaFarge, WI. Experimental Site 4 is operated by Mr. Jerry Schneider and Ms. Lisa Riniker, 1103 Habhegger Avenue, Sparta, WI and consisted of 12 acres of retail pumpkin. Finally, Field Site 5 is operated by Mr. Brian Nelson, S1028 90 Meter Drive, Westby, WI and consisted of approximately 12 acres of cucurbit vine crops as well as a minor component of fruiting vegetables.

Briefly, Field Sites 1, 2, and 4 were included as conventional grower locations which adopted the comprehensive program of IPM-based tactics to limit insect and disease pressure, which included reduced-risk insecticides. Experimental Site 3 was included as the 'organically-managed, comparatively standard location which included all non-chemical approaches to management of the insect pathosystem. Field Site 5 was managed by the grower/operator consistent with their past management practices. This site served as the conventional standard location as many broad spectrum insecticides were used for insect and disease control with very little adoption of IPM-based practices.

Product outcomes of the first season of research included the integration of comprehensive, biologically-based integrated pest management strategies into cucurbit production systems for direct market growers supplying regional produce auctions, and organic producers. Specifically, project participants were asked to incorporate and adopt the following sequence of culturally-based, pest management practices to reduce their reliance on what has become widespread use of both carbaryl and synthetic pyrethroids for control of cucumber beetles. First year project implementation objectives included, but were not limited to;

A.) Approximately 1,500 linear feet of the cucurbit crop was covered with floating row cover. Covered rows were sub-divided into 500 ft sections and placed in 3 separate locations over the melon, pumpkin, or squash crop at each site. Row covers were erected June 2 2008 and maintained over the crop until first flower. Generally, row covers were removed 2 July 2008 to allow for pollination services to ensue on uncovered treatments.

B.) The remainder of the cucurbit crop (1.5 to 6.0 acres/experimental site) was treated with a drench treatment of AdmirePro 2SC at Sites 1 and 2 with an in-furrow treatment of Platinum at Site 4. Treatments at Sites 1 and 2 were applied as a transplant drench at a rate of 1.4 fl oz / 1,000 plants and the in-furrow treatment at Site 4 was applied at a rate of 11.0 fl oz / acre. Product was donated by both Bayer CropSciences and Syngenta Crop Protection.

C.) A single, 300 ft row of Blue Hubbard squash was transplanted as a trap crop along one edge of each field. Trap crops were placed to intercept overwintering cucumber beetles emerging from wooded edges as they colonize the main crop. For all 4 participants with a trap crop (excluding Field Site 5), a total of approximately 1,200 plants were transplanted. Trap crop transplants were initially treated with AdmirePro immediately prior to transplant as previously described. At each site, trap crops were transplanted as a single row spaced 48" within rows over yellow plastic at the same time as the main crop.

D.) Yellow sticky panel traps were placed in 1) unmanaged areas outside the production field, 2) Hubbard squash trap crops, 3) in the main crop (AdmirePro and Platinum treated), and 4) in the covered rows (following row cover removal). A total of 4 traps were placed in each area and insect counts collected and replaced weekly. Very few differences in weekly beetle counts were obtained among the different regions within a locations suggesting that overwintering, colonizing beetles immigrated into experimental sites equally in all directions. The magnitude of colonizing populations did appear to differ among locations with the greatest populations collected at experimental Site 3, the organically-managed site (Fig. 2).

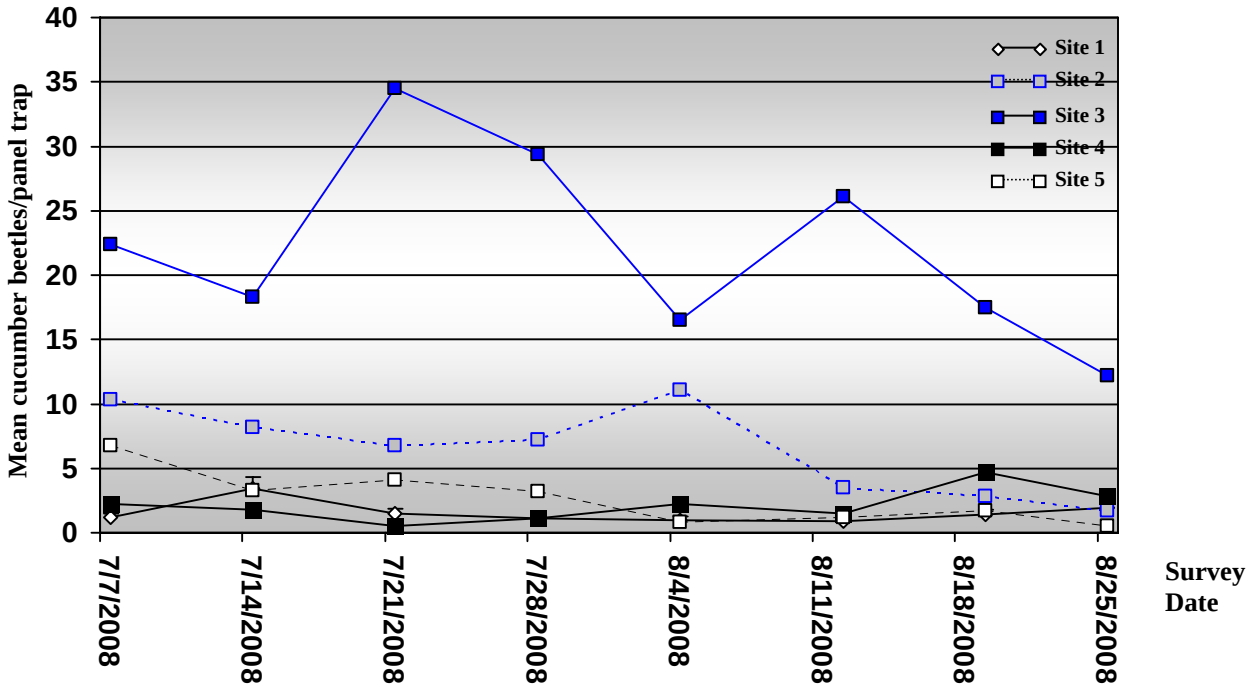

Figure 2. Seasonal capture of striped cucumber beetles among experimental field sites, southwestern Wisconsin, 2008.

E.) Following plot establishment, the total number of adult cucumber beetles were counted on five consecutive plants randomly selected from the 4 field sections described previously (e.g. unmanaged areas, trap crops, main crop, covered rows). Counts were made bi-monthly through the growing season (June – Sept). Beetle counts did vary among the different crop sections at each experimental site with the largest number often encountered on the Blue Hubbard trap crops (Table 1).

F.) Following row cover removal and during regularly scheduled beetle surveys, we continued to survey adult cucumber beetles in anticipation of the possibility of implementing foliar sprays of reduced-risk insecticides as needed / warranted based upon established thresholds for different cucurbit crops. No foliar applications of kaolin clay (Surround) were warranted on any of the infested crops that were under the row cover experiments. Foliar applications on the main crop were also not necessary throughout the remainder of the experimental interval.

G.) Beginning in early July, bacterial wilt surveys were performed monthly over a sub-selected portion of the cucurbit acreage in both insecticide-treated and row-covered areas of the experimental sections. Tissue from symptomatic plants was collected and returned to the laboratory in Madison, WI for confirmation and whole plants were counted, rouged, and composted immediately after a confirmation of symptoms. Similar to beetle counts, the mean incidence of bacterial wilt in affected vine crops varied significantly between the management units on each farm site (Table 2).

H.) A sub-sample of adult cucumber beetles (N=25 / farm / sample date) counted from the main crop have been collected in 95% EtOH and held in the laboratory for later PCR analysis of infectivity. Infectivity assessments will be performed on beetles collected in June, August, and October and these assays will be conducted this Fall, 2008 to determine at which points during the year the risk of potential infection may be greatest relative to the susceptibility of the crop / cultivars.

I.) Non-managed, weedy border areas surrounding the plot area have been maintained as weed free areas as much as possible through the second half of the growing season. This was accomplished by two mowings / cuttings of grassy vegetation in mid-August and again in mid-September.

J.) During bi-monthly field visits, a 10 minute interval of time during the early morning was spent monitoring / recording pollinator services in the main crop and the portion of the crop under row cover. Specifically, the frequency and duration of visits to flowers by domestic honeybees (*Apis mellifera*), wild bumblebees (*Bombus* spp.), and other wild pollinators such as the squash bee (*Peponapis pruinosa*) will be evaluated through visual counts.

Taken together, the proposed management program continues to enhance the close cooperation that has developed between direct market produce growers, wholesale produce buyers, county agricultural extension agents, and extension specialists at the University of Wisconsin. The collaboration team is very much on course towards the development of sustainable, culturally-based, pest management recommendations to limit the damage caused by cucumber beetles and bacterial wilt with an emphasis on reduced pesticide inputs targeted as high risk by FQPA. Field scale trials in the coming year will again be focused on confirming the effectiveness of different strategies within local production systems and verify the suitability of these multiple tactics for direct market producers.

Table 1. Mean number of adult cucumber beetles in each of the 3 management sections (main crop, row cover, trap crop) on each experimental field site in southwestern Wisconsin, 2008.

Field Site	Management Section	Sample Dates Recorded[1]							
		7 July	**14 July**	**21 July**	**28 July**	**4 Aug**	**12 Aug**	**19 Aug**	**25 Aug**
Site 1	Main crop	0.1 ± 0.1 b	0.3 ± 0.1 b	0.5 ± 0.2 b	2.8 ± 0.5 b	0.9 ± 0.2 b	1.1 ± 0.2 a	0.7 ± 0.2 a	0.7 ± 0.2 a
	Row cover	0.0 b	0.0 b	0.5 ± 0.2 b	1.9 ± 0.4 b	0.8 ± 0.1 b	0.5 ± 0.5 ab	0.7 ± 0.2 a	0.7 ± 0.3 a
	Trap Crop	1.6 ± 0.4 a	2.2 ± 0.3 a	2.2 ± 0.4 a	11.8 ± 1.5 a	5.8 ± 0.7 a	0.0 a	1.0 ± 0.3 a	1.7 ± 0.9 a
Site 2	Main crop	1.3 ± 0.3 b	6.3 ± 1.9 a	8.6 ± 1.0 a	8.4 ± 1.0	1.7 ± 0.4 b	1.8 ± 0.4 a	0.9 ± 0.2	6.2 ± 1.8 a
	Row cover	1.3 ± 0.4 b	6.0 ± 1.0 a	3.3 ± 0.6 b	2.0 ± 0.4	0.7 ± 0.2 b	2.7 ± 0.3 a	0.9 ± 0.3	0.9 ± 0.4 b
	Trap Crop	2.7 ± 0.5 a	4.7 ± 1.1 a	6.7 ± 1.4 a	3.7 ± 0.7	2.8 ± 0.3 a	3.3 ± 0.7 a	0.0	0.0 b
Site 3	Main crop	0.0 a	0.1 ± 0.1 a	0.0 b	0.1 ± 0.1	0.0 a	0.1 ± 0.1 a	0.0	0.1 ± 0.1 a
	Row cover	0.0 a	0.2 ± 0.1 a	0.1 ± 0.1 b	0.0	0.0 a	0.1 ± 0.1 a	0.1 ± 0.1	0.0 a
	Trap Crop	0.6 ± 0.3 a	0.2 ± 0.1 a	1.3 ± 0.3 a	0.0	0.1 ± 0.1 a	0.1 ± 0.1 a	0.3 ± 0.1	0.2 ± 0.1 a
Site 4	Main crop	4.7 ± 1.2 b	8.4 ± 2.1 a	4.0 ± 0.6 a	3.4 ± 0.7	5.1 ± 0.6 a	3.6 ± 0.4 a	4.4 ± 0.5	2.7 ± 0.5 a
	Row cover	7.5 ± 1.5 a	8.0 ± 1.8 a	5.7 ± 0.8 a	3.9 ± 0.6	4.9 ± 0.6 a	3.4 ± 0.5 a	3.6 ± 0.8	2.5 ± 0.9 a
	Trap Crop	2.4 ± 0.7 c	6.6 ± 1.4 a	1.8 ± 0.5 b	1.5 ± 0.5	7.2 ± 1.3 a	4.9 ± 0.9 a	5.1 ± 1.4	0.0 b
Site 5	Main crop	2.9 ± 1.1	4.7 ± 1.2	7.9 ± 2.1	4.9 ± 1.3	4.9 ± 1.3	5.9 ± 1.4	3.8 ± 0.9	6.7 ± 1.7
	Row cover	--	--	--	--	--	--	--	--
	Trap Crop	--	--	--	--	--	--	--	--
(P<0.0001)	-	(0.0085)	(<0.0001)	(<0.0001)	(<0.0001)	(0.0377)	(0.0009)	(<0.0001)	(<0.0001)
LSD (P=0.05)		0.3	0.8	1.3	1.6	1.3	0.4	1.0	1.2

[1] Means within a column, by location, followed by the same letter are not significantly different (P>0.05; Fisher's Protected LSD; n = 4).

Table 2. Mean incidence of bacterial wilt, *Erwinia tracheiphila*, in each of the 3 management sections (main crop, row cover, trap crop) on each experimental field site in southwestern Wisconsin, 2008.

Field Site	Management Section	Sample Dates Recorded[1] 7 July	14 July	21 July	28 July	4 Aug	12 Aug	19 Aug	25 Aug
Site 1	Main crop	0.0	0.0	0.1 ± 0.1 a	0.4 ± 0.2	0.1 ± 0.1	0.1 ± 0.1 a	0.0 a	0.0 a
	Row cover	0.0	0.0	0.1 ± 0.1 a	0.1 ± 0.1	0.0	0.0 a	0.0 a	0.0 a
Site 2	Main crop	0.1 ± 0.1	0.1 ± 0.1	0.5 ± 0.2 a	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1 a	0.0 a	0.1 ± 0.1 a
	Row cover	0.0	0.1 ± 0.1	0.2 ± 0.1 b	0.2 ± 0.1	0.1 ± 0.1	0.0 b	0.0 a	0.0 a
Site 3	Main crop	0.0	0.0	0.0 a	0.0 a	0.0	0.0 a	0.0 a	0.0 a
	Row cover	0.0	0.0	0.0 a	0.0 a	0.0	0.0 a	0.0 a	0.0 a
Site 4	Main crop	0.2 ± 0.1	0.4 ± 0.2	0.4 ± 0.2 a	0.3 ± 0.1	0.2 ± 0.1	0.5 ± 0.2 a	0.7 ± 0.3 a	0.5 ± 0.2 a
	Row cover	0.0	0.4 ± 0.2	0.2 ± 0.1 a	0.2 ± 0.1	0.1 ± 0.1	0.2 ± 0.1 b	0.1 ± 0.1 b	0.1 ± 0.1 b
Site 5	Main crop	0.0	0.2 ± 0.1	0.9 ± 0.3	0.6 ± 0.2	0.3 ± 0.1	0.2 ± 0.1	0.8 ± 0.2	0.7 ± 0.4
	Row cover	--	--	--	--	--	--	--	--
(P<0.0001)	-	(0.3381)	(0.0903)	(0.0494)	(0.1177)	(0.2316)	(0.0348)	(<0.0001)	(<0.0001)
LSD (P=0.05)		0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1

1 Means within a column, by location, followed by the same letter are not significantly different (P>0.05; Fisher's Protected LSD; n = 4).

SECTION II. PART 4

Control of Lepidopteran Larvae on Sweet Corn with Foliar Insecticides

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The European corn borer and corn earworm are the most important insect pests of sweet corn in Wisconsin. Both pests cause direct ear damage resulting in yield loss.

The European corn borer (ECB) larvae overwinter in corn stubble and adults emerge in late May and June. Females lay between 500-1000 eggs in their lifespan and eggs are white and are laid in clusters. ECB usually have 2 generations per year in Wisconsin but may have 3 in favorable years. First generation larvae migrate to the whorl and feed on leaf tissue before tunneling into the stalk. Second generation larvae enter the plant near the leaf sheath, or an ear shank, butt, side or tip.

Corn earworms (CEW) do not overwinter in Wisconsin and therefore CEWs are migratory pests in Wisconsin. CEW lay their single eggs on silks and larvae hatch within 2-6 days. Larvae feed down the silk into the developing ear. Once the larvae enter the ear husk, foliar insecticides have little effect.

Triplesweet with Attribute (BC 0805) (treatments 2 and 3) and Providence (treatments 1, 4-15) variety sweet corn (Syngenta Seeds – Rogers Hybrids) were planted on 18 June 2008. Plots consisted of six 50' rows on 30" centers. Treatments were arranged in a randomized complete block experimental design consisting of four replicates. 6-foot alleyways separated replications.

Four applications over an 18 day period were evaluated for ECB and CEW larval control. The initial application occurred at row tassel (11 August), the second application occurred at pollen shed (16 August) and the 3rd and 4th applications occurred on 22 August and 29 August.

Treatments consisted of the following materials:

1. Untreated
2. Triplesweet *Bt* hybrid (BC 0805)
3. Triplesweet *Bt* hybrid (BC 0805) treated with Warrior II (1.92 fl. oz./a)
4. Capture 2EC (6.4 fl. oz./a)
5. Warrior II 2.09CS (1.92 fl oz./a)
6. Mustang Max 0.8EC (4.0 fl oz./a)
7. Hero 1.24EC (5.0 fl. oz./a)
8. Hero 1.24EC (6.0 fl. oz./a)
9. Coragen 1.67SC (3.5 fl. oz./a), MSO (0.5% v/v) added.
10. Coragen 1.67SC (5.3 fl. oz./a) MSO (0.5% v/v) added.
11. Cyazapyr 10OD (1.72 fl. oz./a) MSO (0.5% v/v) added.
12. Belt 4SC (3.0 fl.oz./a) NIS (0.25% v/v) added.
13. Belt 4SC (3.0 fl.oz./a) MSO (0.5% v/v) added.

14. Capture 2EC (6.4 fl. oz./a) 1st 2nd applications followed by 2 applications of Warrior II 2.09CS (1.92 fl. oz./a).
15. Baythroid XL (0.19 lb. a.i./a)

All materials were applied using a Spirit hi-clearance sprayer equipped with TeeJet 8003 XR flat fan nozzles spaced at 20', delivering 26.7 gpa at 2.6 mph and 40 psi. Treatments 4-15 were applied on 11 August, 16 August, 22 August, and 29 August. Treatment 3 was applied on 13 August and 18 August.

The study was evaluated on 8 September by pulling 20 ears from the middle 2 rows of each plot. During evaluation an ear was considered damaged if feeding occurred on 2 or more kernels and an ear was considered infested if larvae were present, regardless of feeding damage.

Results

European corn borer and corn earworm larvae were both found in the study at evaluation but numbers were low in comparison to previous evaluations (Table 1). Ear damage in the untreated plots reached 9.75 mean damaged ears while 8.25 CEW and 2.0 ECBs were found in the untreated samples.

The triplesweet Bt variety from Rogers evaluated in this study provided good CEW (1.25 larvae/20 ears) and ECB (0.00 larvae/20 ears) larval control. This treatment also resulted in the low numbers of damaged ears and kernels. CEW efficacy was enhanced on the Bt hybrid with two applications of Warrior II at 100% silking and 5 days later on 18 August (treatment 3). There were no CEW or EBC larvae found in the treatment and there was no damage recorded either.

The pyrethroids continue to provided CEW efficacy in the trials in Wisconsin. All of the pyrethroids evaluated significantly reduced ECB larval numbers and no ECB larvae were found in the Capture (6.4 fl. oz./a) treatment. All of the remaining pyrethroid treatments limited ECB larval numbers to less than 0.5 larvae per 20 ears. CEW numbers ranged from 0.75 larvae per 20 ears in the Warrior II treatment to 2.00 larvae per 20 ears in the Hero (5 fl. oz./a) treatment.

Coragen, Cyazapyr, and Belt provided excellent ECB larval control at all the rates evaluated. CEW larval numbers were slightly higher than ECB but the number of larvae found on the ears and ear damage was only slightly higher than the Bt treatment with no significant differences statistically.

The author would like to thank Bryan Jenson, IPM Specialist, Department of Entomology, for his assistance in conducting this trial.

Table 1. Corn Earworm larvae sampled from Triplesweet with Attribute and Providence variety sweet corn treated with foliar insecticides. Arlington, WI. 2008.

Treatment	Rate (oz./a)	Mean damage/20 ear sample		Mean larvae/20 ear sample	
		Ears	Kernels	Corn earworm	European corn borer
Untreated	---	9.75 a	4.59 a	8.25 a	2.00 a
Triplesweet *Bt* hybrid	---	1.00 cde	0.15 c	1.25 b	0.00 b
Triplesweet *Bt* hybrid /Warrior II 2.09CS	1.92	0.00 e	0.00 c	0.00 b	0.00 b
Capture 2EC	6.4	2.50 b-e	0.93 bc	1.00 b	0.00 b
Warrior II 2.09CS	1.92	2.25 b-e	0.48 bc	0.75 b	0.25 b
Mustang Max 0.8EC	4.0	3.75 b	1.48 b	1.75 b	0.25 b
Hero 1.24EC	5.0	3.25 bc	0.63 bc	2.00 b	0.25 b
Hero 1.24EC	6.0	1.75 b-e	0.48 bc	1.00 b	0.50 b

(continued)

Means within a column followed by the same letter are not significantly different (P=0.05, Duncan's Multiple Range Test)
[1]NIS added at the rate of 0.25% v/v.
[2]MSO added at the rate of 0.5% v/v.
[3]Capture applied during applications 1 and 2 followed by applications of Warrior II.
[a] "early" corn earworm are larvae up to ½ inch in length
[b] "mid" corn earworm are larvae between ½ inch and ¾ inch in length
[c] "late" corn earworm are larvae larger than ¾ inch in length

Table 1. (Continued). Corn Earworm larvae sampled from Triplesweet with Attribute and Providence variety sweet corn treated with foliar insecticides. Arlington, WI. 2008.

Treatment	Rate (oz./a)	Mean damage/25 ear sample		Mean larvae/25 ear sample	
		Ears	Kernels	Corn earworm	European corn borer
[2]Coragen 2SC	3.5	2.75 bcd	0.86 bc	1.00 b	0.00 b
[2]Coragen 2SC	5.0	1.00 cde	0.39 bc	1.00 b	0.00 b
[2]Cyazapyr 10OD	1.72	2.00 bcde	0.53 bc	1.75 b	0.00 b
[1]Belt 4SC	3.0	3.00 bc	0.98 bc	1.00 b	0.00 b
[2]Belt 4SC	3.0	2.25 bcde	0.60 bc	1.00 b	0.25 b
Capture 2EC /Warrior II 2.09CS	6.4/1.92	0.25 de	0.10 c	0.25 b	0.25 b
[1]Baythroid XL	2.0	1.00 cde	0.58 bc	1.00 b	0.25 b
LSD		2.20	1.12	2.06	0.79

Means within a column followed by the same letter are not significantly different (P=0.05, Duncan's Multiple Range Test)
[1]NIS added at the rate of 0.25% v/v.
[2]MSO added at the rate of 0.5% v/v.
[3]Capture applied during applications 1 and 2 followed by applications of Warrior II.
[a] "early" corn earworm are larvae up to ½ inch in length
[b] "mid" corn earworm are larvae between ½ inch and ¾ inch in length
[c] "late" corn earworm are larvae larger than ¾ inch in length

SECTION II. PART 5.

ONION THRIPS CONTROL USING FOLIAR INSECTICIDES IN DRY BULB ONION PRODUCTION

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Project History. Results presented here are from field research completed during the 2008 growing season. Objectives outlined in this research are directly related to the problematic re-occurrence of onion thrips populations in Wisconsin dry bulb onion production.

Background and Rationale. Effective, economical, and efficient long term management of both onion thrips and continues to be a challenge in the production of dry bulb onion. This insect pest continues to be a high pest priority for Wisconsin onion growers. Many of the currently registered products for control of onion thrips are not equally effective against the insect. As a result, thrips management is a top priority and an improved understanding of the ecology and management of this pest is essential towards the development of long-term control methods.

Experimental Site: Gumz Muck Farms, Endeavor, Wisconsin.

Project Objective: To evaluate currently registered and new, potentially efficacious insecticide foliar treatments to target problematic populations of onion thrips. Develop efficacy data in support of future registration of novel insecticides with unique modes of action.

Experimental Design: The experiment was conducted in a single commercial muck field in the southcentral portion of the state of Wisconsin near Endeavor in 2007. The experiment plot was established on 3 June and arranged as a randomized complete block design with 4 experimental replications of foliar treatment main effects (Table 1).

Foliar Treatments (N=9)	Rate (lb a.i. / ac)	Rate (fl oz /ac)	Treat / Rep Numbers
UTC			(101, 201, 301, 401)
Cyazapyr 10SE	0.088	3.5	(102, 202, 302, 402)
Cyazapyr 10SE	0.134	7.0	(104, 204, 304, 404)
Cyazapyr 10OD	0.088	5.0	(105, 205, 305, 405)
Lannate LV	0.09	48.0	(106, 206, 306, 406)
Radiant 1SC	0.0094	6.0	(107, 207, 307, 407)
	0.0117	8.0	(108, 208, 308, 408)
Vydate L	0.06	32.0	(109, 209, 309, 409)
Experimental #1	0.099	4.0	(110, 210, 310, 410)
	0.2	8.0	(111, 211, 311, 411)
Experimental #2	0.099	4.0	(112, 212, 312, 412)
	0.2	8.0	(113, 213, 313, 413)
Movento	0.1	8.0	(114, 214, 314, 414)
	0.12	12.0	(115, 215, 315, 415)
Carzol SP	0.47	213 g/ac	(116, 216, 316, 416)
	0.7	318 g/ac	(117, 217, 317, 417)
	0.93	422 g/ac	(118, 218, 318, 418)
Assail 30SG	0.15	8.0 oz	(119, 219, 319, 419)
Orthene 75SP	0.75	1.0 lb/ac	(120, 220, 320, 420)
	1.0	1.3 lb/ac	(121, 221, 321, 421)
SpinTor 2SC	0.09	6.0	(122, 222, 322, 422)
	0.12	8.0	(123, 223, 323, 423)
Entrust 80WP	0.075	1.5 oz	(124, 224, 324, 424)
	0.15	3.0 oz	(125, 225, 325, 425)

Experiment combinations were directly compared to registered, industry standards including [1)] Warrior 1EC, [2)] Lannate LV, and [3)] SpinTor 2SC.

Beginning on 10 June 2008, immature onion thrips counts were initiated and destructively obtained from a sub-sample of growing plants in each of the treatment main effects. Specifically, the number of immature onion thrips larvae was recorded weekly for over 11 consecutive weeks through the interval 10 June through 19 August, 2009. Once the mean immature thrips population counts exceeded the established threshold of 3 immature thrips / leaf, foliar insecticides were applied with a 12' boom operating at 30 psi delivering 25 gpa through 8 flat-fan nozzles (8004VS-XR) spaced 18" apart. Thrips counts (efficacy ratings) were made on the day of application (immediately prior to application) and at daily intervals of approximately 3, 7, 14, and 21 days post-application. Each insecticide main effect was comprised of 2 successive applications, spaced 7 days apart. The first insecticide application was applied 25 July and the second application applied 7 days later on 1 August. Data were analyzed using ANOVA, with mean separation by Fisher's protected LSD at $P < 0.05$. Immature thrips count data were transformed using a $\log_{10} (x + 1)$ function before analysis, and untransformed means are presented in the attached table.

Results and Discussion: The onion thrips infestation in 2008 was initially quite low resulting from moderate temperatures and excessive precipitation which occurred throughout much of June. Foliar damage in the untreated control was evident by early to mid August with approximately 40-60% damage, or reduction in photosynthetic area on the leaves (e.g. defoliation). In this trial, the materials that had the greatest overall impact in reducing larval densities included the novel anthrilic diamide Cyazapyr SE, Radiant, Movento, Carzol, Assail, SpinTor, and Entrust (Table 1). Although Lannate, Vydate, and Orthene initially reduced larval densities on the first 2 dates post-application compared with the untreated control, the level of reduction was less than that which was observed with most of the efficacious treatments listed above. Among the top performing treatments, Movento, Radiant, and the highest rates of Carzol and Spintor (1.0 lb and 8.0 fl oz/ac, respectively) significantly reduced larval densities over the term of the 21 day experiment. This is likely the result of a slightly longer residual among these treatments compared with the lower rates of the respective compounds. The experimental anthrilic diamide Cyazapyr SE performed very well in the experiment with the 5.0 and 7.0 fl oz/ac rate maintaining very adequate control of thrips populations. The 2 (unnamed) experimental compounds in the trial performed well through much of the field trial. By the 21 day post-application reading, however, only the highest rate of experimental compound #2 had maintained populations below the prescribed threshold (3 immature thrips / leaf).

Table 1. Mean (± SE) number of immature onion thrips / leaf counted on 10 plants in experimental plots, Endeavor, WI (2008).

Treatment	Trt No	Application Rate	Number of Applications (days)[1]	Mean (± SE) Number of Immature thrips / leaf (3daa) 29 July	(7daa) 1 August	(7daa) 5 August	(14 daa) 12 August	(21 daa) 19 August
UTC	1	--	--	5.2 ± 1.5	6.1 ± 1.2 a	6.6 ± 0.8 a	5.3± 0.5 a	7.1 ± 0.6 a
Cyazapyr 10SE	2	3.5 fl oz/ac	2	1.2 ± 0.3	0.6 ± 0.1 b	1.5 ± 0.3 b	2.5 ± 0.8 b	2.7 ± 1.3 ab
	3	5.0 fl oz/ac	2	1.7 ± 0.3	0.9 ± 0.2 bc	1.4 ± 0.2 b	1.8 ± 0.4 c	1.4 ± 0.4 b
	4	7.0 fl oz/ac	2	1.4 ± 0.3	0.5 ± 0.1 bc	1.3 ± 0.2 cd	0.9 ± 0.2 cd	1.2 ± 0.3 bc
Cyazapyr 10OD	5	5.0 fl oz/ac	2	2.5 ± 0.3	0.8 ± 0.2bc	1.1 ± 0.2 cd	2.9 ± 0.6 d	3.9 ± 0.6 bc
Lannate LV	6	48.0 fl oz/ac	2	1.3 ± 0.3	1.6 ± 0.3 cd	3.3 ± 0.8 c	2.9 ± 0.8 d	4.1 ± 0.7 bc
Radiant SC	7	6.0 fl oz/ac	2	0.7 ± 0.2	0.3 ± 0.1 d	0.6 ± 0.2 de	1.3 ± 0.3 d	2.2 ± 0.5 bc
	8	8.0 fl oz/ac	2	1.0 ± 0.2	0.8 ± 0.2 d	0.8 ± 0.2 de	0.8 ± 0.2 d-f	1.3 ± 0.4 c-e
Vydate L	9	32.0 fl oz/ac	2	1.8 ± 0.3	1.1 ± 0.2 d	1.9 ± 0.5 de	2.2 ± 0.6 ef	3.8 ± 1.7 cd
Experimental 1	10	4.0 fl oz/ac	2	2.4 ± 0.4	1.1 ± 0.3 d	1.5 ± 0.4 de	1.8 ± 0.6 d	3.3 ± 0.9 bc
	11	8.0 fl oz/ac	2	1.8 ± 0.3	0.8 ± 0.2 d	1.1 ± 0.3 de	1.9 ± 0.8 d-f	4.6 ± 0.7 c-e
Experimental 2	12	4.0 fl oz/ac	2	1.9 ± 0.4	1.8 ± 0.4 d	1.5 ± 0.4 de	1.8 ± 0.6 d	3.2 ± 0.9 bc
	13	8.0 fl oz/ac	2	1.5 ± 0.4	1.2 ± 0.2 d	1.0 ± 0.3 de	1.3 ± 0.4 d-f	2.2 ± 0.7 c-e
Movento	14	8.0 fl oz/ac	2	3.2 ± 0.5	2.1 ± 0.5 d	0.7 ± 0.3 e	1.1 ± 0.3 ef	0.9 ± 0.2 e
	15	12.0 fl oz/ac	2	3.5± 0.5	1.1 ± 0.2 d	0.6 ± 0.2 e	1.1 ± 0.2 f	0.6 ± 0.3 de
Carzol SP	16	0.5 lb/ac	2	1.2 ± 0.2	0.8 ± 0.2 cd	1.3 ± 0.2 de	1.5 ± 0.3 d	1.8 ± 0.5 bc
	17	0.75 lb/ac	2	1.4 ± 0.3	0.7 ± 0.2 cd	0.9 ± 0.3 e	0.9 ± 0.2 ef	1.9 ± 0.4 de
	18	1.0 lb/ac	2	1.4 ± 0.3	0.8 ± 0.2 d	0.9 ± 0.2 de	1.2 ± 0.3ef	1.5 ± 0.5 cd
Assail 30SG	19	8.0 oz/ac	2	1.2 ± 0.3	1.0 ± 0.2 d	1.0 ± 0.3 de	1.9 ± 0.4 ef	2.5 ± 0.6 cd
Orthene 75SP	20	1.0 lb/ac	2	1.3 ± 0.4	0.5 ± 0.1 d	1.5 ± 0.4 de	3.8± 0.6 d	3.5 ± 0.8 bc
	21	1.3 lb/ac	2	1.2 ± 0.2	1.3 ± 0.3 d	1.0 ± 0.3 de	3.1 ± 0.8 d-f	4.4 ± 0.7 c-e
SpinTor 2EC	22	6.0 fl oz/ac	2	0.5 ± 0.1	0.6 ± 0.1 cd	1.5 ± 0.4 d	1.9 ± 0.4 de	2.8 ± 0.5 bc
	23	8.0 fl oz/ac	2	1.7 ± 0.2	1.0 ± 0.2 d	0.8 ± 0.3 e	0.7 ± 0.3 de	1.2 ± 0.4 c
Entrust 80WP	24	1.5 oz/ac	2	1.9 ± 0.3	1.3 ± 0.4 d	1.3 ± 0.4 de	2.2 ± 0.3 d-f	2.1 ± 0.7 de
	25	3.0 oz/ac	2	1.6 ± 0.3	1.1 ± 0.2 d	0.8 ± 0.2 e	1.8 ± 0.4 ef	2.4 ± 0.6 cd
(*P*<0.0001)	-	--	--	(<0.0001)	(<0.0001)	(0.0295)	(0.0208)	(<0.0001)
LSD (P=0.05)				0.3	0.3	0.7	0.5	1.3

[1] Spray application dates occurred 25 July and 1 August for all treatments and date values are recorded as *days after application* (daa).

SECTION II. PART 6.

Control of Lepidopteran Larvae on Cabbage with Foliar Insecticides. Arlington.

Several lepidopteran species are serious insect pests on Wisconsin commercial cabbage production. Larvae of the diamondback moth (DBM), *Plutela xylostella* (L.), the imported cabbage worm (ICW), *Artogiea rapae* (L.), and the cabbage looper (CL), *Trichoplusia ni* (Hubner), require control annually by growers.

Diamondback larvae are spring and summer pests on cabbage, frequently requiring control in both seedbeds and on early transplants. Historically, registered insecticides have effectively controlled DBM larvae, however insecticide resistance in Wisconsin has become an issue in recent years due to importation of resistant larvae on southern transplants. Imported cabbage worm larvae occur in June, July, and August and can cause severe foliage and head damage. Larvae require control on both fresh market and kraut cabbage and on other commercial crucifers such as broccoli and cauliflower. Imported cabbage worm larvae are effectively controlled by a wide range of registered insecticides. The cabbage looper is a migratory pest. Cabbage looper adults migrate into Wisconsin from the south and give rise to two or three larval generations per season. Peak cabbage looper larval activities occur in mid August and into the fall and the larvae are difficult to control. Uncontrolled cabbage looper larvae can cause severe economic losses.

Katlin variety cabbage transplants (80 day maturity), donated by Flannery Farms Inc. Bear Creek, WI, were planted on 2 June, 2008. Treatments consisted of two 30' rows on 3' centers with plants 18" apart within rows. Treatments were arranged in a randomized complete block experimental design consisting of four replicates. Twelve-foot alleyways separated all plots. Plots were treated with 3 ounces per acre of Spartan (sulfentrazone) and 1.5 pints Dual II Magnum (metolachlor) pretransplant on 1 June, 2008. Mechanical cultivation and hand weeding also aided in weed control.

Treatments consisted of the following materials:

Registered: Warrior 1CS (0.03 lb. a.i./a)
Tesoro 4E (0.2 lb. a.i./a)
Capture 2EC (0.1 lb. a.i./a)
Mustang Max 0.8EC (0.025 lb. a.i./a),
Spintor 2SC (0.094 lb. a.i./a),
Entrust 80WP (0.125 lb. a.i./a)
Radiant 1SC (0.035 lb. a.i./a)
Aza-Direct (0.0247 lb. a.i./a)

Experimental:	Altacor 2SC (0.044 and 0.066 lb. a.i./a) tank mixed with MSO (0.5% v/v), Cyazapyr 100OD (0.088 and 0.134 lb. a.i./a) tank mixed with MSO (0.5%) Warrior 2ZN (0.03 lb. a.i./a) Alverde 2SC (0.214 lb. a.i./a) tank mixed with Penetrator Plus (0.25% v/v).

All materials were applied with a CO_2 backpack sprayer operating at 30 psi, delivering 25 gpa through four flat fan nozzles (8004VS XR) spaced at 18". All materials were tank mixed with Activator 90 at the rate of 8-oz/100 gallon (unless specified). Treatments were applied on 27 July. Treatments 15, 19 and 20 were reapplied on 31 July. Insect counts were taken from 5 destructively sampled cabbage heads per plot during sampling.

Table 1. Imported cabbage worm larvae sampled from Megaton variety cabbage treated with foliar insecticides. Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 5 heads								
		8 August			13 August			20 August		
		Small	Large	Total	Small	Large	Total	Small	Large	Total
Untreated	---	4.0 ab	15.3 a	33.8 a	1.5 b-e	10.3 a	27.0 a	14.3 a	42.3 a	35.3 a
*Altacor 1.67SC	0.044	4.5 a	3.8 b	13.3 c	1.0 cde	2.3 bc	7.5 cde	6.8 bc	11.3 c	14.6 c
* Altacor 1.67SC	0.066	1.3 b-f	1.0 b	0.0 f	1.8 a-d	1.5 bc	1.0 gh	2.8 c-f	2.0 fgh	1.6 ef
Cyazapyr 100OD	0.088	2.5 a-e	0.3 b	0.0 f	0.5 cde	1.3 bc	1.3 fgh	3.8 cde	1.5 fgh	1.2 f
Cyazapyr 100OD	0.134	1.5 b-f	0.5 b	0.0 f	1.0 cde	0.5 bc	1.5 fgh	2.0 def	2.0 fgh	1.4 ef
Tesoro 4EC	0.2	1.6 c-f	3.5 b	2.0 def	2.7 abc	4.6 b	2.8 d-h	4.5 cde	5.0 c-g	3.7 def
Untreated	---	5.6 abc	14.1 a	19.0 b	2.7 a-d	14.6 a	14.0 b	15.0 ab	24.3 b	20.6 b
Capture 2EC	0.1	0.3 f	0.5 b	0.0 f	0.4 de	0.0 c	0.4 h	0.0 f	0.3 h	1.1 f
Avaunt 30WG	0.066	0.3 ef	1.3 b	0.3 f	1.0 cde	2.5 b	1.5 fgh	2.8 c-f	2.8 d-h	1.6 ef
Warrior 1CS	0.03	0.5 def	0.5 b	0.0 f	1.0 cde	1.5 bc	1.5 fgh	2.0 c-f	2.0 fgh	1.4 ef
Warrior 2ZN	0.03	0.8 def	1.0 b	0.3 f	0.5 cde	1.0 bc	1.8 fgh	1.8 def	2.8 e-h	1.5 ef
Mustang Max 0.8EC	0.025	2.3 a-e	2.3 b	0.3 f	3.3 ab	2.5 b	2.0 fgh	4.8 cde	4.3 c-h	2.3 def
Spintor 2SC	0.07	1.0 c-f	2.8 b	0.5 ef	1.0 cde	2.5 bc	2.0 e-h	3.5 c-f	4.8 c-g	1.9 ef
Entrust 80WP	0.125	0.8 def	1.0 b	0.8 ef	0.3 de	0.5 bc	0.3 h	1.3 ef	1.3 gh	1.9 ef
Radiant 1SC	0.035	2.8 a-d	2.3 b	0.3 f	0.5 cde	2.5 bc	3.8 d-g	5.3 cd	6.0 c-f	1.5 ef
**Alverde 2SC	0.214	0.0 f	2.8 b	5.0 cd	1.5 b-e	2.0 bc	4.5 c-f	2.0 def	7.3 cde	6.5 cd
Aza-direct	0.0247	1.5 b-f	1.8 b	1.3 def	3.8 a	2.8 b	3.0 d-h	4.3 cde	4.8 c-g	3.4 def
LSD		0.71	1.04	1.03	0.55	0.84	0.87	1.02	1.12	0.96
S.D.		0.50	0.73	0.73	0.39	0.60	0.61	0.72	0.79	0.68
C.V.		33.40	43.25	38.17	27.25	34.74	28.92	34.79	31.22	29.13
F		2.157	3.088	12.75	2.263	3.815	10.565	3.665	9.902	12.121
Prob (F)		0.0134	0.0005	0.0001	0.0092	0.0001	0.0001	0.0001	0.0001	0.0001

Means in a column followed by the same letter do not significantly differ (Least Significant Difference Test, P=0.05).
*Tank mixed with MSO at 0.5% v/v.
**Tank mixed with Penetrator Plus at 0.5% v/v.

Table 2. Cabbage looper larvae sampled from Megaton variety cabbage treated with foliar insecticides. Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 5 heads								
		8 August			13 August			20 August		
		Small	Large	Total	Small	Large	Total	Small	Large	Total
Untreated	---	13.0 a	0.8 a	1.5 bc	13.8 ab	5.0 a	1.5 bcd	26.8 a	5.8 a	3.0 bc
*Altacor 1.67SC	0.044	12.0 a	2.8 a	0.5 bcd	11.0 abc	3.5 ab	2.5 bcd	23.0 a	6.3 a	3.0 b-f
* Altacor 1.67SC	0.066	6.0 a-d	1.8 a	0.0 d	8.8 a-e	1.0 bcd	0.0 d	14.8 a-d	2.8 a	0.0 f
Cyazapyr 100OD	0.088	11.8 a	0.5 a	0.3 cd	11.0 abc	1.5 bcd	0.0 d	22.8 a	2.0 a	0.3 ef
Cyazapyr 100OD	0.134	12.5 a	0.8 a	0.0 d	8.0 a-f	0.8 cd	0.0 d	20.5 ab	1.5 a	0.0 f
Tesoro 4EC	0.2	9.5 abc	2.1 a	0.8 bcd	15.4 a-d	3.6 abc	1.8 abc	18.5 a-d	4.5 a	2.5 b-e
Untreated	---	12.9 ab	2.5 a	1.0 bcd	22.0 ab	2.3 bcd	1.8 abc	26.0 a	3.8 a	2.8 bcd
Capture 2EC	0.1	1.9 d	0.1 a	0.0 d	1.7 g	0.1 d	0.0 d	2.5 e	0.3 a	0.0 f
Avaunt 30WG	0.066	2.0 cd	0.8 a	0.0 d	3.3 efg	1.3 bcd	0.3 cd	5.3 de	2.0 a	0.3 ef
Warrior 1CS	0.03	4.5 bcd	0.5 a	0.0 d	6.8 a-g	0.8 cd	0.5 cd	11.3 a-e	1.3 a	0.5 def
Warrior 2ZN	0.03	2.0 cd	0.8 a	0.8 bcd	3.3 d-g	0.5 d	0.8 bcd	5.3 de	1.3 a	1.5 b-f
Mustang Max 0.8EC	0.025	7.0 abc	0.8 a	0.3 cd	11.0 a-d	0.8 cd	0.0 d	18.0 abc	1.5 a	0.3 ef
Spintor 2SC	0.07	6.8 abc	2.0 a	0.3 cd	5.0 b-g	1.5 bcd	0.5 cd	11.8 a-e	3.5 a	0.8 c-f
Entrust 80WP	0.125	3.5 bcd	0.8 a	0.3 cd	4.3 c-g	1.5 bcd	0.8 bcd	7.8 b-e	2.3 a	1.0 b-f
Radiant 1SC	0.035	6.0 a-d	2.0 a	1.5 bcd	6.8 a-g	1.5 bcd	2.0 abc	12.8 a-d	3.5 a	3.5 bcd
**Alverde 2SC	0.214	8.8 ab	2.0 a	1.3 bcd	14.8 a	1.3 bcd	2.8 ab	23.5 a	3.3 a	4.0 b
Aza-direct	0.0247	9.8 ab	1.0 a	0.3 cd	9.0 a-e	0.5 d	0.3 cd	18.8 ab	1.5 a	0.5 def
LSD		1.18	0.60	0.49	1.39	0.64	0.59	1.76	0.81	0.76
S.D.		0.83	0.42	0.35	0.98	0.45	0.42	1.25	0.58	0.54
C.V.		31.22	30.02	27.21	34.94	30.55	30.59	33.23	32.26	34.53
F		2.514	0.713	2.998	2.187	1.926	2.614	2.508	1.485	3.654
Prob (F)		0.0038	0.7899	0.0007	0.0121	0.0297	0.0027	0.0039	0.1267	0.0001

Means in a column followed by the same letter do not significantly differ (Least Significant Difference Test, P=0.05).
*Tank mixed with MSO at 0.5% v/v.
**Tank mixed with Penetrator Plus at 0.5% v/v.

Table 3. Diamondback moth larvae sampled from Megaton variety cabbage treated with foliar insecticides. Arlington, WI 2008.

Treatment	Rate (lb. a.i./a)	Mean larvae per 5 heads								
		8 August			13 August			20 August		
		Small	Large	Total	Small	Large	Total	Small	Large	Total
Untreated	---	4.8 a	1.3 a	0.0 a	2.5 ab	1.8 a	0.0 a	7.3 a	3.0 a	0.0 a
*Altacor 1.67SC	0.044	1.3 a	0.3 a	0.0 a	0.0 d	0.0 a	0.0 a	1.3 bc	0.3 a	0.0 a
* Altacor 1.67SC	0.066	0.5 a	0.0 a	0.0 a	1.5 bcd	0.0 a	0.0 a	2.0 bc	0.0 a	0.0 a
Cyazapyr 100OD	0.088	1.0 a	0.0 a	0.0 a	0.8 bcd	0.0 a	0.0 a	1.8 bc	0.0 a	0.0 a
Cyazapyr 100OD	0.134	0.8 a	0.3 a	0.0 a	0.5 cd	1.0 a	0.0 a	1.3 bc	1.3 a	0.0 a
Tesoro 4EC	0.2	0.1 a	0.4 a	0.0 a	2.0 bc	0.4 a	0.0 a	1.5 bc	0.5 a	0.0 a
Untreated	---	1.9 a	0.4 a	0.0 a	0.3 cd	0.1 a	0.0 a	1.8 bc	0.3 a	0.0 a
Capture 2EC	0.1	0.2 a	0.0 a	0.0 a	0.0 d	0.1 a	0.0 a	0.3 c	0.0 a	0.0 a
Avaunt 30WG	0.066	1.3 a	0.0 a	0.0 a	0.5 cd	0.0 a	0.0 a	1.8 bc	0.0 a	0.0 a
Warrior 1CS	0.03	0.0 a	0.0 a	0.0 a	0.3 cd	0.0 a	0.0 a	0.3 c	0.0 a	0.0 a
Warrior 2ZN	0.03	0.8 a	0.0 a	0.0 a	0.3 cd	0.0 a	0.0 a	1.0 bc	0.0 a	0.0 a
Mustang Max 0.8EC	0.025	0.8 a	0.5 a	0.0 a	0.0 d	0.0 a	0.0 a	0.8 bc	0.5 a	0.0 a
Spintor 2SC	0.07	1.3 a	0.5 a	0.0 a	0.5 cd	0.0 a	0.3 a	1.8 bc	0.5 a	0.3 a
Entrust 80WP	0.125	1.0 a	0.3 a	0.0 a	0.0 d	0.3 a	0.0 a	1.0 bc	0.5 a	0.0 a
Radiant 1SC	0.035	1.3 a	0.5 a	0.0 a	1.0 bcd	0.3 a	0.5 a	2.3 bc	0.8 a	0.5 a
**Alverde 2SC	0.214	1.3 a	0.0 a	0.3 a	0.3 cd	0.5 a	0.3 a	1.5 bc	0.5 a	0.5 a
Aza-direct	0.0247	3.3 a	0.3 a	0.3 a	4.3 a	0.0 a	0.0 a	7.5 a	0.3 a	0.3 a
LSD		0.68	0.32	0.09	0.52	0.35	0.15	0.82	0.50	0.19
S.D.		0.48	0.22	0.07	0.37	0.25	0.10	0.58	0.35	0.13
C.V.		34.56	20.31	6.54	29.15	23.13	10.19	36.43	30.46	12.74
F		1.543	0.928	0.931	2.531	1.170	0.923	2.245	1.018	0.883
Prob (F)		0.1056	0.5531	0.5500	0.0036	0.3139	0.559	0.0098	0.4558	0.6036

Means in a column followed by the same letter do not significantly differ (Least Significant Difference Test, P=0.05).
*Tank mixed with MSO at 0.5% v/v.
**Tank mixed with Penetrator Plus at 0.5% v/v.

SECTION II. PART 7.

Sustainable management solutions for the cucumber beetle - bacterial wilt pathosystem in Wisconsin.

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Abstract: Wisconsin has a history in the production of fresh market and processing fruits and vegetables including cucurbit crops such as melons, cucumber, squash, and pumpkins. While acreages and crops have changed over the years, growers have adapted and remained leaders in several crops. Additionally, small-acreage fresh market production, particularly organic, continues to expand in Wisconsin. The demographics of these growers are also in transition in the state. Increasingly, a growing proportion of Amish growers are resettling in Wisconsin from Eastern states. These growers are contributing to an expanding fresh market produce industry through establishment of regional produce markets, multi-farm cooperatives and produce auctions. The geographic and social isolation of Amish communities creates a unique extension challenge in providing integrated pest management training for key pests. A key limiting factor for all cucurbit farmers includes cucumber beetles (e.g. cucumber beetles, *Acalymma vittatum*) and subsequent transmission of the bacterial wilt pathogen, *Erwinia tracheiphila*. This project focuses on the development of enhanced IPM practices for cucurbit production employing a combination of novel cultural and pest management practices. A special focus has been to emphasize practices that limit impacts on domestic and native pollinators. To date, we have documented significant reductions in both populations of cucumber beetles and the bacterial pathogen they transmit in susceptible vine crops using these tactics. Specifically, mean incidence of bacterial wilt was 2-3 X less prevalent among grower cooperators who implemented a combination of IPM-based practices when compared to both commercial and organic farm operators. The seasonal abundance and species composition of insect pollinators did vary among farms locations with *Apis* and *Bombus* spp occurring most frequently. We have demonstrated the ability to significantly reduce the reliance on broad spectrum insecticides by incorporating IPB-based, cultural practices that prevent damaging beetle feeding.

Background and Rationale:

Wisconsin Agricultural Statistics report vegetable production on over 112,000 acres in Wisconsin with a total of 2,850 reported processed and fresh market growers. Fresh market vegetables are grown and packaged for direct market sales (road-side stands & farmers markets), produce auctions throughout the state, and for large emerging produce cooperatives emphasizing locally sourced, value-added products (Organic Valley, LaFarge, WI). While acreages and crops continue to evolve in response to market demands and production limitations, growers have adapted and remained leaders in several crops. Although no "official" statistics are collected on fresh market production, the WI Fresh Market grower association estimates nearly 1,500 small-acreage producers rowing over 50 crop cultivars in the state. Recent increases in locally grown food has fostered the growth of local produce auctions, expansion of farmers' markets, and roadside stands in many locations in western Wisconsin. This has provided Amish and some small acreage, non-Amish farmers in the area an opportunity to diversify their farms and enhance farm income by adding vegetable enterprises. Several farms use a significant portion of their land for raising fresh market vegetables. This has presented two primary challenges; first, they have limited experience in growing vegetables commercially, creating the need for training on cultural and pest management practices on a variety of vegetable crops. Secondly, they need to make sure they have enough quality production from their field crops to meet the needs of rapidly emerging markets driven by the regional food sourcing initiatives. These farmers have been seeking information to help with these two concerns from several sources including Agribusinesses, Wisconsin Cooperative Extension, and other producers.

Among the range of production issues faced by this clientele group, cucumber beetles and the bacterial pathogen *Erwinia tracheiphila*, continue to rank high among limiting factors annually recurring in many areas. The overwintering adult insect causes feeding damage on young, emerging plants as well as blossoms and fruit. In addition to direct damage on plants, cucumber beetles are vectors of the bacterial wilt pathogen. The transmission of bacterial wilt disease is even more serious than direct damage because the disease will kill the plant. Because grower access to IPM strategies for management of this insidious pest complex has been limited, insecticides have been commonly used in conventional cucurbit production for control of cucumber beetles especially in melons and summer squash. Very often, the insecticide options used have been inappropriate formulations applied at inappropriate times leading to direct impacts on native and domestic pollinators and ultimately poor fruit set. IPM practices crucial for successfully improving our management of these beetles and the bacterial wilt pathogen they transmit are the focus of this project.

Research Objectives / Performance Targets:

To develop a comprehensive set of IPM-based tools to manage the cucumber beetle – bacterial wilt pathosystem and document reductions in total pesticide use and avoidance of risk associated with adoption of IPM.

Associated Research Goals.

1. Participating growers will grow a field of highly-susceptible, cucurbit crops with greater than a 50% reduction in the use of high risk insecticides required to produce a non-resistant variety.

2. Participating growers will achieve a > 75% reduction in disease incidence by layering multiple management tactics with minimal adverse effects on fruit yield or quality.
3. The long-term persistence of cucumber beetle populations and incidence of bacterial wilt inoculum will be reduced by greater than 50% through sanitation and source reduction efforts.

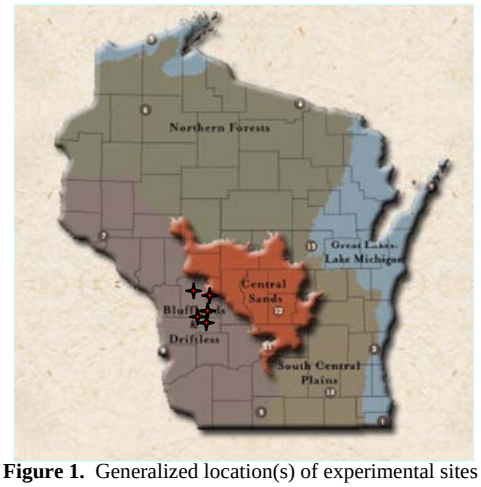

Figure 1. Generalized location(s) of experimental sites (+) in the 'Driftless Region' of southwest,WI 2008.

Research Approach and Outcomes to Date:

Site Selection(s): A total of 5 experimental farms were identified on which the proposed research was conducted in 2008 (**Fig. 1**). Field locations 1-3 were located approximately 8.8 km southwest of Cashton, WI in both Monroe and Vernon Counties. Field Site 1 is operated by Mr. Joseph Kauffman and located at S805 Irish Ridge Road, Cashton, WI. The principal agricultural outputs of the operation include manufactured wood products, greenhouse bedding plants, and field grown fruiting vegetables and cucurbit vine crops occupying approximately 8.5 acres. Both greenhouse and field grown vegetable produce are sold locally at the Cashton, WI produce auction. Field Site 2 is operated by Mr. Christ Hershberger, S2185 County Highway D, Westby, WI. Here again, agricultural outputs of the farm operation include cucurbit vine crops, fruiting vegetables, and greenhouse bedding plants and hanging baskets produced on approximately 4.5 acres and also retail sold at the Cashton WI produce auction. Field Site 3 is operated by Mr. James Yoder, S3718 County Highway D, Westby, WI and is operated as a certified organic produce operation occupying approximately 12.5 acres. Similar to the other local farm operations, the range of vegetable offerings are similar in kind but sold as wholesale raw product to Organic Valley's, Organic Produce Pool, LaFarge, WI. Experimental Site 4 is operated by Mr. Jerry Schneider and Ms. Lisa Riniker, 1103 Habhegger Avenue, Sparta, WI and consisted of 12 acres of retail pumpkin. Finally, Field Site 5 is operated by Mr. Brian Nelson, S1028 90 Meter Drive, Westby, WI and consisted of approximately 12 acres of cucurbit vine crops as well as a minor component of fruiting vegetables.

Briefly, Field Sites 1, 2, and 4 were included as conventional grower locations which adopted the comprehensive program of IPM-based tactics to limit insect and disease pressure, which included reduced-risk insecticides. Experimental Site 3 was included as the 'organically-managed, comparatively standard location which included all non-chemical approaches to management of the insect pathosystem. Field Site 5 was managed by the grower/operator consistent with their past management practices. This site served as the conventional standard location as many broad spectrum insecticides were used for insect and disease control with very little adoption of IPM-based practices.

Product outcomes of the first season of research included the integration of comprehensive, biologically-based integrated pest management strategies into cucurbit production systems for direct market growers supplying regional produce auctions, and organic producers. Specifically, project participants were asked to incorporate and adopt the following sequence of culturally-

based, pest management practices to reduce their reliance on what has become widespread use of both carbaryl and synthetic pyrethroids for control of cucumber beetles. First year project implementation objectives included, but were not limited to;

A.) Approximately 1,500 linear feet of the cucurbit crop was covered with floating row cover. Covered rows were sub-divided into 500 ft sections and placed in 3 separate locations over the melon, pumpkin, or squash crop at each site. Row covers were erected June 2 2008 and maintained over the crop until first flower. Generally, row covers were removed 2 July 2008 to allow for pollination services to ensue on uncovered treatments.

B.) The remainder of the cucurbit crop (1.5 to 6.0 acres/experimental site) was treated with a drench treatment of AdmirePro 2SC at Sites 1 and 2 with an in-furrow treatment of Platinum at Site 4. Treatments at Sites 1 and 2 were applied as a transplant drench at a rate of 1.4 fl oz / 1,000 plants and the in-furrow treatment at Site 4 was applied at a rate of 11.0 fl oz / acre. Product was donated by both Bayer CropSciences and Syngenta Crop Protection.

C.) A single, 300 ft row of Blue Hubbard squash was transplanted as a trap crop along one edge of each field. Trap crops were placed to intercept overwintering cucumber beetles emerging from wooded edges as they colonize the main crop. For all 4 participants with a trap crop (excluding Field Site 5), a total of approximately 1,200 plants were transplanted. Trap crop transplants were initially treated with AdmirePro immediately prior to transplant as previously described. At each site, trap crops were transplanted as a single row spaced 48” within rows over yellow plastic at the same time as the main crop.

D.) Yellow sticky panel traps were placed in 1) unmanaged areas outside the production field, 2) Hubbard squash trap crops, 3) in the main crop (AdmirePro and Platinum treated), and 4) in the covered rows (following row cover removal). A total of 4 traps were placed in each area and insect counts collected and replaced weekly. Very few differences in weekly beetle counts were obtained among the different regions within a locations suggesting that overwintering, colonizing beetles immigrated into experimental sites equally in all directions. The magnitude of colonizing populations did appear to differ among locations with the greatest populations collected at experimental Site 3, the organically-managed site (**Fig. 2**).

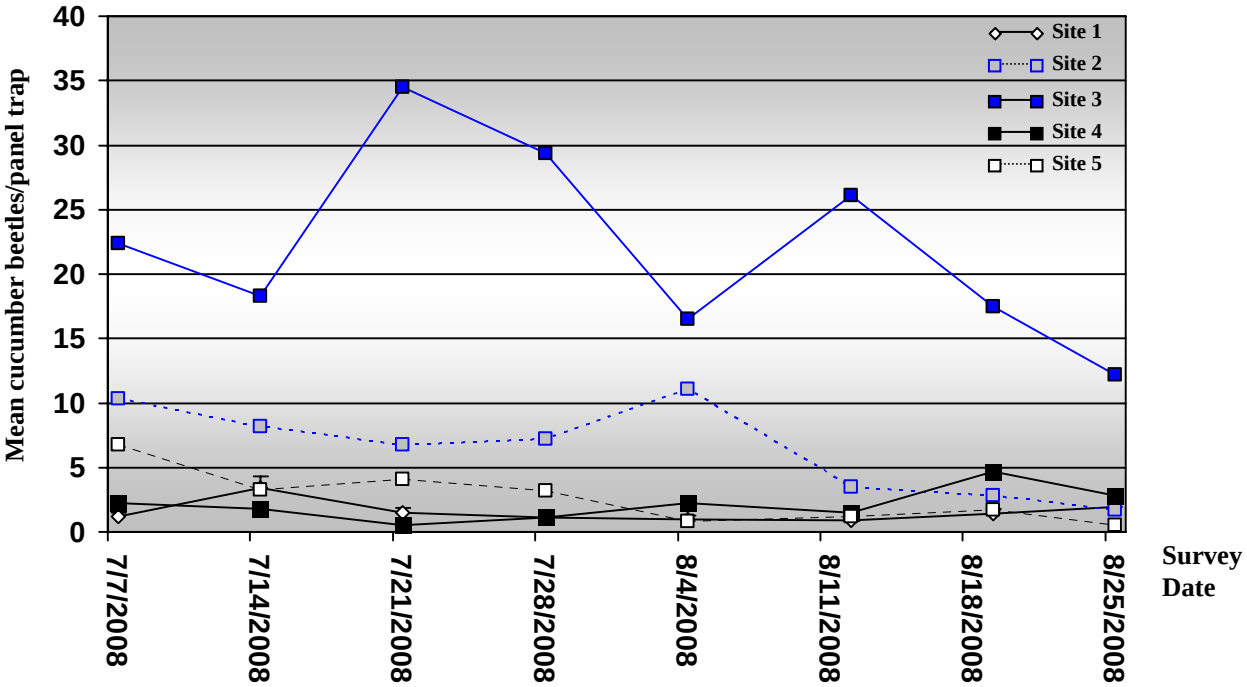

Figure 2. Seasonal capture of striped cucumber beetles among experimental field sites, southwestern Wisconsin, 2008.

E.) Following plot establishment, the total number of adult cucumber beetles were counted on five consecutive plants randomly selected from the 4 field sections described previously (e.g. unmanaged areas, trap crops, main crop, covered rows). Counts were made bi-monthly through the growing season (June – Sept). Beetle counts did vary among the different crop sections at each experimental site with the largest number often encountered on the Blue Hubbard trap crops (**Table 1**).

F.) Following row cover removal and during regularly scheduled beetle surveys, we continued to survey adult cucumber beetles in anticipation of the possibility of implementing foliar sprays of reduced-risk insecticides as needed / warranted based upon established thresholds for different cucurbit crops. No foliar applications of kaolin clay (Surround) were warranted on any of the infested crops that were under the row cover experiments. Foliar applications on the main crop were also not necessary throughout the remainder of the experimental interval.

G.) Beginning in early July, bacterial wilt surveys were performed monthly over a sub-selected portion of the cucurbit acreage in both insecticide-treated and row-covered areas of the experimental sections. Tissue from symptomatic plants was collected and returned to the laboratory in Madison, WI for confirmation and whole plants were counted, rouged, and composted immediately after a confirmation of symptoms. Similar to beetle counts, the mean incidence of bacterial wilt in affected vine crops varied significantly between the management units on each farm site (**Table 2**).

Table 1. Mean number of adult cucumber beetles in each of the 3 management sections (main crop, row cover, trap crop) on each experimental field site in southwestern Wisconsin, 2008.

Field Site	Management Section	Sample Dates Recorded[1] 7 July	14 July	21 July	28 July	4 Aug	12 Aug	19 Aug	25 Aug
Site 1	Main crop	0.1 ± 0.1 b	0.3 ± 0.1 b	0.5 ± 0.2 b	2.8 ± 0.5 b	0.9 ± 0.2 b	1.1 ± 0.2 a	0.7 ± 0.2 a	0.7 ± 0.2 a
	Row cover	0.0 b	0.0 b	0.5 ± 0.2 b	1.9 ± 0.4 b	0.8 ± 0.1 b	0.5 ± 0.5 ab	0.7 ± 0.2 a	0.7 ± 0.3 a
	Trap Crop	1.6 ± 0.4 a	2.2 ± 0.3 a	2.2 ± 0.4 a	11.8 ± 1.5 a	5.8 ± 0.7 a	0.0 a	1.0 ± 0.3 a	1.7 ± 0.9 a
Site 2	Main crop	1.3 ± 0.3 b	6.3 ± 1.9 a	8.6 ± 1.0 a	8.4 ± 1.0	1.7 ± 0.4 b	1.8 ± 0.4 a	0.9 ± 0.2	6.2 ± 1.8 a
	Row cover	1.3 ± 0.4 b	6.0 ± 1.0 a	3.3 ± 0.6 b	2.0 ± 0.4	0.7 ± 0.2 b	2.7 ± 0.3 a	0.9 ± 0.3	0.9 ± 0.4 b
	Trap Crop	2.7 ± 0.5 a	4.7 ± 1.1 a	6.7 ± 1.4 a	3.7 ± 0.7	2.8 ± 0.3 a	3.3 ± 0.7 a	0.0	0.0 b
Site 3	Main crop	0.0 a	0.1 ± 0.1 a	0.0 b	0.1 ± 0.1	0.0 a	0.1 ± 0.1 a	0.0	0.1 ± 0.1 a
	Row cover	0.0 a	0.2 ± 0.1 a	0.1 ± 0.1 b	0.0	0.0 a	0.1 ± 0.1 a	0.1 ± 0.1	0.0 a
	Trap Crop	0.6 ± 0.3 a	0.2 ± 0.1 a	1.3 ± 0.3 a	0.0	0.1 ± 0.1 a	0.1 ± 0.1 a	0.3 ± 0.1	0.2 ± 0.1 a
Site 4	Main crop	4.7 ± 1.2 b	8.4 ± 2.1 a	4.0 ± 0.6 a	3.4 ± 0.7	5.1 ± 0.6 a	3.6 ± 0.4 a	4.4 ± 0.5	2.7 ± 0.5 a
	Row cover	7.5 ± 1.5 a	8.0 ± 1.8 a	5.7 ± 0.8 a	3.9 ± 0.6	4.9 ± 0.6 a	3.4 ± 0.5 a	3.6 ± 0.8	2.5 ± 0.9 a
	Trap Crop	2.4 ± 0.7 c	6.6 ± 1.4 a	1.8 ± 0.5 b	1.5 ± 0.5	7.2 ± 1.3 a	4.9 ± 0.9 a	5.1 ± 1.4	0.0 b
Site 5	Main crop	2.9 ± 1.1	4.7 ± 1.2	7.9 ± 2.1	4.9 ± 1.3	4.9 ± 1.3	5.9 ± 1.4	3.8 ± 0.9	6.7 ± 1.7
	Row cover	--	--	--	--	--	--	--	--
	Trap Crop	--	--	--	--	--	--	--	--
(*P*<0.0001)	-	(0.0085)	(<0.0001)	(<0.0001)	(<0.0001)	(0.0377)	(0.0009)	(<0.0001)	(<0.0001)
LSD (P=0.05)		0.3	0.8	1.3	1.6	1.3	0.4	1.0	1.2

[1] Means within a column, by location, followed by the same letter are not significantly different (*P*>0.05; Fisher's Protected LSD; n = 4).

Table 2. Mean incidence of bacterial wilt, *Erwinia tracheiphila*, in each of the 3 management sections (main crop, row cover, trap crop) on each experimental field site in southwestern Wisconsin, 2008.

Field Site	Management Section	Sample Dates Recorded[1] 7 July	14 July	21 July	28 July	4 Aug	12 Aug	19 Aug	25 Aug
Site 1	Main crop	0.0	0.0	0.1 ± 0.1 a	0.4 ± 0.2	0.1 ± 0.1	0.1 ± 0.1 a	0.0 a	0.0 a
	Row cover	0.0	0.0	0.1 ± 0.1 a	0.1 ± 0.1	0.0	0.0 a	0.0 a	0.0 a
Site 2	Main crop	0.1 ± 0.1	0.1 ± 0.1	0.5 ± 0.2 a	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1 a	0.0 a	0.1 ± 0.1 a
	Row cover	0.0	0.1 ± 0.1	0.2 ± 0.1 b	0.2 ± 0.1	0.1 ± 0.1	0.0 b	0.0 a	0.0 a
Site 3	Main crop	0.0	0.0	0.0 a	0.0 a	0.0	0.0 a	0.0 a	0.0 a
	Row cover	0.0	0.0	0.0 a	0.0 a	0.0	0.0 a	0.0 a	0.0 a
Site 4	Main crop	0.2 ± 0.1	0.4 ± 0.2	0.4 ± 0.2 a	0.3 ± 0.1	0.2 ± 0.1	0.5 ± 0.2 a	0.7 ± 0.3 a	0.5 ± 0.2 a
	Row cover	0.0	0.4 ± 0.2	0.2 ± 0.1 a	0.2 ± 0.1	0.1 ± 0.1	0.2 ± 0.1 b	0.1 ± 0.1 b	0.1 ± 0.1 b
Site 5	Main crop	0.0	0.2 ± 0.1	0.9 ± 0.3	0.6 ± 0.2	0.3 ± 0.1	0.2 ± 0.1	0.8 ± 0.2	0.7 ± 0.4
	Row cover	--	--	--	--	--	--	--	--
(*P*<0.0001)	-	(0.3381)	(0.0903)	(0.0494)	(0.1177)	(0.2316)	(0.0348)	(<0.0001)	(<0.0001)
LSD (P=0.05)		0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1

[1] Means within a column, by location, followed by the same letter are not significantly different (*P*>0.05; Fisher's Protected LSD; n = 4).

H.) A sub-sample of adult cucumber beetles (N=25 / farm / sample date) counted from the main crop have been collected in 95% EtOH and held in the laboratory for later PCR analysis of infectivity. Infectivity assessments will be performed on beetles collected in June, August, and October and these assays will be conducted this Fall, 2008 to determine at which points during the year the risk of potential infection may be greatest relative to the susceptibility of the crop / cultivars.

I.) Non-managed, weedy border areas surrounding the plot area have been maintained as weed free areas as much as possible through the second half of the growing season. This was accomplished by two mowings / cuttings of grassy vegetation in mid-August and again in mid-September.

J.) During bi-monthly field visits, a 10 minute interval of time during the early morning was spent monitoring / recording pollinator services in the main crop and the portion of the crop under row cover. Specifically, the frequency and duration of visits to flowers by domestic honeybees (*Apis mellifera*), wild bumblebees (*Bombus* spp.), and other wild pollinators such as the squash bee (*Peponapis pruinosa*) will be evaluated through visual counts. See the attached Appendix A to note the details of the protocol we employed to document the impact(s) of selected management strategies on pollinators.

Taken together, the proposed management program continues to enhance the close cooperation that has developed between direct market produce growers, wholesale produce buyers, county agricultural extension agents, and extension specialists at the University of Wisconsin. The collaboration team is very much on course towards the development of sustainable, culturally-based, pest management recommendations to limit the damage caused by cucumber beetles and bacterial wilt with an emphasis on reduced pesticide inputs targeted as high risk by FQPA. Field scale trials in the coming year will again be focused on confirming the effectiveness of different strategies within local production systems and verify the suitability of these multiple tactics for direct market producers.

Insecticide Efficacy Trial Results
Field Corn 2008:

Corn Rootworm Trials

University of Wisconsin, Madison
Department of Entomology
Arlington Agricultural Research Station

Scott Chapman[2], Bryan Jensen[3] and Eileen M. Cullen[1]

Field History: The 2008 corn rootworm larval insecticide efficacy trial was established at the Arlington Agricultural Research Station, in field 710. Field 710 was chisel plowed in fall 2007 and cultivated in the spring of 2008. No manure was applied. Soil in the test plot is classified as Plano silt loam (sand: 13%, silt: 68%, clay: 19%). Soil test results from spring 2008 in field 710 are; pH: 6.6; Organic matter: 4.1%; Phosphorus: 67 ppm; Potassium: 171 ppm. Field corn was grown in field 710 during 2007 with glyphosate (Roundup) used for weed control. No supplemental irrigation was applied to the plots.

Treatments, Planting, and Experimental Design:
Thirty five treatments were evaluated in a large replicated field corn study (Standards trial) for efficacy against corn rootworm larval injury to field corn roots. Treatments included nicotinoid seed treatments (Cruiser and Poncho), at the corn rootworm rate of 1.25 mg a.i. per kernel; ten synthetic pyrethroid treatments (T-band, T-band spray and/or in-furrow); six organophosphate treatments (T-band, T-band spray, and in furrow); two transgenic *Bt* corn rootworm hybrids, (Cry 3Bb1) and (Cry 1F, Cry 34/35Ab1); and untreated checks (Table 1).

Two transgenic *Bt* corn rootworm hybrids were used in this trial [Renk RK488YGRW and Herculex XTRA (Dow AgroSciences Hybrid)]. Two non-*Bt* isolines, RK488 and Herculex were used as untreated checks in the trial. RK488 was pretreated with 2.5 oz. ai/cwt. Maxim XL, 0.64 fl oz./cwt. Apron XL fungicides upon receipt from Renk Seeds, Sun Prairie, WI and was used in five treatments and Herculex was used in 13 of the treatments. Seed (RK488) was shipped to Bayer CropScience and Syngenta Crop Protection to be treated with the appropriate pesticides. In furrow, T-band, T-band spray, and Smartbox® treatments were applied with attachments mounted on the corn planter.
The corn rootworm larval trial was planted into an area of field 710 that was trap cropped in 2007. A field corn trap crop was planted June 21, 2007 to provide corn silks and pollen in July and August when western and northern corn rootworm beetle adults were feeding, mating and depositing eggs into the soil; attracting a potentially economically damaging rootworm population to the site where the corn rootworm larval insecticide efficacy trial would be conducted the subsequent (2008) season.

The Standards trial was planted 30 April, 2008 with a two-row John Deere model 7100 planter, modified to accept either cone seeder attachments or standard hopper boxes. This trial was planted with the standard hopper boxes attached. A target seeding rate of 30,200 plants per acre was planted and actual plant populations can be found in Table 2. The weed management program consisted of a application of Dual (s-metolachlor) at the rate of 1.3 pints product per

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acre applied on 8 May and Callisto (mesotrione) at the rate of 3 ounces product per acre on 12 June. 130 pounds of nitrogen in the form of anhydrous ammonia was applied broadcast across field 710 preplant. Plots consisted of four 50-foot rows spaced at 30 inches. Treatments were assigned to plots in a completely randomized block design and replicated 4 times. Thirty-foot alleyways were maintained between replicate blocks.

Table 1. Corn rootworm insecticide efficacy Trial. Insecticidal seed treatment, soil applied insecticides and Yieldgard *Bt* corn rootworm corn hybrids. Arlington Agricultural Research Station, Arlington, WI. 2008**.**

Trade Name	Active Ingredient (insecticide class)	Rate	Placement
	Yieldgard or Isoline		
Untreated (RK488)	---	---	---
YieldGard RW + Cruiser 5FS[1]	*Bt* CRW (Cry3Bb1) + thiamethoxam (GMO + nicotinoid)	0.25 mg a.i./kernel	Seed Treatment
Poncho 1250[3]	clothianidin (nicotinoid)	1.25 mg a.i./ kernel	Seed Treatment
Cruiser 5FS	thiamethoxam (nicotinoid)	1.25 mg a.i./ kernel	Seed Treatment
Force 3G + Yieldgard RW	tefluthrin (pyrethroid) + *Bt* CRW (Cry3Bb1)	4.0 oz./1000 ft	T-band + Seed Treatment
Capture LFR + Yieldgard RW	bifenthrin (pyrethroid) + *Bt* CRW (Cry3Bb1)	0.49 oz./1000 ft	T-band + Seed Treatment
Capture LFR + Yieldgard RW	bifenthrin (pyrethroid) + *Bt* CRW (Cry3Bb1)	0.49 oz./1000 ft	In furrow + Seed Treatment
Counter 15G + Yieldgard RW	terbufos (organophosphate) + *Bt* CRW (Cry3Bb1)	8.0 oz./1000 row ft	In furrow + Seed Treatment
Counter 20G + Yieldgard RW	terbufos (organophosphate) + *Bt* CRW (Cry3Bb1)	6.0 oz./1000 row ft	In furrow + Seed Treatment

Table 2. Corn rootworm insecticide efficacy Trial. Insecticidal seed treatment, soil applied insecticides and Herculex Xtra *Bt* corn rootworm corn hybrids. Arlington Agricultural Research Station, Arlington, WI. 2008**.**

Trade Name	Active Ingredient (insecticide class)	Rate	Placement
Herculex Xtra or Isoline			
Counter 15G + Herculex Xtra	terbufos (organophosphate) + *Bt* CRW (Cry 1F, 34/35Ab1)	6.0 oz./1000 row ft	T-band + Seed Treatment
Fortress 5G + Herculex Xtra	chlorethoxyfos (organophosphate) + *Bt* CRW (Cry 1F, 34/35Ab1)	3.7 oz./1000 ft	In furrow (Smartbox®) + Seed Treatment
Herculex Xtra	*Bt* CRW (Cry 1F, 34/35Ab1)	---	Seed Treatment
Capture LFR	bifenthrin (pyrethroid)	0.49 oz./1000 ft	T-band
Fortress 5G	Chlorethoxyfos (organophosphate)	3.0 oz./1000 ft	In furrow
Aztec 2.1G	tebupirimphos + cyfluthrin (organophosphate + pyrethroid)	6.7 oz./1000 row ft	T-band
Lorsban 15G	chlorpyrifos (organophosphate)	8.0 ozi/1000 ft	T-band
Counter 15G	terbufos (organophosphate)	8.0 oz./1000 row ft	In furrow
Counter 20G	terbufos (organophosphate)	6.0 oz./1000 row ft	In furrow
Capture LFR	bifenthrin (pyrethroid)	0.49 oz./1000 ft	In furrow
Aztec 2.1G	tebupirimphos + cyfluthrin (organophosphate + pyrethroid)	6.7 oz./1000 row ft	In furrow
Force 3G	tefluthrin (pyrethroid)	4.0 oz./1000 ft	In furrow
Force 3G	tefluthrin (pyrethroid)	4.0 oz./1000 ft	In furrow
Untreated (isoline)	---	---	---

Table 3. Corn rootworm insecticide efficacy Trial 1. **Stand counts** of insecticidal seed treatment, soil applied insecticide, transgenic *Bt* corn rootworm hybrid and check treatment plots. Arlington Agricultural Research Station, Arlington, WI.

Treatment	Rate	Placement	Stand counts [No. Plants/50 feet][2] 26 May[1]
Untreated (RK488)	---	---	84.9 a
YieldGard RW + Cruiser 5FS[1]	0.25 mg a.i./kernel	Seed Treatment	81.8 a
Poncho 1250[3]	1.25 mg a.i./ kernel	Seed Treatment	84.8 a
Cruiser 5FS	1.25 mg a.i./ kernel	Seed Treatment	83.1 a
Force 3G + Yieldgard RW	4.0 oz./1000 ft	T-band + Seed Treatment	81.6 a
Capture LFR + Yieldgard RW	0.49 oz./1000 ft	T-band + Seed Treatment	79.7 a
Capture LFR + Yieldgard RW	0.49 oz./1000 ft	In furrow + Seed Treatment	79.7 a
Counter 15G + Yieldgard RW	8.0 oz./1000 row ft	In furrow + Seed Treatment	79.8 a
Counter 20G + Yieldgard RW	6.0 oz./1000 row ft	In furrow + Seed Treatment	82.1 a

[1] P = 0.0867; F = 1.419; df = 36, 147; LSD = 2.95

[2]Means within the same column followed by the same letter do not significantly differ at α = 0.05 (ARM 7, Gylling Data Management Inc. Brookings, SD, 2004).

Table 4. Corn rootworm insecticide efficacy Trial. **Root ratings** of insecticidal seed treatment, soil applied insecticide, Herculex Xtra *Bt* corn rootworm hybrid and check treatment plots. Arlington Agricultural Research Station, Arlington, WI.

Treatment	Rate	Placement	Stand counts [No. Plants/50 feet][2] 26 May[1]
Counter 15G + Herculex Xtra	6.0 oz./1000 row ft	T-band + Seed Treatment	85.9 cde
Fortress 5G + Herculex Xtra	3.7 oz./1000 ft	In furrow (Smartbox®) + Seed Treatment	89.8 a-d
Herculex Xtra	---	Seed Treatment	89.8 a-d
Capture LFR	0.49 oz./1000 ft	T-band	91.2 ab
Fortress 5G	3.0 oz./1000 ft	In furrow	83.1 e
Aztec 2.1G	6.7 oz./1000 row ft	T-band	90.3 abc
Lorsban 15G	8.0 oz./1000 ft	T-band	89.4 a-d
Counter 15G	8.0 oz./1000 row ft	In furrow	83.0 e
Counter 20G	6.0 oz./1000 row ft	In furrow	85.4 de
Capture LFR	0.49 oz./1000 ft	In furrow	86.1 cde
Aztec 2.1G	6.7 oz./1000 row ft	In furrow	90.0 abc
Force 3G	4.0 oz./1000 ft	In furrow	93.4 a
Force 3G	4.0 oz./1000 ft	T-band	88.4 bcd
Untreated (isoline)	---	---	88.7 bcd

[1] P = 0.0867; F = 1.419; df = 36, 147; LSD = 2.95

[2]Means within the same column followed by the same letter do not significantly differ at α = 0.05 (ARM 7, Gylling Data Management Inc. Brookings, SD, 2004).

Root Evaluation for Corn Rootworm Larval Injury: The Iowa State University Node-Injury root rating scale was used to evaluate the level of root protection between treatments [Oleson and Tollefson, http://www.ent.iastate.edu/pest/rootworm/nodeinjury/nodeinjury.html]. This root rating system evaluates damage based on each node, and equivalency of roots pruned to within ~ 1.5 inches of the stalk. Damage may be sustained entirely on one node or on a combination of nodes. Using this system, economic root injury ranges between 0.0 and 3.0. For example, a rating of 1.25 represents the equivalent of one entire node pruned (number to the left of the decimal), plus 25% of an additional partial node (number to the right of the decimal). Root ratings between 0.25 and 0.75 fall within the economic injury range. We use a root rating cut-off at or above 0.50 (some pruning has occurred, but never the equivalent of an entire node) to determine whether a product has provided adequate root protection. The closer a root rating is to 0.25 or below, the more effective it is.

Root ratings were taken on July 24, 2008. Five plants were evaluated per plot. Plants were cut to within 12 inches of the ground, dug up, tagged and removed. Roots were soaked in water and then washed with a high pressure water stream to remove soil prior to node injury rating.

Harvest and Yield: Yields taken using Joe Lauers Methods for Calculating Yield, http://corn.agronomy.wisc.edu/AA/A033.htm

Statistical Analysis: All data (stand counts, node-injury root rating and yield) were subjected to analysis of variance using ARM7 (Gylling Data Management, Inc. 2004) at $\alpha = 0.05$. Means separation (Least Significant Difference Test) was used to rank results.

Corn Rootworm Trial Results:

Table 5. Corn rootworm insecticide efficacy Trial 1. **Stand counts** of insecticidal seed treatment, soil applied insecticide, transgenic *Bt* corn rootworm hybrid and check treatment plots. Arlington Agricultural Research Station, Arlington, WI.

Treatment	Rate	Placement	Node-Injury Rating[1,3]	Yield (Bu/A)[2,3]
Force 3G + Yieldgard RW	4.0 oz./1000 ft	T-band + Seed Treatment	0.01 d	144.84 bcd
Capture LFR + Yieldgard RW	0.49 oz./1000 ft	In furrow + Seed Treatment	0.01 d	150.24 a-d
Counter 20G + Yieldgard RW	6.0 oz./1000 row ft	In furrow + Seed Treatment	0.01 d	155.16 abc
Counter 15G + Yieldgard RW	8.0 oz./1000 row ft	In furrow + Seed Treatment	0.03 d	131.45 d
YieldGard RW + Cruiser 5FS[1]	0.25 mg a.i./kernel	Seed Treatment + Seed Treatment	0.04 d	159 62 ab
Capture LFR + Yieldgard RW	0.49 oz./1000 ft	T-band + Seed Treatment	0.04 d	166.77 ab
Poncho 1250[3]	1.25 mg a.i./ kernel	Seed Treatment	1.39 b	167.49 a
Cruiser 5FS	1.25 mg a.i./ kernel	Seed Treatment	1.95 a	133.99 cd
Untreated (RK488)	---	---	1.99 a	155 65 abc

[1] P = 0.0001; F = 19.244; df = 8, 35; LSD = 0.539
[2] P = 0.0409; F = 1.419; df = 8, 35; LSD = 22.423
[3]Means within the same column followed by the same letter do not significantly differ at α = 0.05 (ARM 7, Gylling Data Management Inc. Brookings, SD, 2004).

Table 6. Corn rootworm insecticide efficacy Trial. **Stand counts** of insecticidal seed treatment, soil applied insecticide, Herculex Xtra *Bt* corn rootworm hybrid and check treatment plots. Arlington Agricultural Research Station, Arlington, WI.

Treatment	Rate	Placement	Node-Injury Rating[1,3]	Yield (Bu/A)[2,3]
Counter 15G + Herculex Xtra	6.0 oz./1000 row ft	T-band + Seed Treatment	0.01 f	150.67 a
Fortress 5G + Herculex Xtra	3.7 oz./1000 ft	In furrow (Smartbox®) + Seed Treatment	0.02 f	152.87 a
Herculex Xtra	---	Seed Treatment	0.03 f	137.76 a
Capture LFR	0.49 oz./1000 ft	In furrow	0.03 f	147.91 a
Fortress 5G	3.0 oz./1000 ft	In furrow	0.27 ef	156.19 a
Aztec 2.1G	6.7 oz./1000 row ft	T-band	0.38 def	156.62 a
Lorsban 15G	8.0 oz/1000 ft	T-band	0.43 def	167.77 a
Counter 15G	8.0 oz./1000 row ft	In furrow	0.45 def	151.85 a
Counter 20G	6.0 oz./1000 row ft	In furrow	0.80 cde	174.94 a
Capture LFR	0.49 oz./1000 ft	T-band	0.85 cd	147.91 a
Aztec 2.1G	6.7 oz./1000 row ft	In furrow	0.85 cd	158.73 a
Force 3G	4.0 oz./1000 ft	In furrow	1.10 bc	145.76 a
Force 3G	4.0 oz./1000 ft	T-band	1.54 b	165.42 a
Untreated (isoline)	---	---	2.26 a	161.90 a

[1] P = 0.0001; F = 12.68; df = 12, 51; LSD = 0.525
[2] P = 0.8989; F = 0.519; df = 12, 51; LSD = 38.386
[3]Means within the same column followed by the same letter do not significantly differ at α = 0.05 (ARM 7, Gylling Data Management Inc. Brookings, SD, 2004).

Results Summary:

a. Corn rootworm larval efficacy trials

Node-injury root ratings are listed for the 2008 trials (Tables 5 and 6) with root damage in descending order within the column. Root rating scores were statistically significant among treatments, detecting a difference among treatments at the 5 percent probability level. Corn rootworm pressure was high with node-injury scores of 1.99 and 2.26 in the untreated check plots. In all Tables the more effective treatments are listed towards the top of the table, with the lower node-injury root rating scores. Root ratings below a level of 0.50 generally provide acceptable root protection, while root ratings under 0.25 are well below the level of economic root damage. Statistically speaking, the transgenic *Bt* CRW hybrids in combination with Counter 15G, Counter 20G, Capture LFR, and Force 3G provided the highest level of corn rootworm larval control with average node-injury ratings between 0.0-0.1. Counter 15G (In furrow) in combination with Yieldgard, Capture LFR in combination with Yieldgard, Fortress 5G in combination with Herculex Xtra and Capture LFR at the rate of 0.49 oz./1000 row ft limited root pruning to less than 0.04. The treatments of The *Bt* CRW hybrids (Herculex XTRA and YieldGard RW) also provided a high level of corn rootworm larvae control with average node-injury ratings between 0.03-0.04. The treatments of Counter 20G at the rate of 6.0 oz./1000 row ft, Aztec 2.1G at the rate of 6.7 oz/1000 row ft T-band), Lorsban 15G at the rate of 8.0 oz/1000 row ft, and Counter 15G at the rate of 8.0 oz/1000 row ft limited root pruning to less than 0.5. The remaining treatments had root node-injury ratings between 0.8 and 2.26 (Table 8).

Keep in mind that corn rootworm insecticides, whatever the class, vary between years in terms of root rating results and yield. In years of heavy corn rootworm pressure, any given product can be overwhelmed by the larval population, resulting in root damage. As you evaluate corn rootworm trials within one state over the years, and compare product performance between states within the same year, look for consistency of results. That is, "how often did a particular control option result in satisfactory root protection?". Also keep in mind that poor root protection may not result in reduced yields if the environment conditions are favorable for corn growth. It is during poor growing conditions that root pruning adds to crop stress and impacts yield.

It is also important to note that these are small plot data and tend to yield higher under research station conditions. While small plot yields are not necessarily representative of commercial field expectations, it is the difference between treatments that we are interested in.

In addition to corn rootworm larval feeding (a function of larval population, planting date, weather and timing of the larval hatch), corn yield is influenced by hybrid root structure, soil type, soil fertility and nutrient availability, moisture, temperature, and other factors. Over time as we continue to include yield data in the UW corn rootworm trials, we'll be able to accumulate data on how often a particular control option results in a statistically significant higher yield than the untreated control, even when control options do not differ in yield from each other. Yield data over time, along with the more tangible root rating injury data, rootworm pressure and general growing conditions in a given year, provides supplemental information on which to evaluate and select a corn rootworm control product in fields where larval hatch is a concern.

Insecticide Efficacy Trial Results-Soybean 2008

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Scott Chapman[2], Bryan Jensen[3], and Eileen M. Cullen[1]

Field History: Soybean aphid foliar insecticide efficacy trial was conducted in field 582 at the Arlington Agricultural Research Station. Soil in the test plot is classified as a Plano silt loam.

Treatments, Planting, and Experimental Design:
The foliar insecticide residue trial evaluating residual activity against the soybean aphid was conducted in field 582. A Northrup King (NK S20-P3RR) was planted on 21 June, 2008 at the rate of 225,000 seeds per acre.
The foliar trial was planted with a John Deere model 7100 4 row planter with 30 inch row spacing at a depth of 1 inch. The 2008 herbicide program included Dual II Magnum at 1.5 pt./A and Sencor at 0.33 lb./A applied pre emergence on 21 June, 2008. Replicate dimensions were 10 ft. (4 rows wide) by 50 feet long. Alley buffers were maintained between replications.
Foliar insecticide efficacy trials were staked one day prior to foliar insecticide application and aphid counts were taken from these plots (see below), but the field was not designed to obtain small plot yield data at harvest and none were taken.

Foliar Insecticide Trial (residual activity)
The foliar insecticide trial, designed to evaluate residual activity as measured by aphid counts at successive intervals post treatment, included 36 treatments (10 pyrethroids, 2 nicotinoids, and 2 organophosphates) (Table 1) in a completely randomized block design with four replications per treatment. Plots were designated by stake markers 7 August 2008, one day prior to treatment when mean aphid counts had reached 170 aphids/plant. Each replicate was 10 ft wide by 30 ft long. Plots were sprayed 8 August, 2008 with a CO2 pressurized backpack sprayer operating at 30 psi while delivering 36 gpa through 6 flat fan nozzles (TeeJet 8002VS) on a 10 foot boom. Aphid counts were taken 3, 6, and 13 days post treatment. Whole plant counts were taken on 10 randomly selected plants from the middle of each plot, and mean aphids per plot determined across sampling dates. No yields were taken from the plots.

Statistical Analysis: Aphid count data was subjected to analysis of variance using ARM 7 (Gylling Data Management, Inc. 2004) at $\alpha = 0.05$, with treatment the classification variable and aphids/plot as response variables. Means separation (Least Significant Difference Test) was used to rank response variables.

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Table 1. Residual foliar insecticide efficacy for soybean aphid on soybean. Arlington Agricultural Research Station, Arlington, WI. 2008**.**

Treatment	Rate (oz/a)	Mean aphids per 10 plants		
		11 August	14 August	21 August
Untreated	---	1716.3 b	734.3 b	1119.3 bc
Centrics 40WG	1.5	181.8 fgh	98.0 efg	27.8 d
Centrics 40WG	2.0	62.5 ghi	4.0 g	23.3 d
Endigo 2SC	2.0	9.8 i	1.8 g	5.8 d
Endigo 2SC	2.75	3.8 i	0.0 g	1.0 d
Lorsban 4E	8.0	0.0 i	0.0 g	17.3 d
Lorsban 4E	12.0	3.5 i	0.8 g	20.8 d
Lorsban 4E	16.0	0.5 i	0.0 g	13.3 d
Warrior II 2CS	1.28	59.8 ghi	18.5 fg	1.3 d
Warrior II 2CS	1.6	15.8 hi	0.0 g	2.0 d
Warrior 1CS	3.33	13.3 i	7.5 g	0.0 d
Cobalt 2.54EC	13.0	0.5 i	0.0 g	3.8 d
Cobalt 2.54EC	15.0	0.0 i	0.0 g	15.8 d
Hero 1.14EC	5.0	0.0 i	0.3 g	0.3 d
GF-2153 3.75EW	16.0	0.5 i	0.8 g	27.0 d
LSD (P=0.05)		9.64	9.27	9.99
Standard deviation		6.89	6.62	7.13
C.V.		68.74	113.81	95.12
F		19.394	8.825	10.404
Probability (F)		0.0001	0.0001	0.0001

(Continued)

Mean separation determined after data transformation (Square root (X + 1). df = 35, 143.
Means within a column followed by a different letter are significantly different at P<0.05 and Least Significant Difference test (ARM 7, Gylling Data Management, Inc.).

Table 1. (Continued). **Residual foliar insecticide efficacy for soybean aphid on soybean.** Arlington Agricultural Research Station, Arlington, WI. 2008**.**

Treatment	Rate (oz/a)	Mean aphids per 10 plants		
		11 August	14 August	21 August
Untreated	---	6098.5 a	3158.5 a	2789.5 a
Lorsban 4E	16.0	1.8 i	7.3 g	34.0 d
Baythroid 1E	2.43	908 bc	533.3 bc	569.5 c
Leverage 2.7EC + NIS	3.8 + 0.125%	57.3 ghi	16.3 fg	23.5 d
Lorsban 4E + Baythroid 1E	8.0 + 2.0	3.3 i	0.0 g	39.8 d
Baythroid 1E	2.0	818.3 bcd	278.3 bcd	1399.8 b
Proaxis 0.5SC	3.2	41.8 ghi	6.3 g	3.8 d
Asana XL 0.66EC	9.6	1077 bc	216.3 cde	641.3 c
Asana XL 0.66EC + Lorsban 4E	6.4+ 8.0	18.0 hi	0.0 g	5.5 d
Dimethoate 4E	16.0	297.3 efg	161.5 def	99.0 d
Brigade 2EC	4.0	0.0 i	0.0 g	0.0 d
Untreated	---	653.8 cde	447.8 bcd	1064.8 c
Brigade 2EC	5.12	0.0 i	0.0 g	0.3 d
Discipline 2EC	4.0	0.0 i	0.0 g	0.5 d
Discipline 2EC	5.12	0.0 i	0.0 g	0.0 d
KFD 47-01 1ME	3.2	26.5 ghi	1.8 g	0.0 d
Orthene 97SP	14.0	45.3 ghi	9.5 g	15.3 d
LSD (P=0.05)		9.64	9.27	9.99
Standard deviation		6.89	6.62	7.13
C.V.		68.74	113.81	95.12
F		19.394	8.825	10.404
Probability (F)		0.0001	0.0001	0.0001

Mean separation determined after data transformation (Square root (X + 1). df = 35, 143.
Means within a column followed by a different letter are significantly different at P<0.05 and Least Significant Difference test (ARM 7, Gylling Data Management, Inc.).

SECTION V

MINT BUD MITE MANAGEMENT IN WISCONSIN PEPPERMINT PRODUCTION: APPLICATION TIMING AND NEW TOOLS

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Project History. This is the second year of a project supported by the Wisconsin Mint Board (2007-09) to investigate long-term, IPM-based pest management solutions for the control of mint bud mite.

Background and Rationale. Effective, economical, and efficient long term management of mint bud mite continues to be a challenge for specific field locations and the production of black peppermint. In addition to effective crop rotation, bud mites are managed almost exclusively using acaricides. Some acaricides used for control perform adequately, while others continue to perform poorly. Several reasons to explain poor performance include an inappropriate choice of active ingredient, a short residual activity, an application made too late, inadequate application coverage, or a resistant population. Wisconsin mint growers, unlike mint producers in other portions of the US, have a limited number of acaricide management tools for use in controlling mint bud mites. Currently, propargite (Comite® / Omite®) and more recently fenpyroximate (Fujimite) are the only registered acaricides for use in Wisconsin against mint bud mite. Some insensitivity of mint bud mite to propargite combined with concerns regarding environmental persistence, cost, and its listing as a B2 carcinogen make this an increasingly non-viable control option. Spiromesifen (Oberon®) is a relatively new mode of action with both insecticide and acaricide activity which is currently under review with the Federal IR-4 Program. Additional new compounds which may show promise in controlling mint bud mite include Abamectin, (Temprano™), bifenazate (Acramite® 4SC), and diflubenzuron, (Dimilin® 2L) under optimized spray conditions. The use of these new tools has not been well defined in Wisconsin production systems. The goal of this research will be to refine the use of Fujimite and Comite, and document the potential for Acramite, Dimilin, Oberon, and Temprano as feasible, future control options.

Experimental Site: Jack's Pride Farms, John and Ned Crescio, Randolph, Wisconsin.

Project Objective: To continue evaluation of currently registered and new foliar applied acaricides (N=6) targeting 1) emerging, over-wintered populations of mint bud mite and, 2) bud mite populations which have exceeded established, treatment thresholds.

Experimental Design: A total of 13 treatments were arranged in a randomized, complete-block design with 2 acaricide application intervals (at emergence & at threshold) combined with 6 foliar acaricides replicated 4 times on *Mentha piperita* 'peppermint'. Experimental plots were constructed as 20 X 6 ft (0.003 ac) plots with a 5 ft buffer surrounding each experimental replicate.

			Application Number	Application Rate
I.	**Shoot emergence:**			
1)	UTC			
2)	propargite	(Comite EC)	2	2.5 pints/ac
3)	fenpyroximate	(Fujimite 5EC)	1	2.0 pints/ac

II. At-Threshold: (cont.)			Application Number	Application Rate
4)	propargite	(Comite EC)	2	2.5 pints/ac
5)	fenpyroximate	(Fujimite 5EC)	1	2.0 pints/ac
6)	spiromesifen	(Oberon 2SC)	2	8 fl oz./ac
7)		(Oberon 2SC)	2	12 fl oz./ac
8)		(Oberon 2SC)	2	16 fl oz./ac
9)	bifenazate	(Acramite 4SC)	1	16.0 fl oz./ac
10)		(Acramite 4SC)	1	24.0 fl oz./ac
11)	abamectin	(Temprano 0.15EC)	2	8.0 fl oz./ac
12)	abamectin	(Temprano 0.15EC)	2	12.0 fl oz./ac
13)	diflubenzuron	(Dimilin 2L)	1	40 fl oz/ac

Treatment Evaluations: Foliar acaricides were applied at emergence and at threshold using a CO_2 pressurized, backpack sprayer with a 6' boom operating at 30 psi delivering 54.9 gpa through 4 flat-fan nozzles (8004VS-XR) spaced 18" apart. Mint bud mite populations were surveyed weekly by counting all mobile lifestages (larvae & adults) on 10 buds of 10 plants randomly selected from the center of each experimental plot. Plots were initially sprayed on 4 June when plants had reached nearly 100% emergence from the soil and an additional application was applied 7 days later on 11 June. An additional set of applications were made on 28 July and again one week later on 4 August when bud mite populations had exceeded the established threshold of 10 mobile lifestages per bud. Efficacy of treatments was evaluated by recording the number of larvae and adults from 10 randomly selected buds per plot. The combined number of larvae and adults per plot was recorded 7, 14, and 21 days after each application. Data were analyzed using ANOVA, with mean separation by Fisher's protected LSD at $P < 0.05$. Bud mite count data were transformed using a $\log_{10}(x + 1)$ function before analysis, but untransformed means are presented.

Mint Bud Mite Control:

Applications at Emergence. Mint bud mite infestations exceeded established action thresholds (10 lifestages / bud) in the experimental control plots and reached damaging levels only during the later half of the season when warmer conditions became favorable for population increase (**Fig. 1.**). Precipitation and standing water which occurred in the first 2 weeks of June appeared to have a significant negative impact upon the early development of populations of mint bud mite. Peak populations of mint bud mite are often expected to occur in early to mid-July throughout much of Wisconsin and treatment thresholds are often exceeded by late June. This year, however, populations did not peak until late July and into early August with a treatment threshold occurring on 23 July. Accumulated degree days (DD) (base 43°F) reported for Madison, WI (http://pestbulletin.wi.gov/pdf/07-25-08.pdf) had yet to exceed 1,400 DD by July 24 when the treatment threshold had been reached when the normal accumulated DD's should have exceeded 1,600 DD by this date. Effective, season-long control of mint bud mite populations was not achieved with either acaricide (Comite or Fujimite) when used during early stand emergence (**Table 1**). Over the first six weeks of the growing season, populations of bud mites were not significantly affected by either control treatment. More importantly, the heavy precipitation combined with standing likely set populations back equally among these early season treatments consistent with the untreated control.

Applications at Threshold. A portion of the acaricide treatments examined in the study effectively reduced bud mite densities when applied at threshold (10 mites / bud) compared with the untreated control (**Table 2**). Both the Comite and Dimilin applications (48 and 40 fl oz/ac, respectively) resulted in insufficient levels of control where populations were not reduced below established thresholds. Acramite performed moderately well against bud mite populations at the highest rate (24 fl oz/A), although the level of reduction is likely insufficient to maintain populations below damaging levels. The most effective acaricides for reducing mint bud mite densities included Fujimite, Oberon, and Temprano. Fujimite is currently registered for control of mint bud mite in Wisconsin, although few rotational options exist to pair with this material for effective resistance management. Currently, Oberon is in review with the Federal, IR-4 Project with a proposed registration of date of 2010-2011 (http://ir4.rutgers.edu/FoodUse/food_Use2.cfm?Prnum=09753). Current investigations propose to permit 2, 16 fl oz / acre applications on a 7 day interval, 7 day PHI, and a maximum allowable application volume of 32 fl oz /acre/ season. For products that have good activity against mint bud mite, but have a relatively short residual activity (less than 6 to 7 days), we will likely recommend two sequential applications of the product spaced 1 week apart once populations have reached or exceeded threshold.

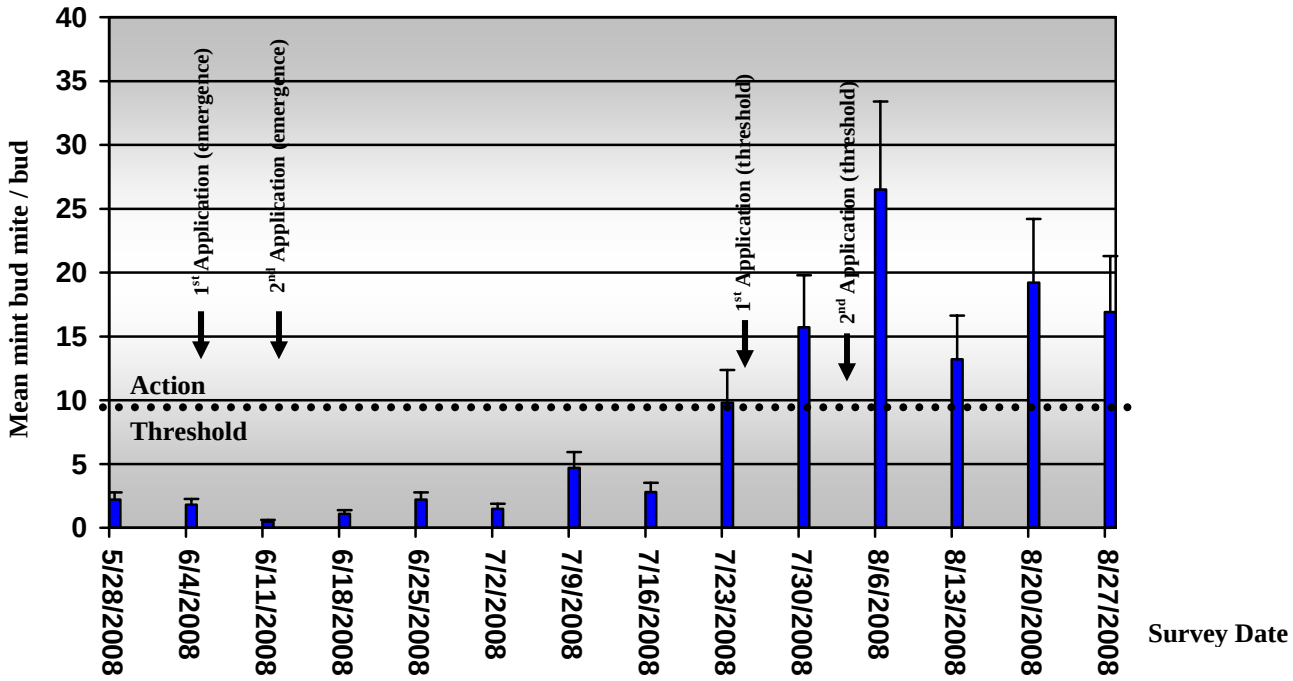

Figure 1. Seasonal abundance of mint bud (adult & larvae) mites collected from untreated control plots, Randolph, WI 2008.

Table 1. Efficacy of early-season, acaricide treatments applied at 100% soil emergence for the control of overwintered, adult mint bud mite in black peppermint Randolph, WI in 2008. ***Denotes products not labeled for mint bud mite in WI mint**.

Treatment	Active Ingredient	Appl. No.	Application Rate	Mean number of mint bud mites/bud[1]					
				May 28[2]	June 4[2]	June 11	June 18	June 25	July 2
Untreated	--	--	--	2.2 a	1.8 a	0.5 a	1.1 a	2.2 a	1.5 a
Comite EC	propargite	2	48 fl oz/A	--	0.7 a	0.8 a	0.5 a	0.8 a	1.1 a
Fujimite 5EC	fenpyroximate	1	40 fl oz/A	--	0.8 a	0.3 a	0.4 a	1.2 a	1.0 a

[1] Means within a column followed by the same letter are not significantly different ($P>0.05$; Fisher's Protected LSD; n = 4).
[2] Initial applications of Comite EC and Fujimite 5EC were applied 4 June 2008 and a second application of Comite EC was applied 11 June 2008

Table 2. Efficacy of acaricide treatments applied at threshold (10 mites / bud) to control of adult and larval mint bud mite in black peppermint Randolph, WI in 2008. ***Denotes products not labeled for mint bud mite in WI mint**.

Treatment	Active Ingredient	Appl. No.	Application Rate	Mean number of mint bud mites/bud[1]			
				August 6[2]	August 13	August 20	August 27
Untreated	--	--	--	26.5 a	13.2 a	19.2 ab	16.9 a
Comite EC	propargite	2	48 fl oz/A	31.4 a	24.8 a	33.6 a	22.9 a
Fujimite 5EC	fenpyroximate	1	40 fl oz/A	18.3 a	27.2 a	25.9 a	17.3 a
Comite EC	propargite	2	48 fl oz/A	13.6 b	8.8 b	10.4 b	14.1 ab
Fujimite 5EC	fenpyroximate	1	40 fl oz/A	4.8 bc	2.1 c	0.8 c	3.0 bc
Oberon 2SC*	spiromesifen	2	8.0 fl oz/A	5.1 bc	0.8 c	1.3 c	1.8 bc
		2	12.0 fl oz/A	5.6 bc	1.4 c	1.9 c	0.8 c
		2	16.0 fl oz/A	3.9 c	2.1 c	1.8 c	0.2 c
Acramite 4SC*	bifenazate	1	16.0 fl oz/A	8.6 bc	4.9 bc	7.1 bc	15.2 ab
		1	24.0 fl oz/A	7.3 bc	7.7 bc	5.3 bc	9.8 b
Temprano	abamectin	2	8.0 fl oz/A	2.3 c	3.4 bc	5.3 bc	5.6bc
		2	12.0 fl oz/A	2.8 c	1.5 c	1.4 c	1.9 c
Dimilin 2L*	diflubenzuron	1	40 fl oz/A	14.6 b	12.0 b	18.9 ab	17.9 ab

[1] Means within a column followed by the same letter are not significantly different ($P>0.05$; Fisher's Protected LSD; n = 4).
[2] Initial applications of Comite EC, Fujimite 5EC, Oberon 2SC, Acramite 4SC, Temprano, and Dimilin were applied 28 July 2008 and a second set of applications of Comite EC, Oberon 2SC, and Temprano were applied 4 August 2008