Research Report for Grant Titled: Optimizing Control of Annual Bluegrass Weevils On Golf Course Turf Through Monitoring, Synergists and New Chemical Controls

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Results

My laboratory has been researching the most effective monitoring and control methods for the annual bluegrass weevil for the past several years. This report outlines what we are doing for funding from NERTF.

New findings:

1) Table 1 – 11 (pp. 4-5) in the Appendix evaluated all of the "optimal" and guaranteed programs proposed by various companies or researchers (e. g. Arysta, Bayer, Valent, DuPont, Niemczyk, etc.). The DuPont program was the most effective, however, it also requires the greatest number of applications. The DuPont program will most likely minimize resistance development due to the number of different modes of action involved (three) and may be needed where resistance is already high. In other locations the single application of Aloft may provide adequate control.

2) We took numerous trips to Pt. Judith and The Misquamicut Club to collect *Poa annua* clippings weekly throughout the season to determine the amounts of clothianidin and imidacloprid in the tissues (pp 18-19 and 23-24). We also took plugs weekly and caged adult weevils on them to determine toxicity of clothianidin and imidacloprid to adult weevils. Our findings with Petri dish assays and simulated field trials demonstrated that the neonicotinoids have a fast "knockdown" effect on adults but they recover within 24 hrs. We also found that adult feeding on clothianidin and imidacloprid treated plugs was minimal. This research demonstrates that the neonicotinoid effect must be on the larvae. We need to conduct on the amounts of neonicotinoids in the plant tissue required to kill larvae. This research should help in possibly making a change in the recommendations from one or two applications of a systemic to three or four to keep the titer of chemical high enough in the plant tissue to kill larvae.

3) In 2011, we found that the fungus *Beauveria bassiana* (BotaniGard) would kill adult ABW's overnight in Petri dishes but was not as effective in field trials. Even if this fungus is only partially successful in the field, it would help prevent resistance development. It is generally more difficult for insects to develop resistance to bacteria or fungi. We are researching why field applications are not as effective as well as combinations with chemicals. In one assay (Stonington Petri Dish Assay page 13 in this report) we showed that 1/10 the labeled rate of BotaniGard combined with some chemicals was very effective against adult ABW's. We will conduct field trials in 2012.

4) Conserve showed good results in adult mortality trials in 2011 (p. 9).

5) We also monitored degree-days at four golf courses in 2011 and made the findings available through DuPont's WeevilTrak. Thank you for your support for this important research project.

Appendix

(Data from 2011 Experiments)

Table 1 - 11. Efficacy of Aloft, Allectus, Talstar, Acelepryn, Provaunt, Arena, Merit, and Conserve for control of annual bluegrass weevil adults and larvae in a golf course fairway, Baltic, CT, 2011.

Treatment	Rate (product/acre)	Timing (DD[b])	$\overline{X}$ ± SEM live larvae, pupae, adults / 0.5 ft^2 14 June[a]	Percent Control
Aloft SC (0.1 lb ai bifenthrin + 0.2 lb ai clothianidin)	11.65 fl oz	18 Apr + 9 May (46 + 190)	49.3 ± 11.2b	48
Allectus SC (0.09 lb ai bifenthrin + 0.22 lb ai imidacloprid)	64 fl oz	18 Apr + 9 May (46 + 190)	25.0. ± 5.9bc	73
Allectus SC	64 fl oz	18 Apr. + 16 May (46 + 241)	27.5 ± 4.3bc	71
Aloft SC (0.123 lb ai bifenthrin + 0.249 lb ai clothianidin)	14 fl oz	5 May (164)	15.0 ± 1.2c	84
Aloft SC	11.65 fl oz	5 May (164)	27.8 ± 3.3bc	71
Talstar SC +	20 fl oz	25 Apr (67)		
Acelepryn SC	12.0 fl oz	5 May (164)		
Provaunt SC (0.1 lb ai bifenthrin + 0.157 lb ai chlorantraniliprole + 0.225 lb ai indoxacarb)	12.0 fl oz	2 June (490)	11.0 ± 2.9c	88
Arena 50WDG (0.4 lb ai clothianidin)	12.8 oz	5 May (164)	29.5 ± 6.8bc	69
Arena 50WDG (0.2 lb ai clothianidin)	6.4 oz	5 May (164)	17.0 ± 4.6c	82
Arena 50WDG	6.4 oz	5 May (164)	26.0 ± 8.2bc	73
Merit 2F (0.3 lb ai imidacloprid)	1.25 pts	5 May (164)	26.5 ± 6.6bc	72
Merit 2F (0.4 lb ai imidacloprid)	1.6 pts	5 May (164)	14.0 ± 4.1c	85
Conserve SC (0.4 lb ai spinosad)	52 fl oz	5 May (164)	32.5 ± 9.9bc	66
Control	---		95.0 ± 9.7a	--

$F = 13.46$, df = 12,36 $P < 0.01$

[a]Means in the same column followed by the same letter are not significantly different, *P* = 0.05, Tukey's HSD test.

[b]DD (=Degree Days base 50°F), (46 = daffodil full bloom; 67 = forsythia full bloom; 164 – 190 = Forsythia ½ green ½ gold - dogwood full bloom)

DATES OF APPLICATION: Applications were made based on company timing recommendations or experimental timings. For example, treatments 1 & 2 timings were experimental timings: daffodil full bloom and 21 days later. Treatment 3 timings were based on Bayer's recommendations: daffodil full bloom and 28 days later. Treatments 4 & 5 were based on Arysta's recommendations: treatment 4: forsythia ½ green ½ gold; treatment 5: ½ green ½ gold and 42 days later. Treatment 6 timings were based on DuPont's recommendations on weeviltrak.com. Treatments 7 - 12 timings were experimental (approximately ½ green ½ gold - dogwood full bloom). Randomized complete block design, four replicates, plot size = 40 ft^2; application water was equivalent to 2 gal./1,000 ft^2, the turf consisted of annual bluegrass; thatch = 0.25"; texture = sandy loam. Treatments were evaluated by taking five 4.25" cores per plot on 14 June (DAT) and extracting live larvae, pupae, and adults in a saturated salt solution.

DATA RESULTS AND ANALYSIS: The two split applications of Aloft at 11.65 fl oz per acre (treatment 1) have worked well in other trials. This was an experimental early timing which appears to have been applied too early for maximum effectiveness. Arysta's suggested timing coincides with Forsythia ½ green ½ gold which showed better control at that timing with both the 14 and 11.65 fl oz rates (treatments 4 & 5). The Allectus treatments (2 & 3) were both effective in split applications and only slightly different on the timing of the second application. The program for treatment 6 was the most effective of all treatments. Treatments 7 – 12 were not significantly different from each other, but demonstrated significant control from the untreated plots. The neonicotinoid treatments without bifenthrin (7 – 11) applied at forsythia ½ green ½ gold at higher ai's per acre were as effective as the bifenthrin/pyrethroid combinations applied earlier. This suggests the neonicotinoids may be more effective versus larvae.

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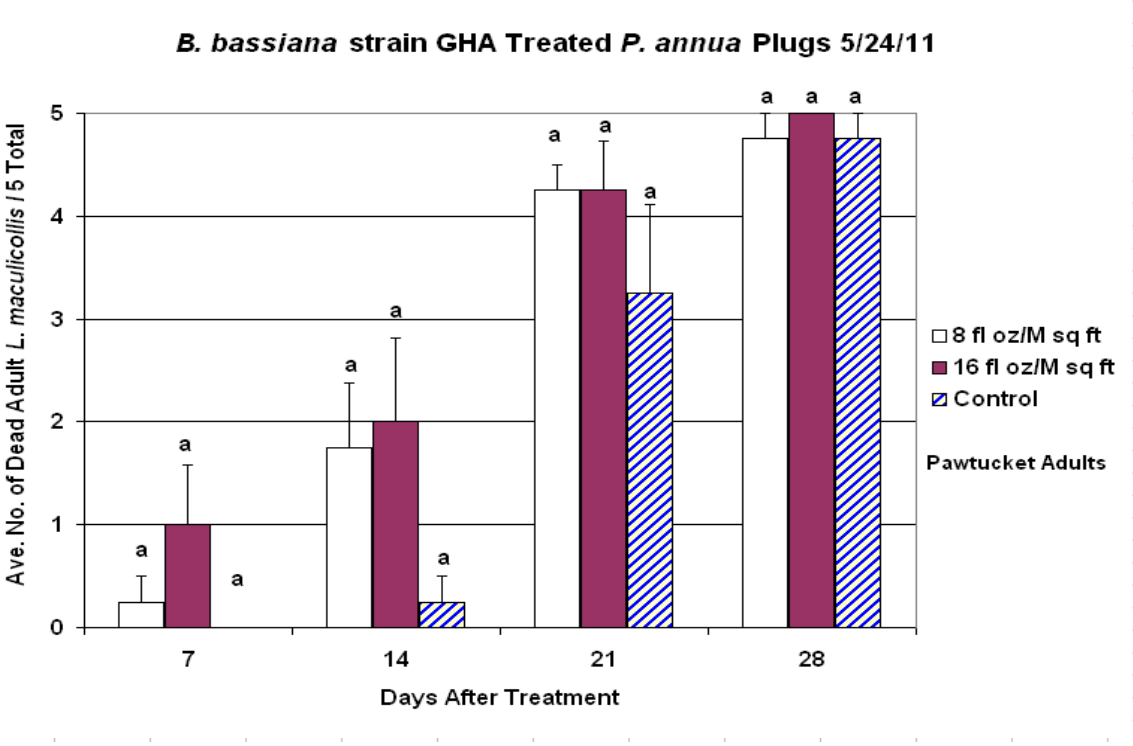
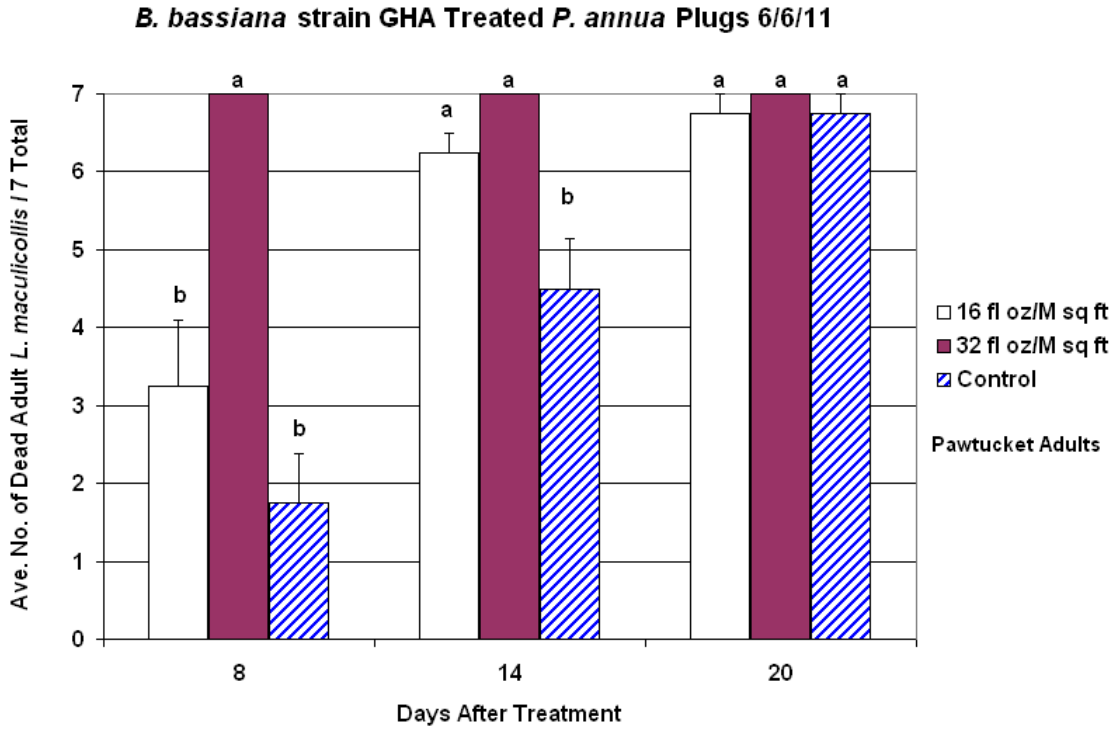
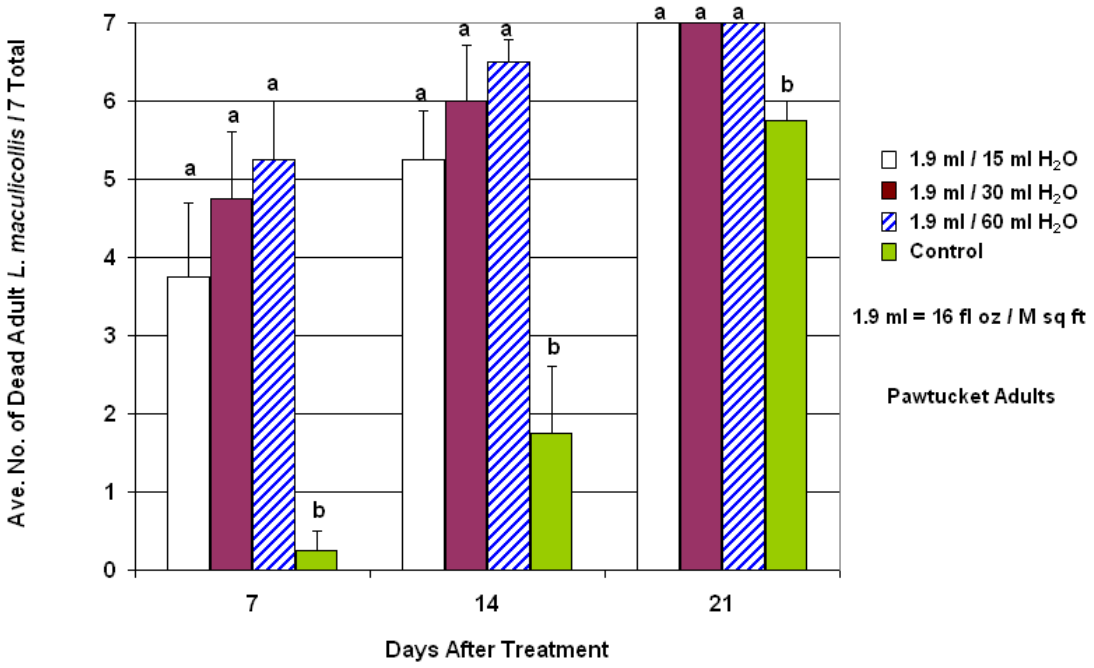
BotaniGard Turf Plug Assays

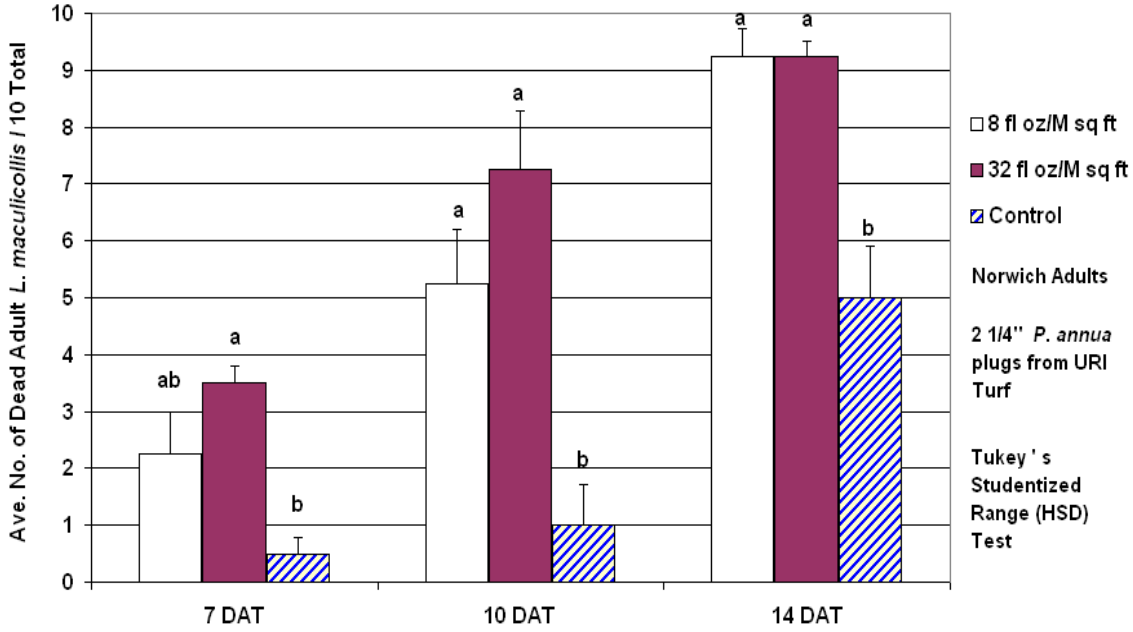


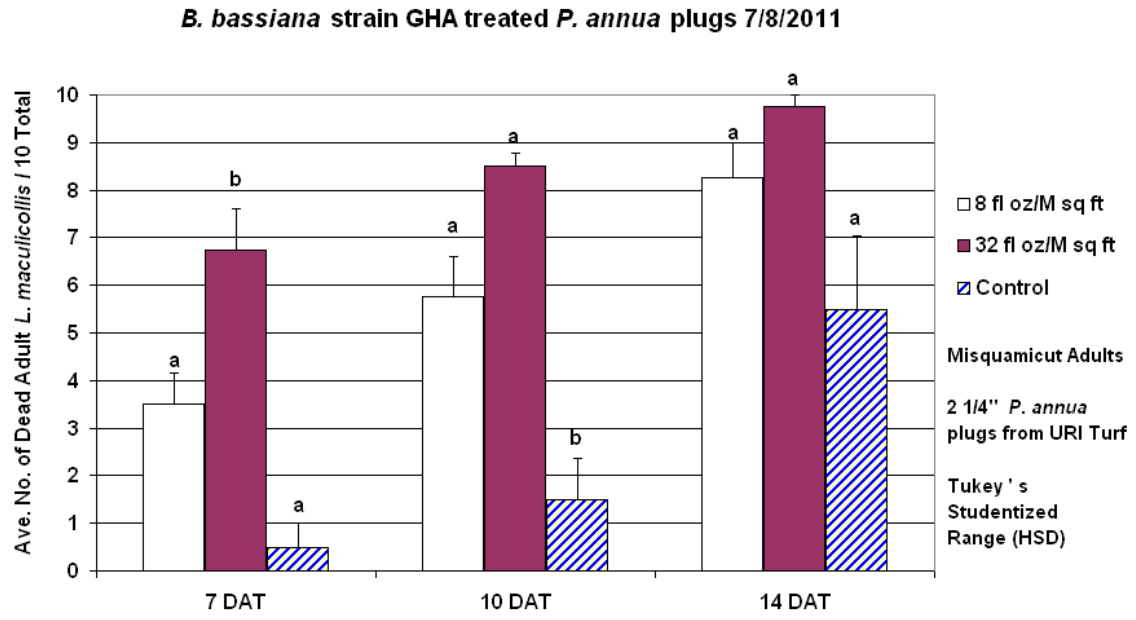


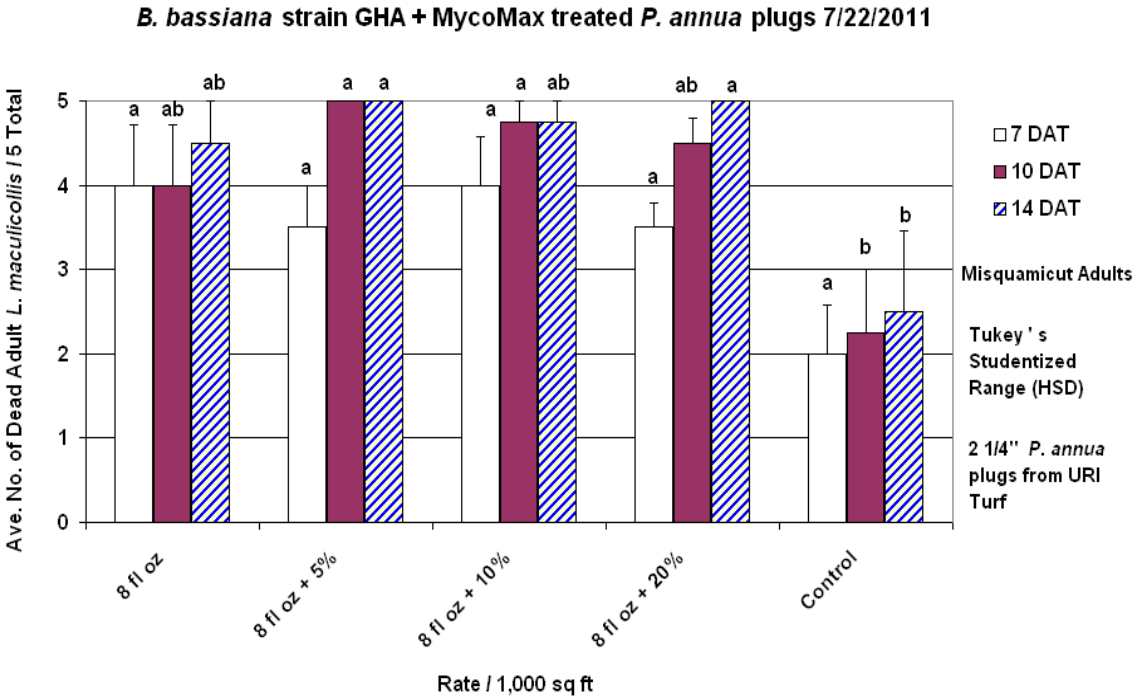
B. bassiana strain GHA treated _P. annua_ plugs 6/9/11

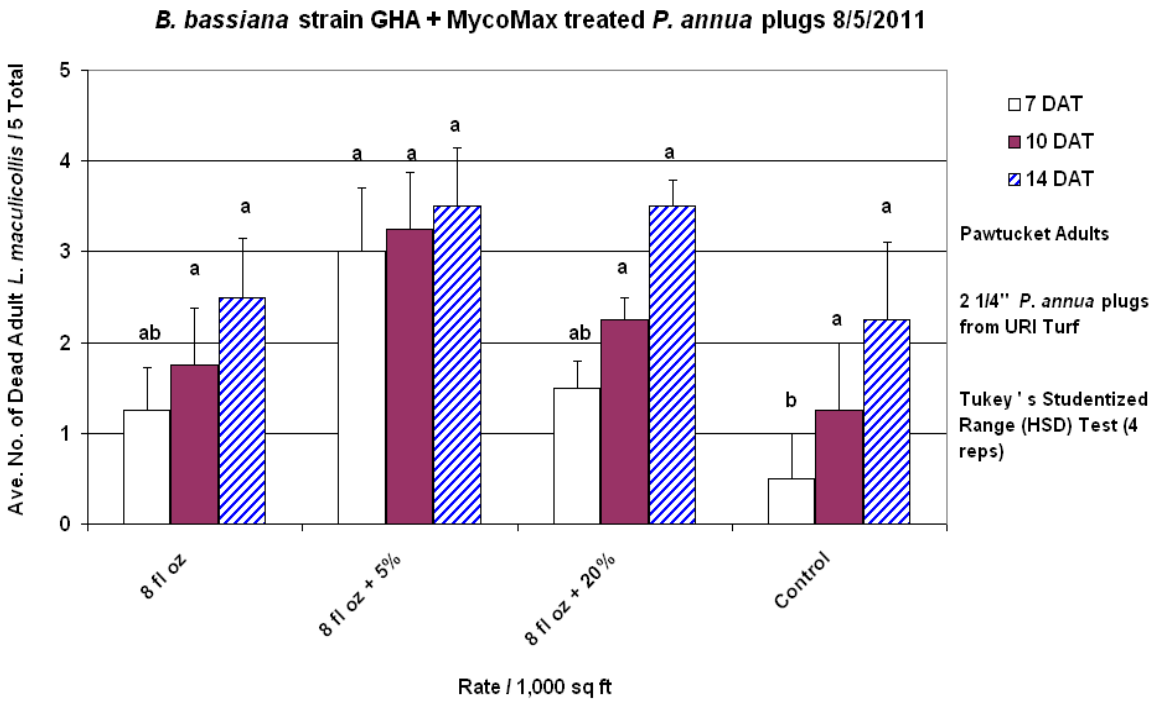


B. bassiana strain GHA treated _P. annua_ plugs 7/7/2011

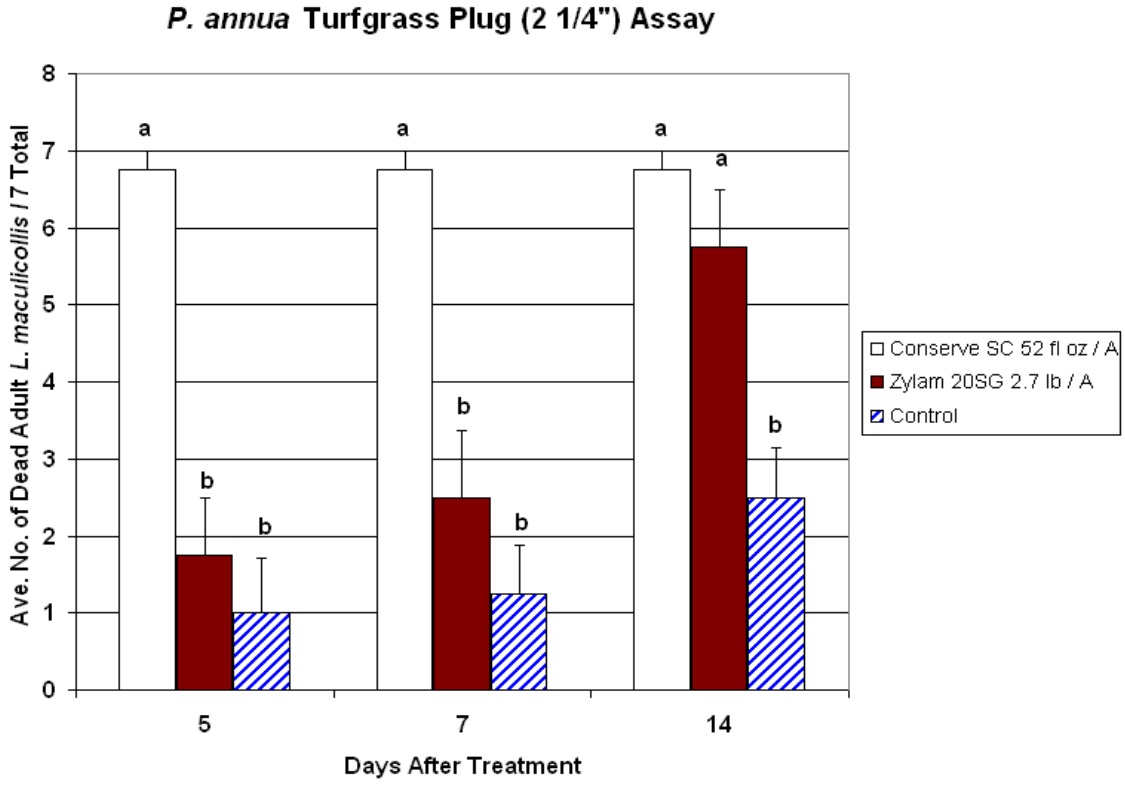



B. bassiana strain GHA treated P. annua plugs 7/8/2011
Ave. No. of Dead Adult L. maculicollis / 10 Total
7 DAT
10 DAT
14 DAT
8 fl oz/M sq ft
32 fl oz/M sq ft
Control
Misquamicut Adults
2 1/4" P. annua plugs from URI Turf
Tukey ' s Studentized Range (HSD)

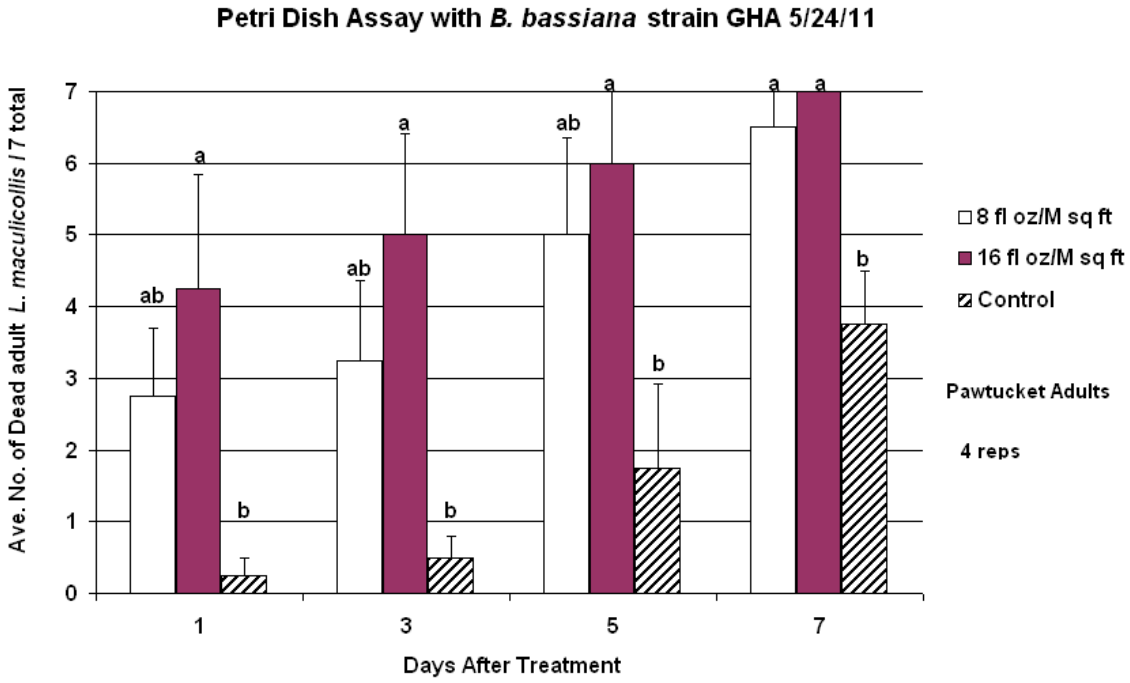

B. bassiana strain GHA + MycoMax treated P. annua plugs 7/22/2011
Ave. No. of Dead Adult L. maculicollis / 5 Total
8 fl oz
8 fl oz + 5%
8 fl oz + 10%
8 fl oz + 20%
Control
Rate / 1,000 sq ft
7 DAT
10 DAT
14 DAT
Misquamicut Adults
Tukey ' s Studentized Range (HSD)
2 1/4" P. annua plugs from URI Turf

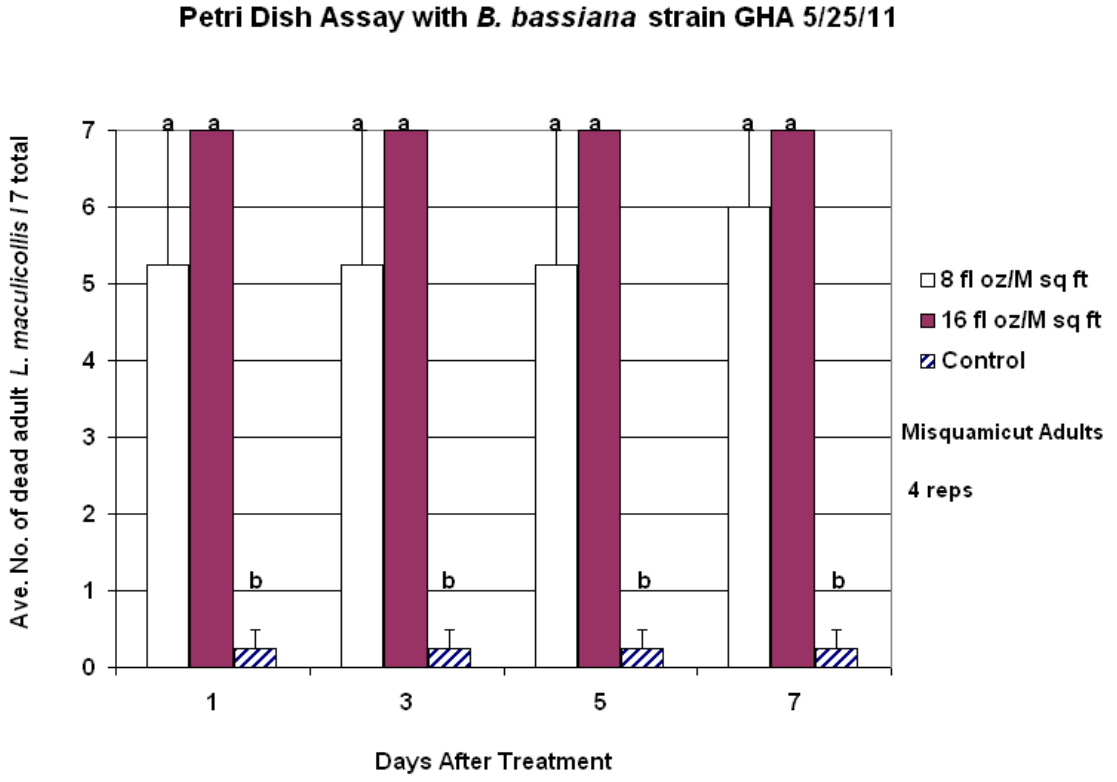


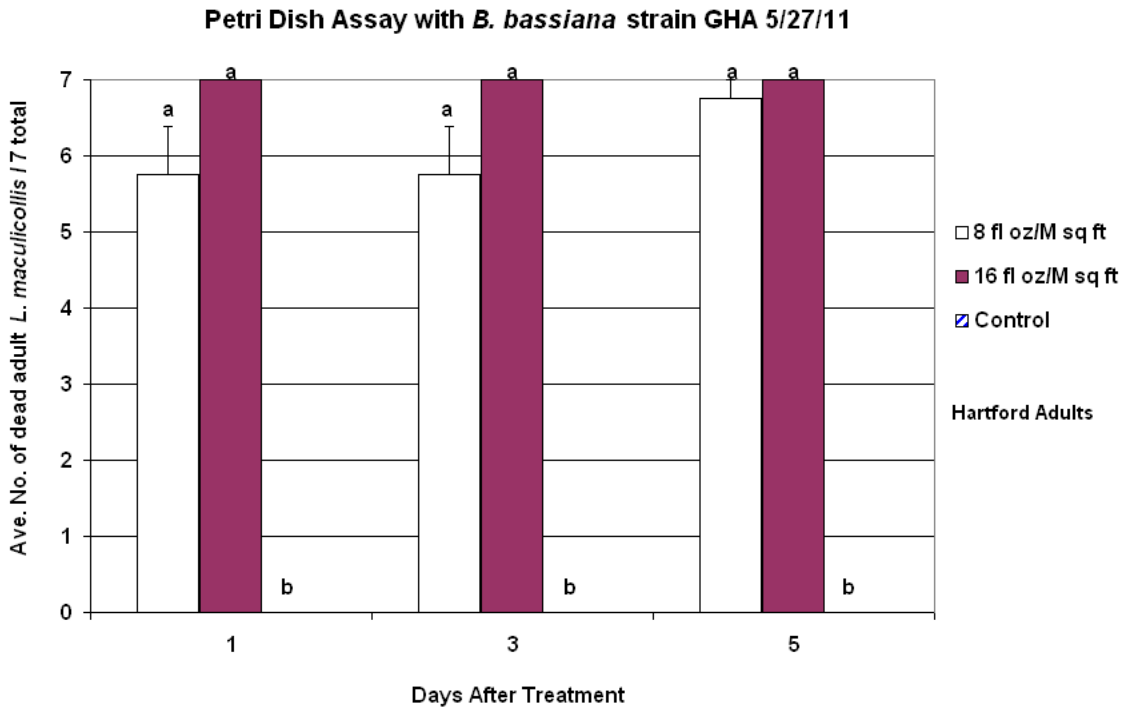
Conserve Turf Plug Assay

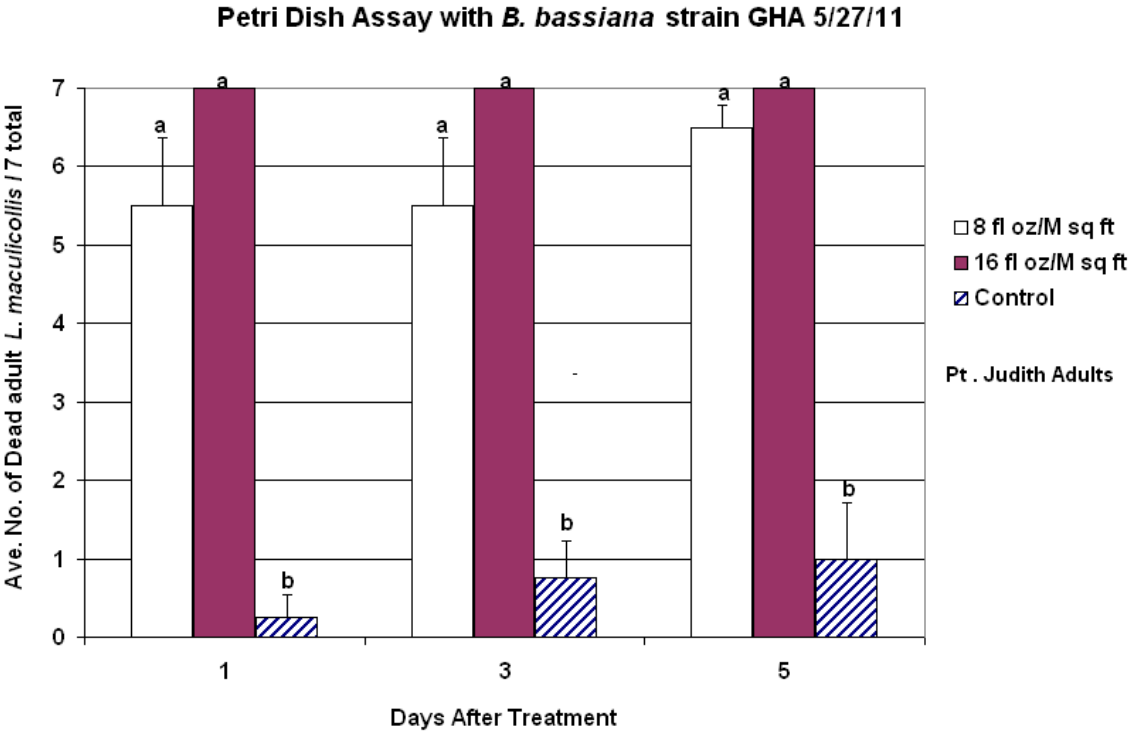


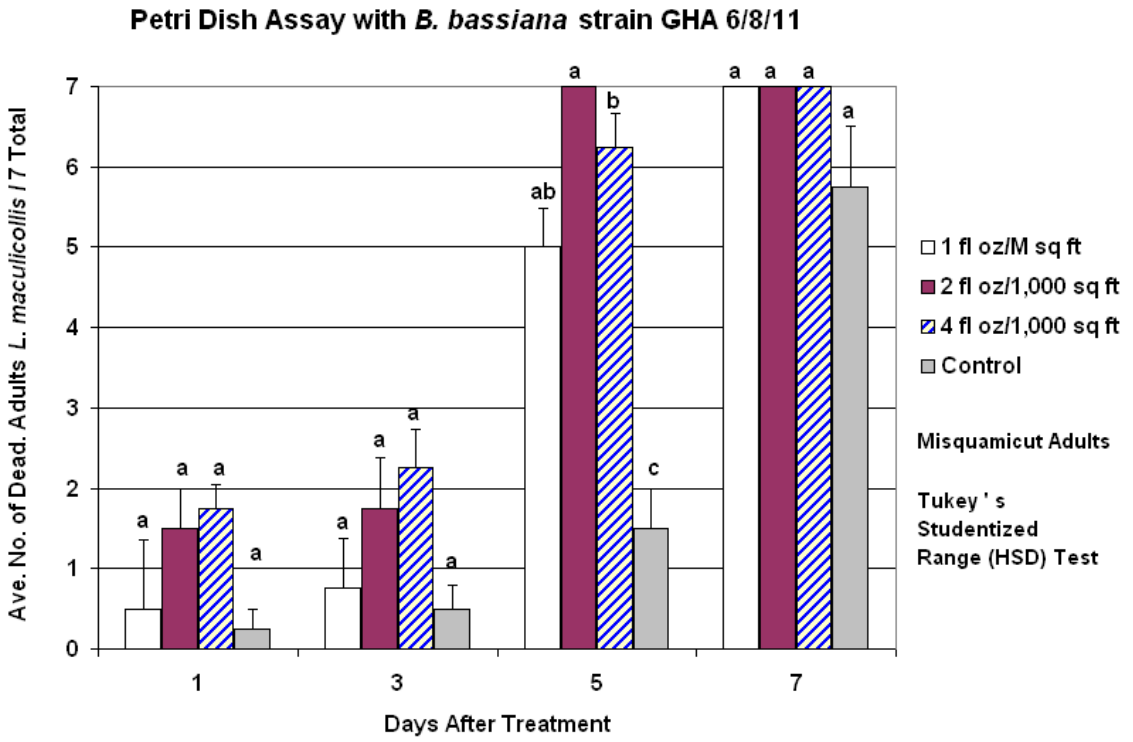
BotaniGard Petri Dish Assay

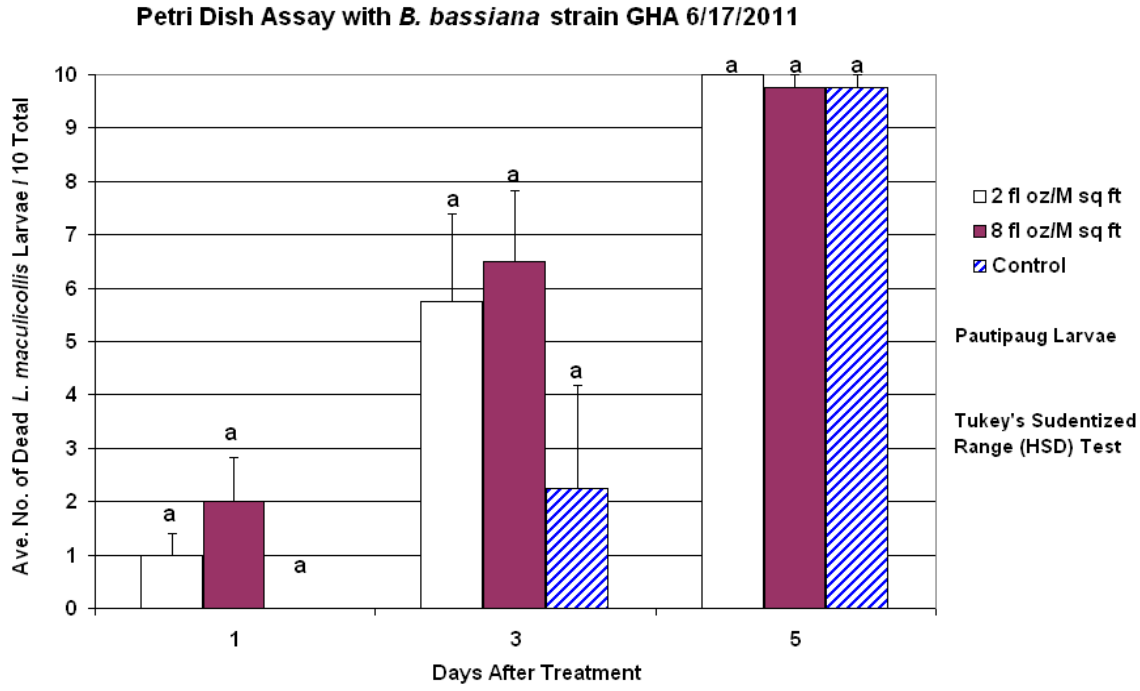




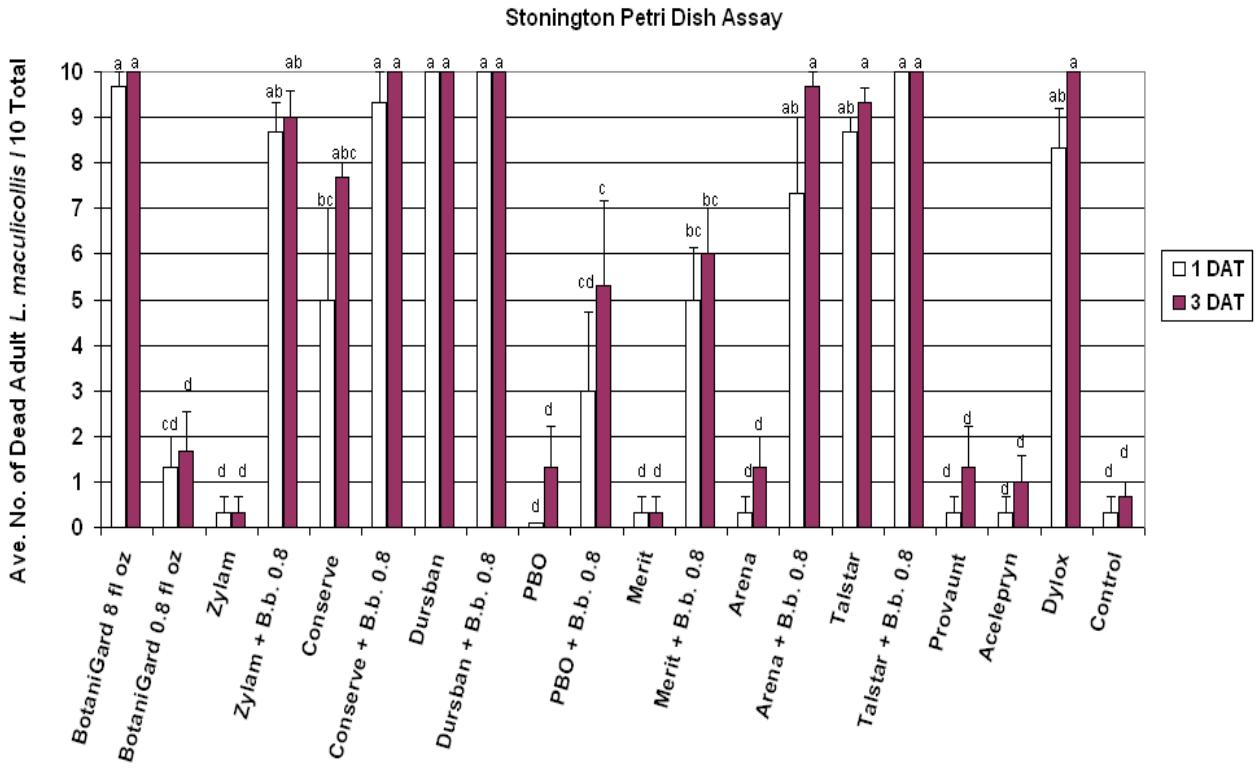

Petri Dish Assay with B. bassiana strain GHA 5/27/11
Ave. No. of dead adult L. maculicollis / 7 total
0
1
2
3
4
5
6
7
a
a
b
a
a
b
a
a
b
1
3
5
Days After Treatment
8 fl oz/M sq ft
16 fl oz/M sq ft
Control
Hartford Adults


Petri Dish Assay with B. bassiana strain GHA 5/27/11
Ave. No. of Dead adult L. maculicollis / 7 total
0
1
2
3
4
5
6
7
a
a
b
a
a
b
a
a
b
1
3
5
Days After Treatment
8 fl oz/M sq ft
16 fl oz/M sq ft
Control
Pt . Judith Adults

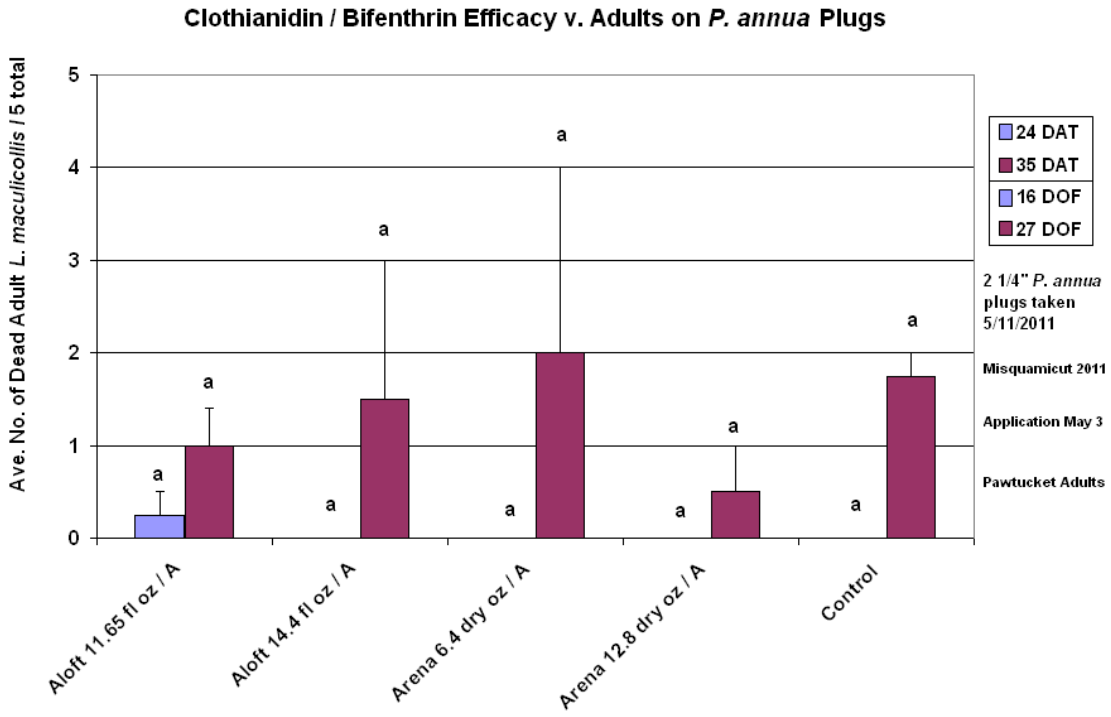

Petri Dish Assay with B. bassiana strain GHA 6/8/11
Ave. No. of Dead. Adults L. maculicollis / 7 Total
Days After Treatment
1 fl oz/M sq ft
2 fl oz/1,000 sq ft
4 fl oz/1,000 sq ft
Control
Misquamicut Adults
Tukey ' s Studentized Range (HSD) Test

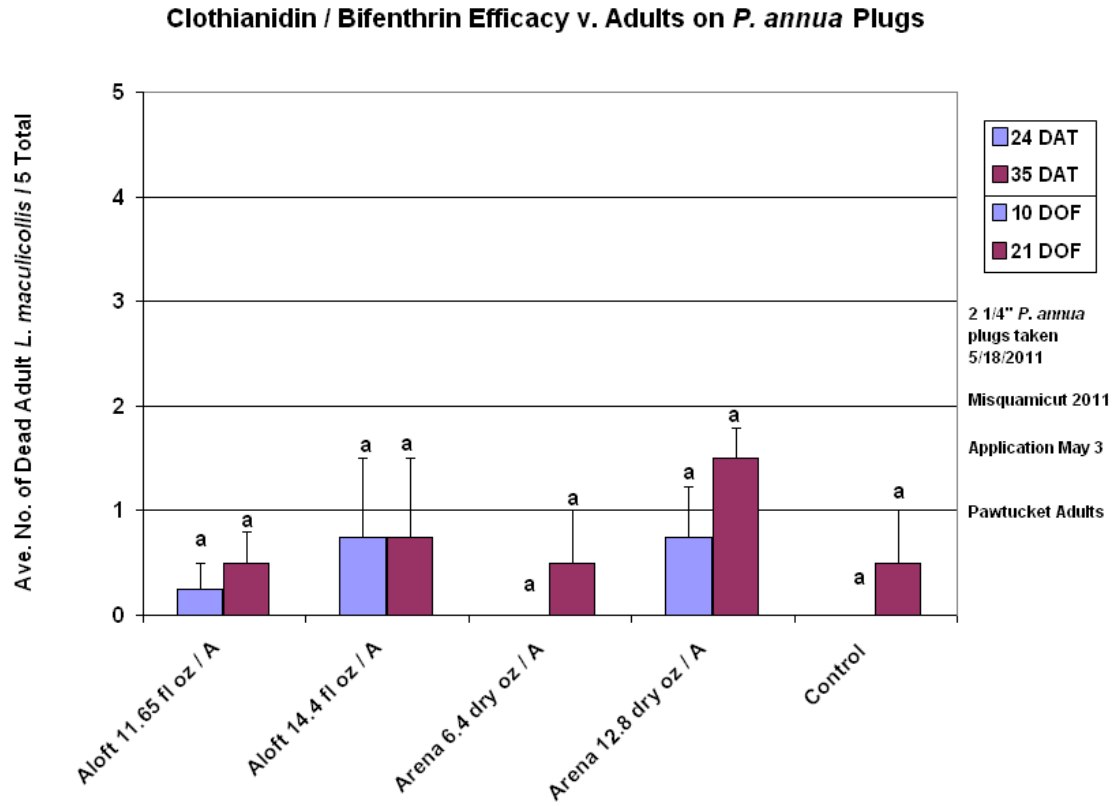

Petri Dish Assay with B. bassiana strain GHA 6/17/2011
Ave. No. of Dead L. maculicollis Larvae / 10 Total
Days After Treatment
2 fl oz/M sq ft
8 fl oz/M sq ft
Control
Pautipaug Larvae
Tukey's Sudentized Range (HSD) Test

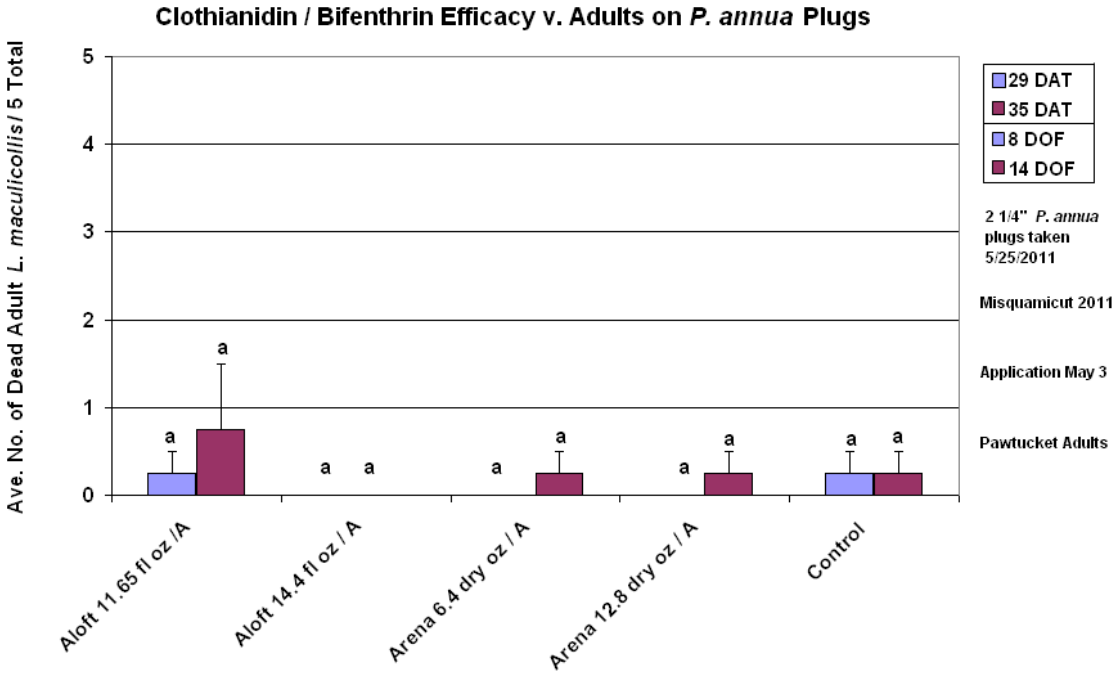
Stonington Combination Petri Dish Assay

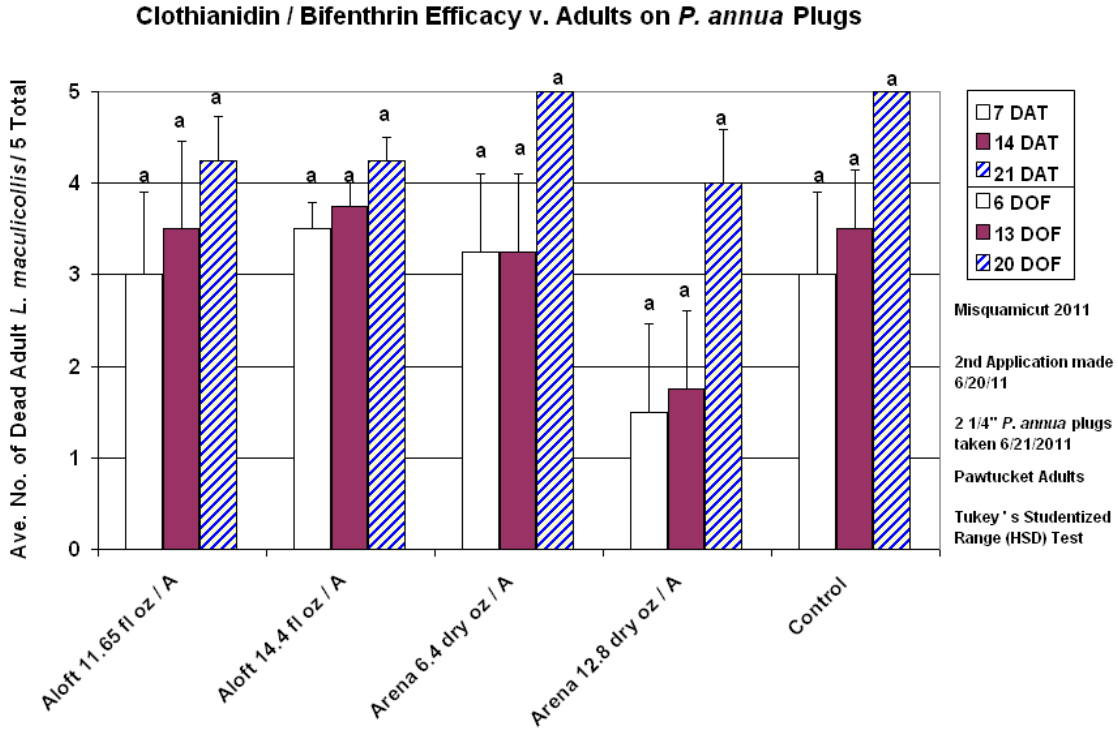


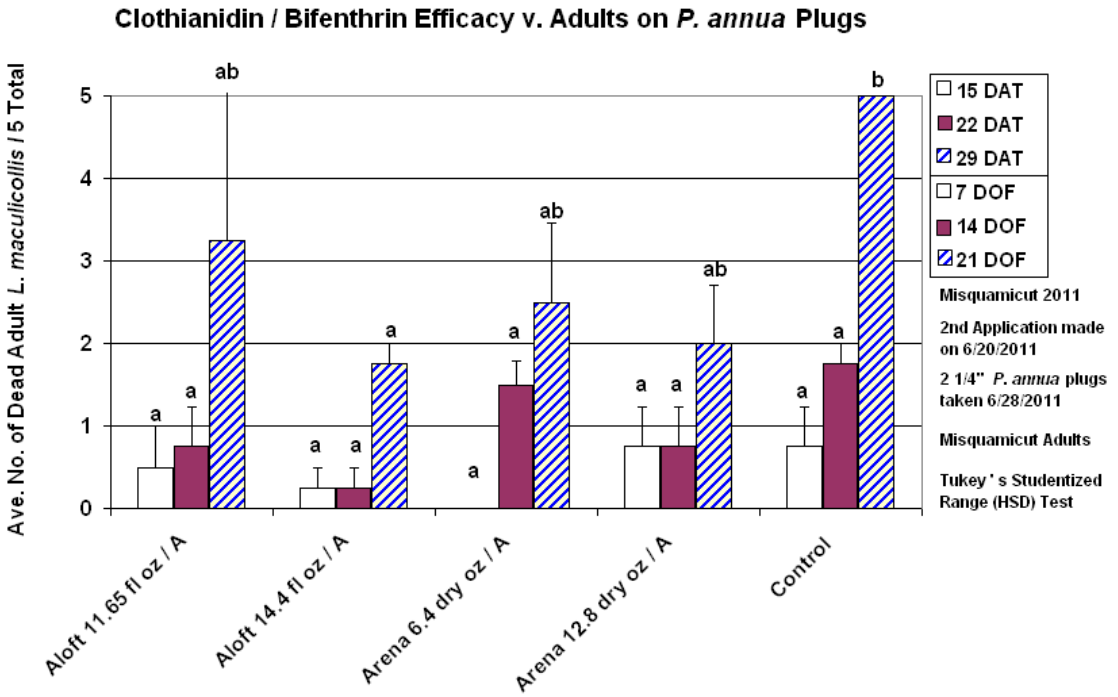
Misquamicut Feeding Trials

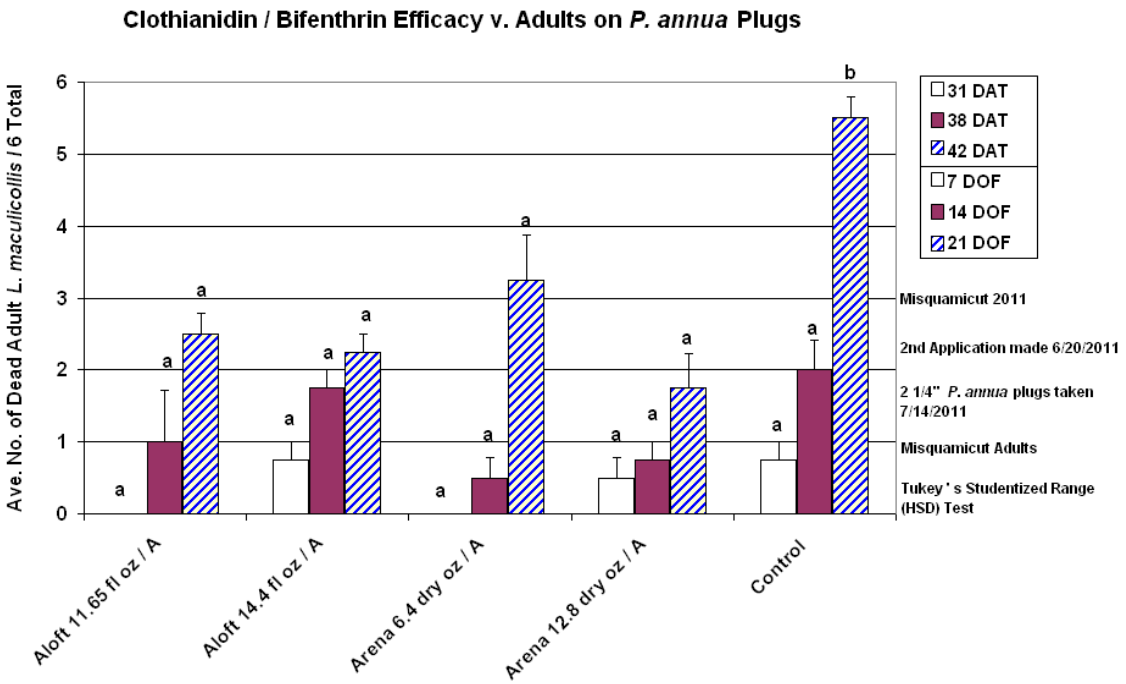


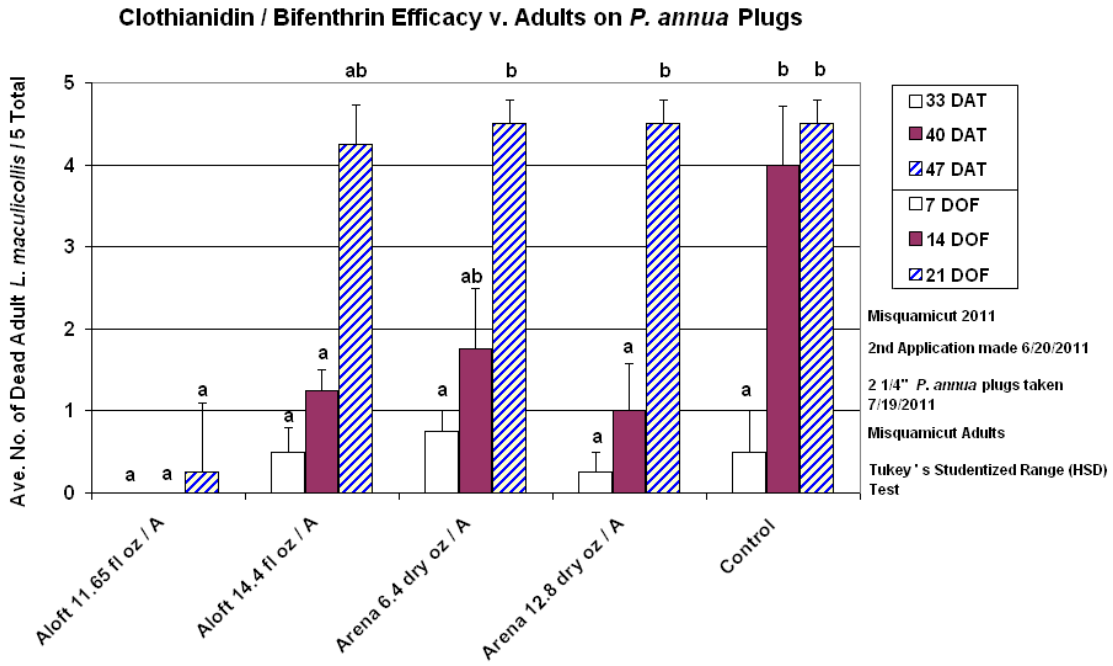

Clothianidin / Bifenthrin Efficacy v. Adults on P. annua Plugs
Ave. No. of Dead Adult L. maculicollis / 5 Total
0
1
2
3
4
5
a
Aloft 11.65 fl oz / A
Aloft 14.4 fl oz / A
Arena 6.4 dry oz / A
Arena 12.8 dry oz / A
Control
24 DAT
35 DAT
10 DOF
21 DOF
2 1/4" P. annua plugs taken 5/18/2011
Misquamicut 2011
Application May 3
Pawtucket Adults

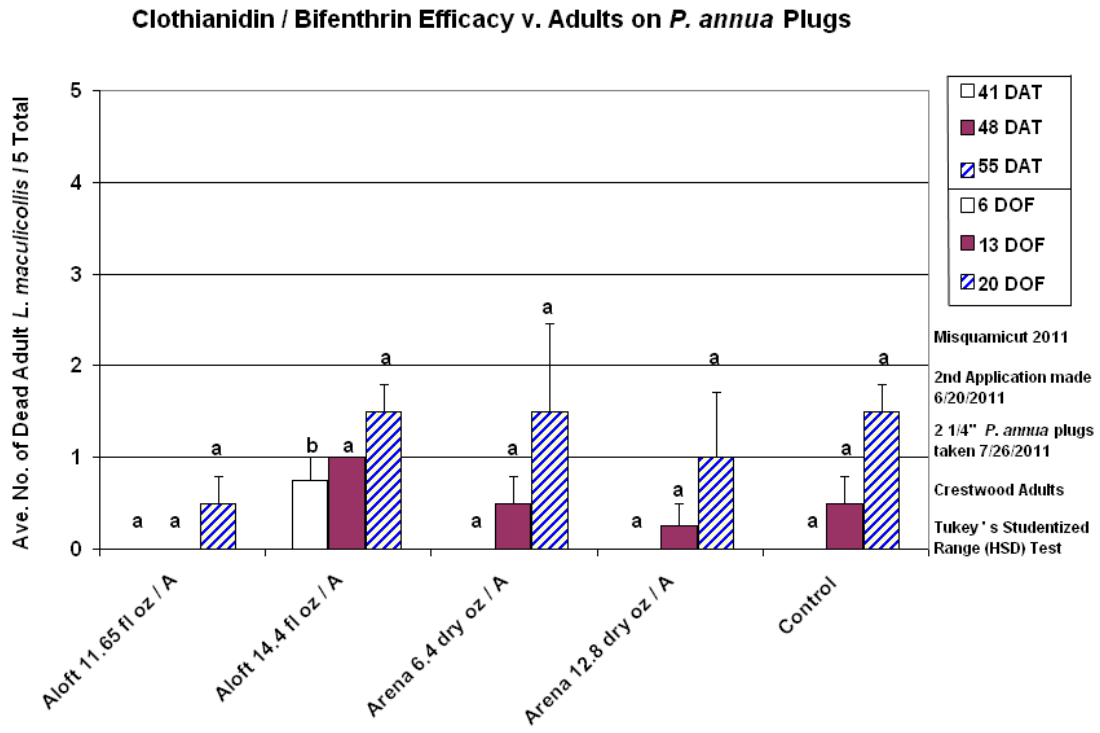

Clothianidin / Bifenthrin Efficacy v. Adults on P. annua Plugs
Ave. No. of Dead Adult L. maculicollis/ 5 Total
0
1
2
3
4
5
a
Aloft 11.65 fl oz /A
Aloft 14.4 fl oz / A
Arena 6.4 dry oz / A
Arena 12.8 dry oz / A
Control
29 DAT
35 DAT
8 DOF
14 DOF
2 1/4" P. annua plugs taken 5/25/2011
Misquamicut 2011
Application May 3
Pawtucket Adults


Clothianidin / Bifenthrin Efficacy v. Adults on P. annua Plugs
Ave. No. of Dead Adult L. maculicollis / 5 Total
7 DAT
14 DAT
21 DAT
6 DOF
13 DOF
20 DOF
Misquamicut 2011
2nd Application made 6/20/11
2 1/4" P. annua plugs taken 6/21/2011
Pawtucket Adults
Tukey ' s Studentized Range (HSD) Test
Aloft 11.65 fl oz / A
Aloft 14.4 fl oz / A
Arena 6.4 dry oz / A
Arena 12.8 dry oz / A
Control

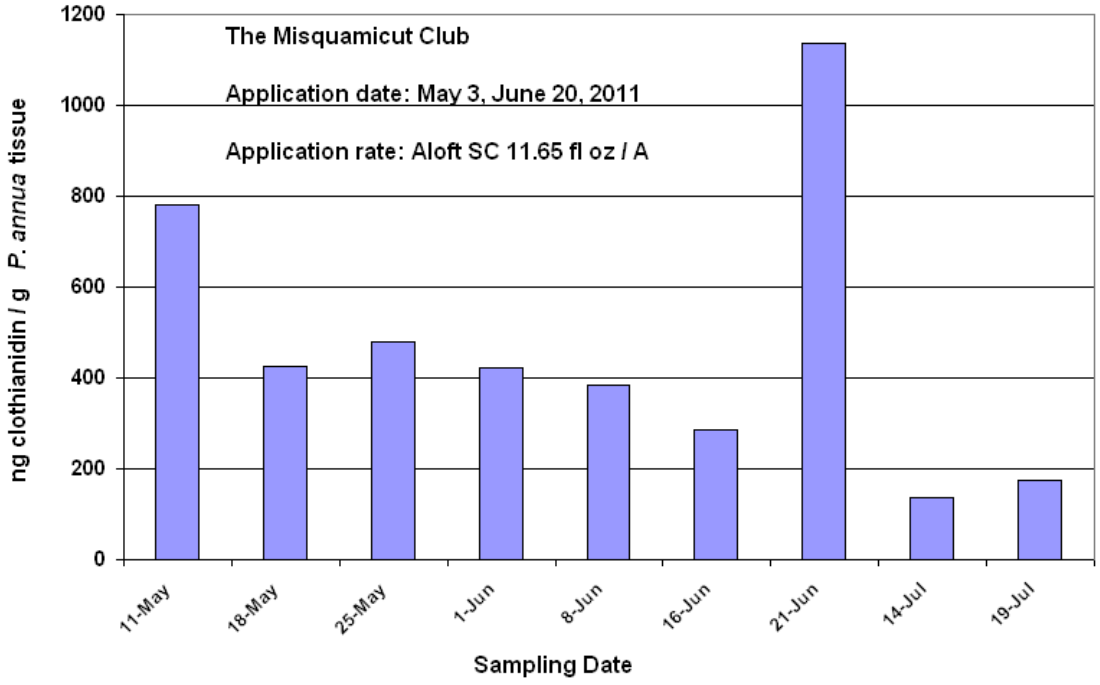

Clothianidin / Bifenthrin Efficacy v. Adults on P. annua Plugs
Ave. No. of Dead Adult L. maculicollis / 5 Total
15 DAT
22 DAT
29 DAT
7 DOF
14 DOF
21 DOF
Misquamicut 2011
2nd Application made on 6/20/2011
2 1/4" P. annua plugs taken 6/28/2011
Misquamicut Adults
Tukey ' s Studentized Range (HSD) Test
Aloft 11.65 fl oz / A
Aloft 14.4 fl oz / A
Arena 6.4 dry oz / A
Arena 12.8 dry oz / A
Control

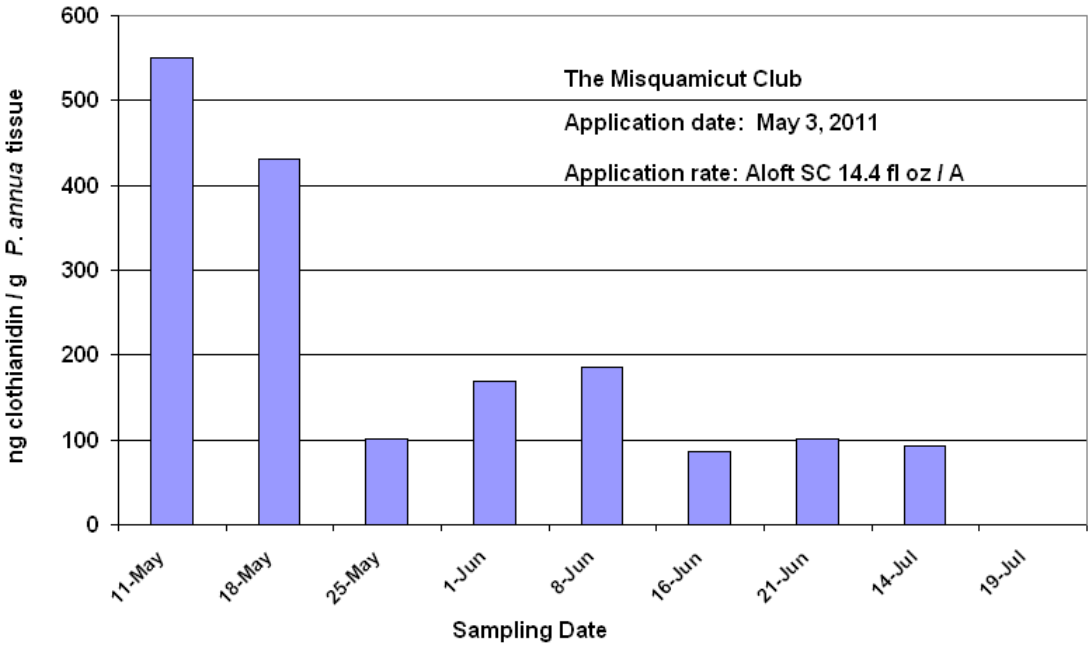

Clothianidin / Bifenthrin Efficacy v. Adults on P. annua Plugs
Ave. No. of Dead Adult L. maculicollis / 6 Total
31 DAT
38 DAT
42 DAT
7 DOF
14 DOF
21 DOF
Misquamicut 2011
2nd Application made 6/20/2011
2 1/4" P. annua plugs taken 7/14/2011
Misquamicut Adults
Tukey ' s Studentized Range (HSD) Test
Aloft 11.65 fl oz / A
Aloft 14.4 fl oz / A
Arena 6.4 dry oz / A
Arena 12.8 dry oz / A
Control

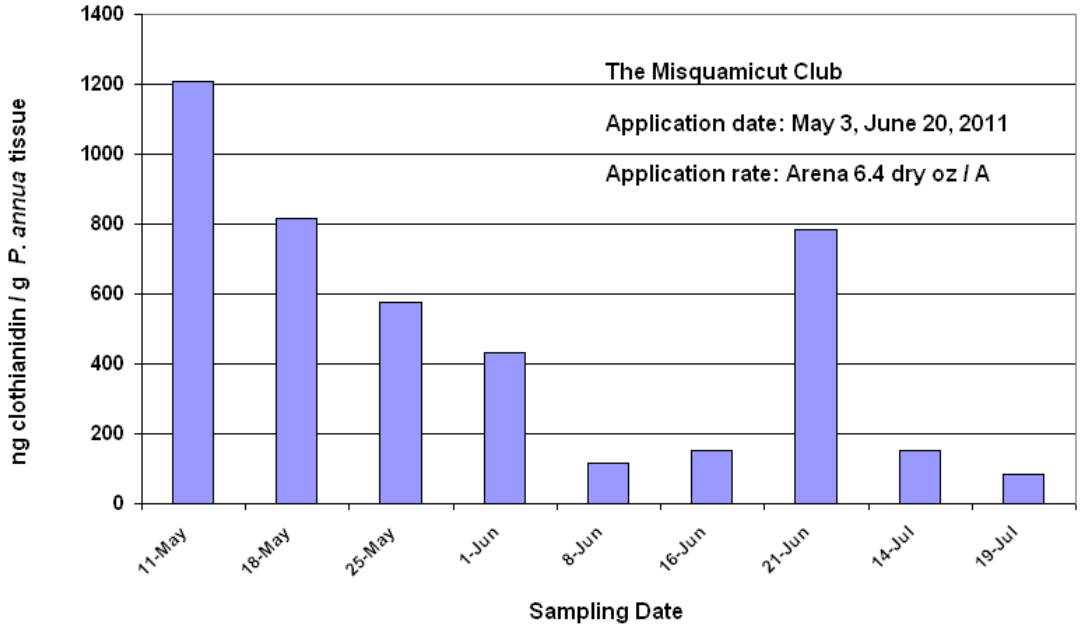

Clothianidin / Bifenthrin Efficacy v. Adults on P. annua Plugs
Ave. No. of Dead Adult L. maculicollis / 5 Total
33 DAT
40 DAT
47 DAT
7 DOF
14 DOF
21 DOF
Misquamicut 2011
2nd Application made 6/20/2011
2 1/4" P. annua plugs taken 7/19/2011
Misquamicut Adults
Tukey ' s Studentized Range (HSD) Test
Aloft 11.65 fl oz / A
Aloft 14.4 fl oz / A
Arena 6.4 dry oz / A
Arena 12.8 dry oz / A
Control

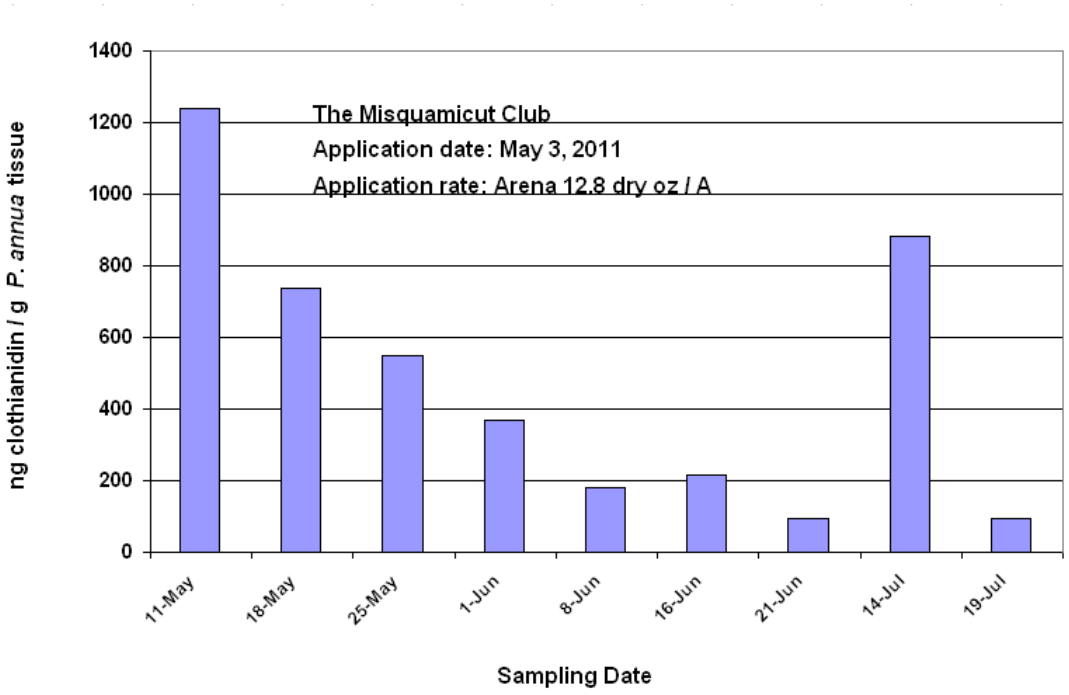


Misquamicut Tissue Concentration

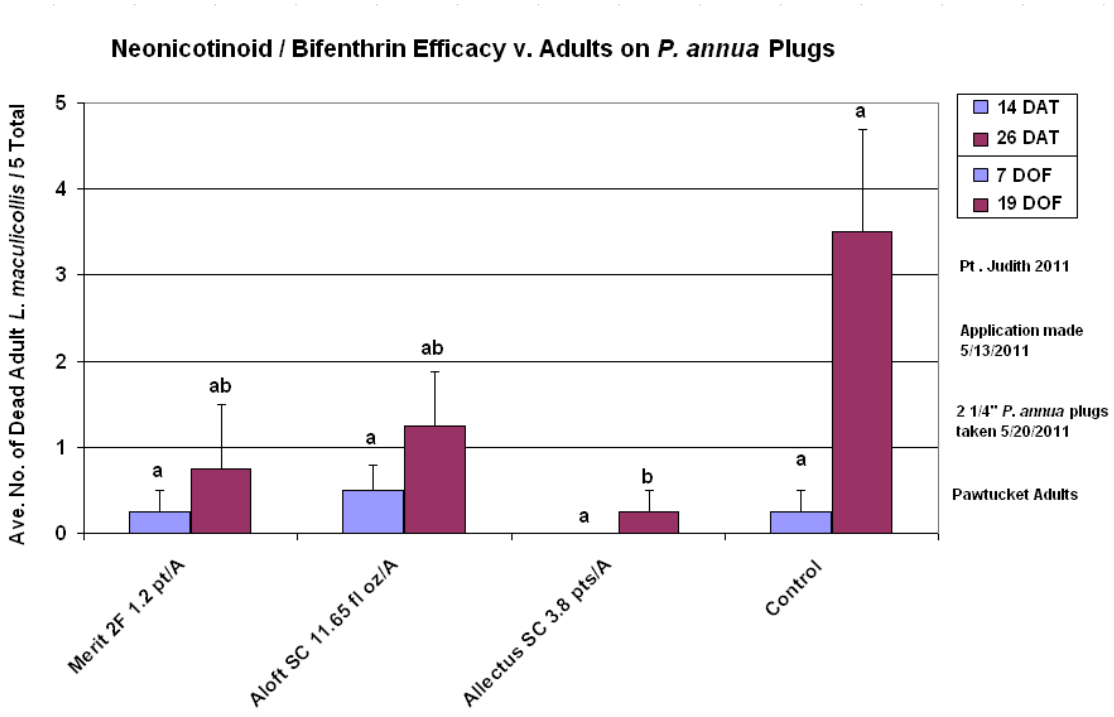



The Misquamicut Club
Application date: May 3, 2011
Application rate: Aloft SC 14.4 fl oz / A
ng clothianidin / g P. annua tissue
600
500
400
300
200
100
0
11-May
18-May
25-May
1-Jun
8-Jun
16-Jun
21-Jun
14-Jul
19-Jul
Sampling Date

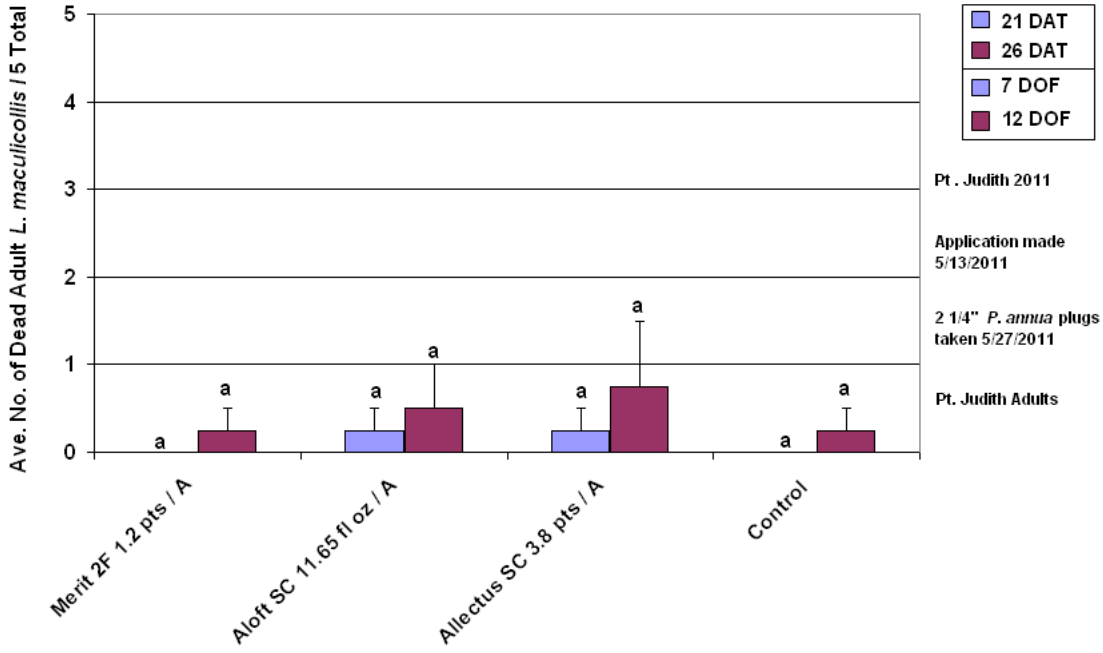

The Misquamicut Club
Application date: May 3, June 20, 2011
Application rate: Arena 6.4 dry oz / A
ng clothianidin / g P. annua tissue
1400
1200
1000
800
600
400
200
0
11-May
18-May
25-May
1-Jun
8-Jun
16-Jun
21-Jun
14-Jul
19-Jul
Sampling Date



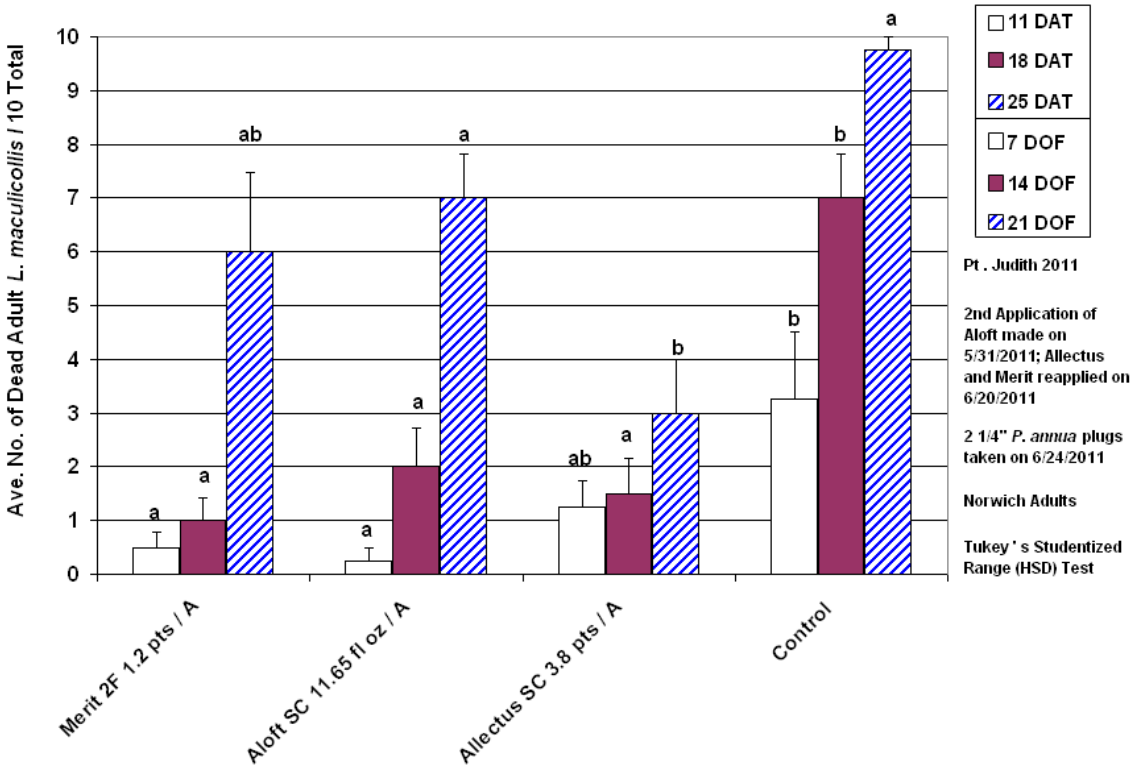
Point Judith Feeding Trials

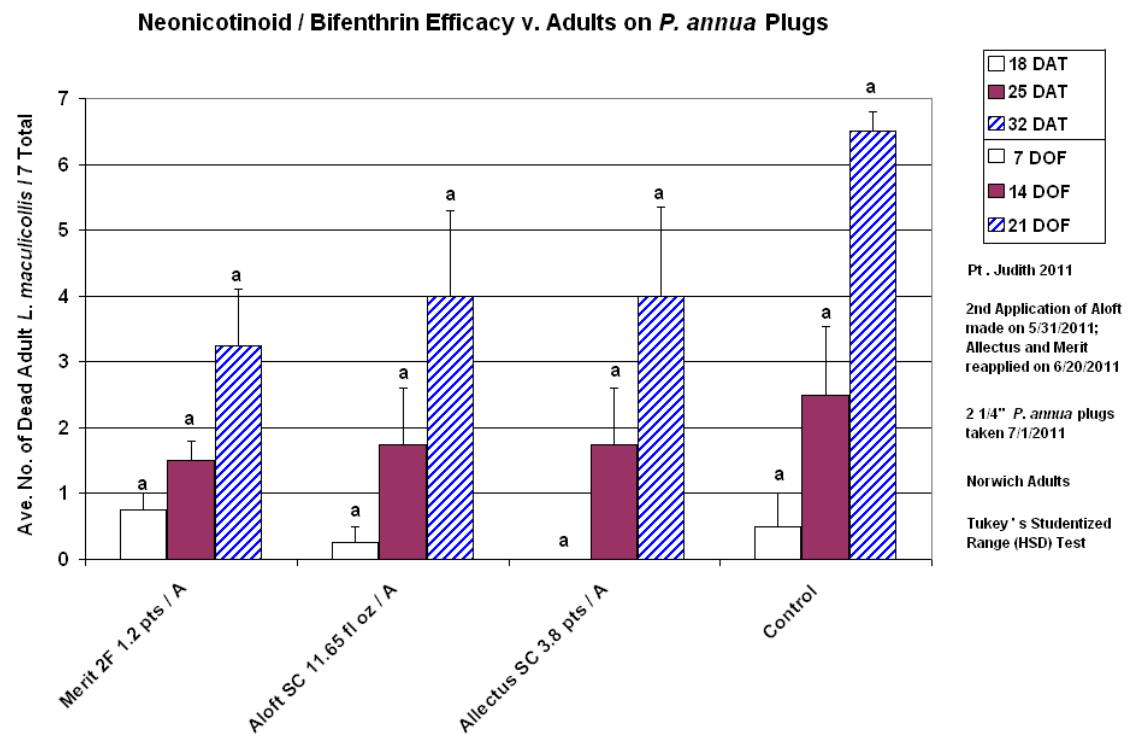


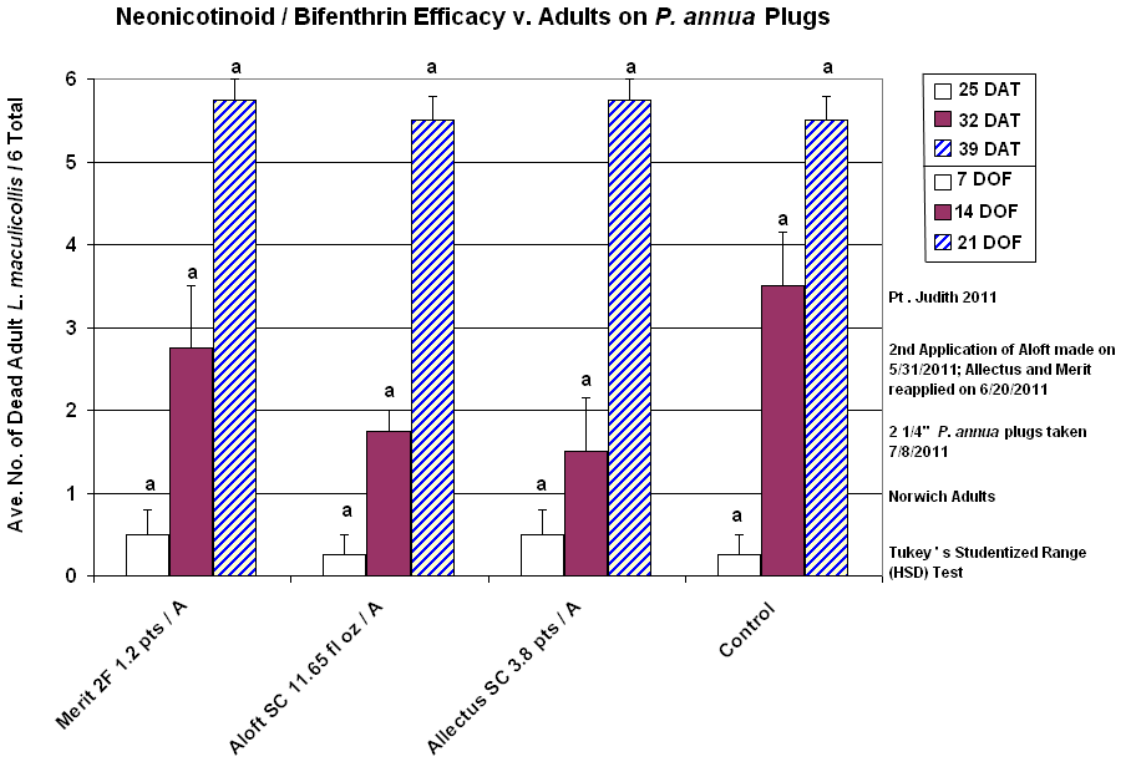
Neonicotinoid / Bifenthrin Efficacy v. Adults on *P. annua* Plugs

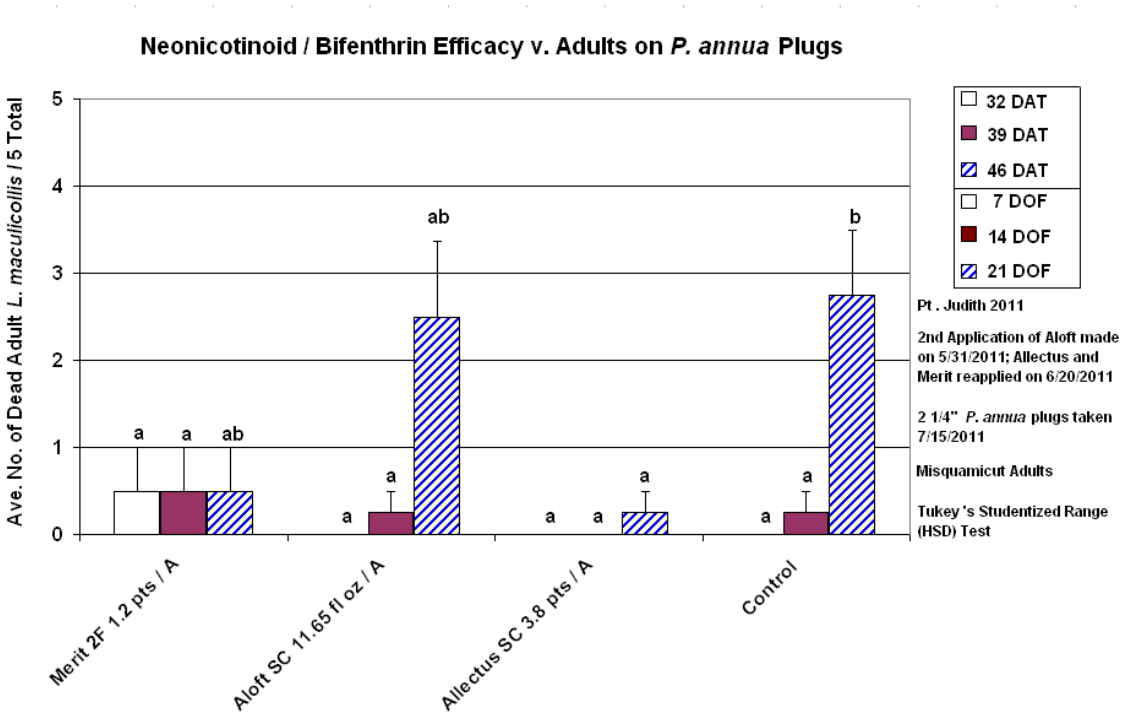


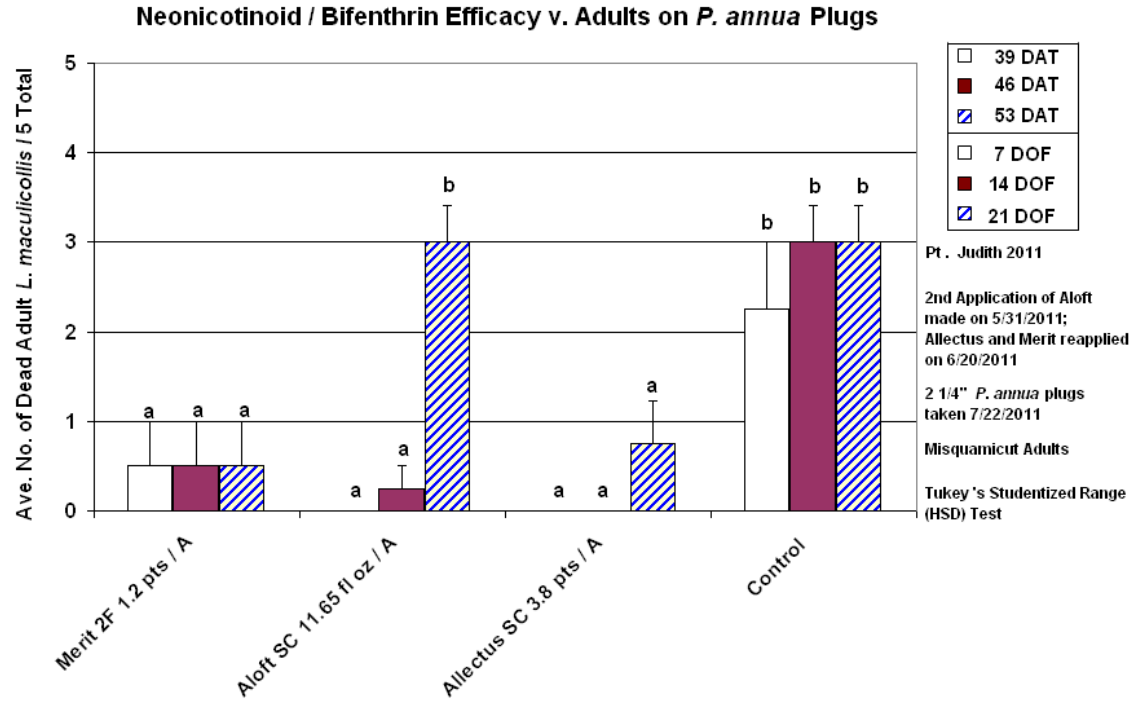
Neonicotinoid / Bifenthrin Efficacy v. Adults on *P. annua* Plugs

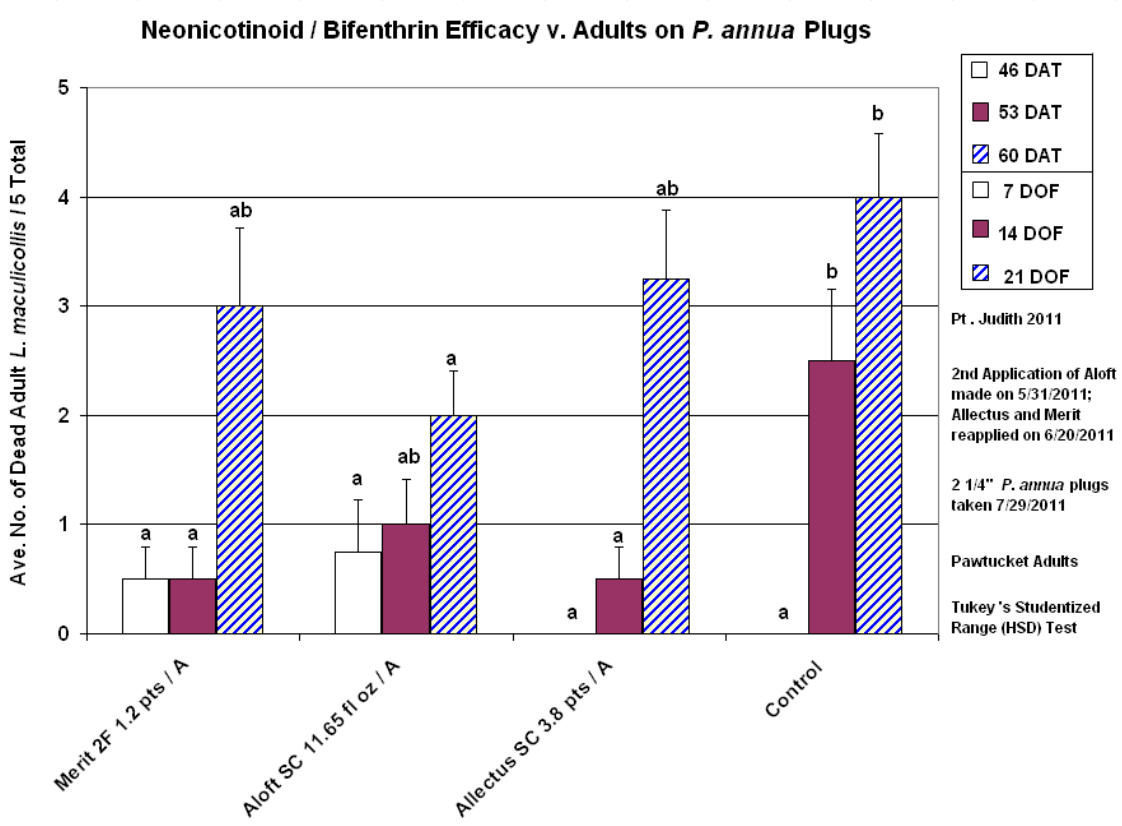



Neonicotinoid / Bifenthrin Efficacy v. Adults on P. annua Plugs
Ave. No. of Dead Adult L. maculicollis / 7 Total
18 DAT
25 DAT
32 DAT
7 DOF
14 DOF
21 DOF
Pt . Judith 2011
2nd Application of Aloft made on 5/31/2011; Allectus and Merit reapplied on 6/20/2011
2 1/4" P. annua plugs taken 7/1/2011
Norwich Adults
Tukey ' s Studentized Range (HSD) Test
Merit 2F 1.2 pts / A
Aloft SC 11.65 fl oz / A
Allectus SC 3.8 pts / A
Control

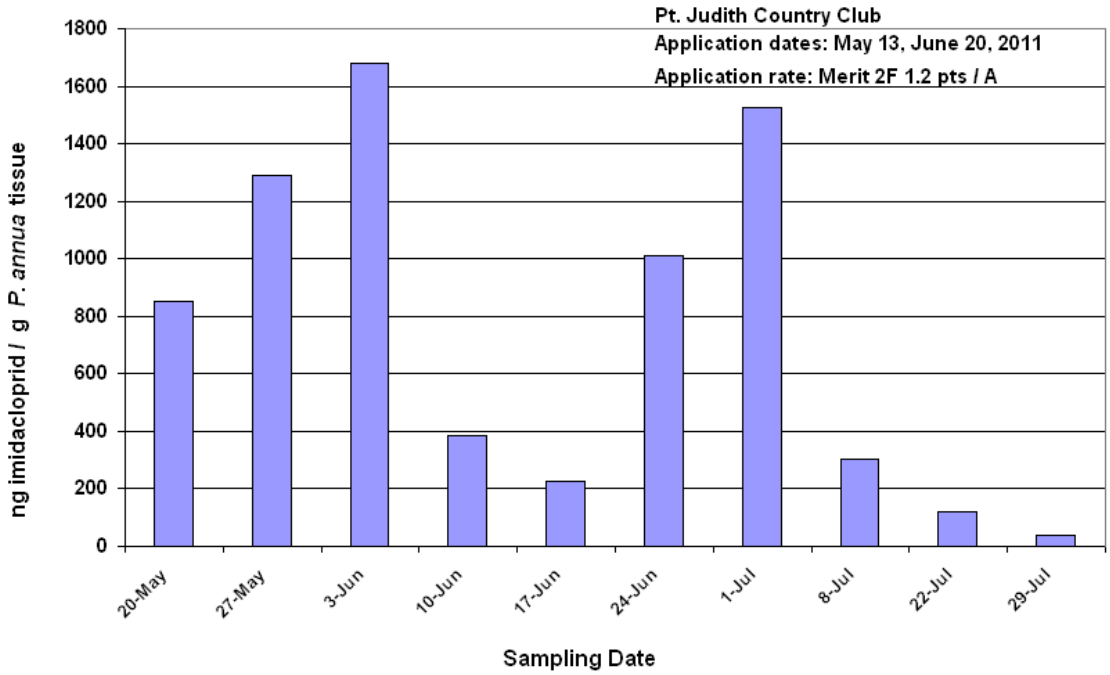

Neonicotinoid / Bifenthrin Efficacy v. Adults on P. annua Plugs
Ave. No. of Dead Adult L. maculicollis / 6 Total
25 DAT
32 DAT
39 DAT
7 DOF
14 DOF
21 DOF
Pt . Judith 2011
2nd Application of Aloft made on 5/31/2011; Allectus and Merit reapplied on 6/20/2011
2 1/4" P. annua plugs taken 7/8/2011
Norwich Adults
Tukey ' s Studentized Range (HSD) Test
Merit 2F 1.2 pts / A
Aloft SC 11.65 fl oz / A
Allectus SC 3.8 pts / A
Control

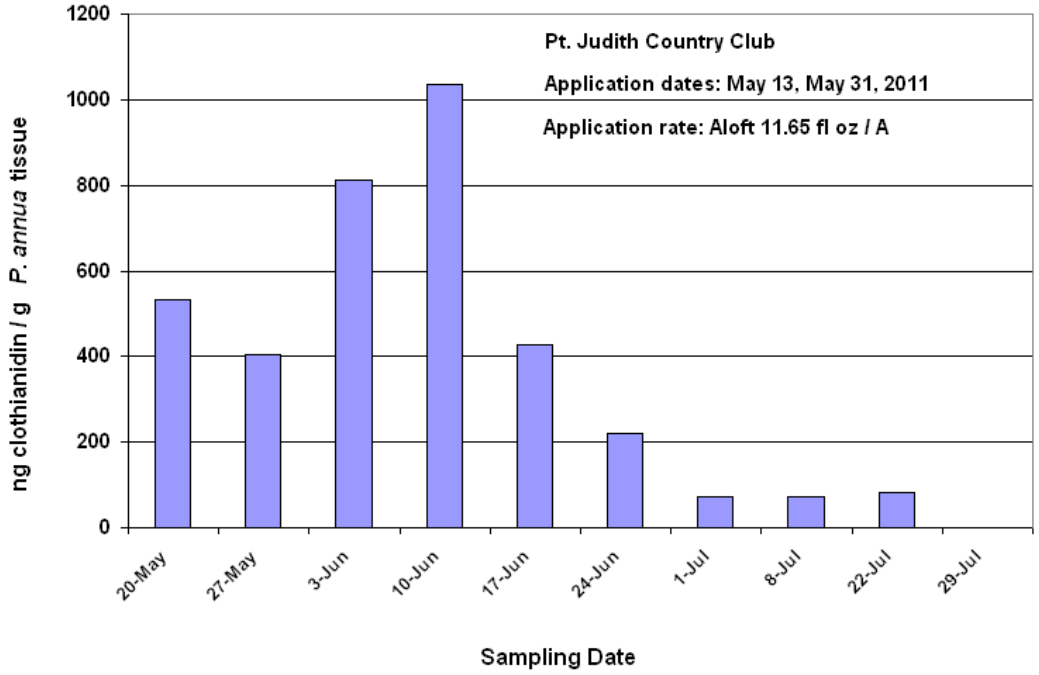

Neonicotinoid / Bifenthrin Efficacy v. Adults on P. annua Plugs
Ave. No. of Dead Adult L. maculicollis / 5 Total
0
1
2
3
4
5
a a ab
a a ab
a a a
a a b
Merit 2F 1.2 pts / A
Aloft SC 11.65 fl oz / A
Allectus SC 3.8 pts / A
Control
32 DAT
39 DAT
46 DAT
7 DOF
14 DOF
21 DOF
Pt . Judith 2011
2nd Application of Aloft made on 5/31/2011; Allectus and Merit reapplied on 6/20/2011
2 1/4" P. annua plugs taken 7/15/2011
Misquamicut Adults
Tukey 's Studentized Range (HSD) Test

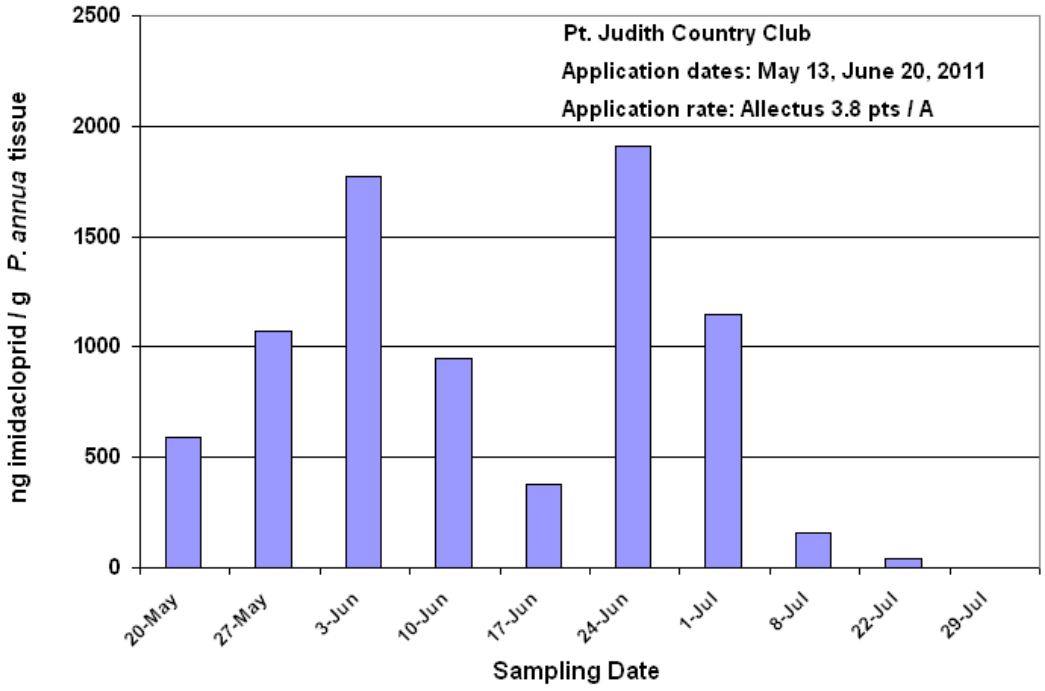

Neonicotinoid / Bifenthrin Efficacy v. Adults on P. annua Plugs
Ave. No. of Dead Adult L. maculicollis / 5 Total
0
1
2
3
4
5
a a a
a a b
a a a
b b b
Merit 2F 1.2 pts / A
Aloft SC 11.65 fl oz / A
Allectus SC 3.8 pts / A
Control
39 DAT
46 DAT
53 DAT
7 DOF
14 DOF
21 DOF
Pt . Judith 2011
2nd Application of Aloft made on 5/31/2011; Allectus and Merit reapplied on 6/20/2011
2 1/4" P. annua plugs taken 7/22/2011
Misquamicut Adults
Tukey 's Studentized Range (HSD) Test



Point Judith Tissue Concentration




Pt. Judith Country Club
Application dates: May 13, May 31, 2011
Application rate: Aloft 11.65 fl oz / A
ng clothianidin / g P. annua tissue
1200
1000
800
600
400
200
0
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
22-Jul
29-Jul
Sampling Date


Pt. Judith Country Club
Application dates: May 13, June 20, 2011
Application rate: Allectus 3.8 pts / A
ng imidacloprid / g P. annua tissue
2500
2000
1500
1000
500
0
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
22-Jul
29-Jul
Sampling Date