The IR-4 Project

Providing Safe and Effective Pest Management Solutions for Specialty Crop Growers

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Biopesticide Research Report 2003

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BIOPESTICIDE RESEARCH REPORT 2003

Executive Summary

This document contains reports of biopesticide research funded entirely or in part by the IR-4 Biopesticide Research Grant Program in 2003. The research reports compiled in this report are from individual researchers and were not conducted by the IR-4 Project. Therefore, the researchers should be contacted directly regarding any questions about their studies. Please note, mention of trade names does not constitute an endorsement of a particular product, but rather reflects the information provided by the researchers.

BIOINSECTICIDES

Western Poplar Clearwing Moth Pheromone (E,Z-3,13-Octadecadienol and Z,Z-3,13-Octadecadienol) completely eliminated trap captures of the Western Poplar Clearwing Moth (1)[*]. This averted the application of over 44,000 pounds of Lorsban (Chlorpyriphos). The pheromone Z tetradecen-one was effective in causing mating disruption of Oriental Beetle in blueberry and ornamentals (9). Codling moth control in pears with CM granulosis virus was superior to the untreated control, but not as effective as Entrust (Spinosad) or Guthion (Azinphos-methyl) (13). Mating disruption with Isomate (E,E 8, 10-Dodecadien) reduced moth damage compared to the control and CM granulosis virus improved codling moth control over mating disruption alone. The Gypsy Moth Pathogen *Entomophaga maimaiga* spores have now been successfully grown *in vitro* without going into dormancy (29). Repel (Garlic)and Mycotrol (*Beauvaria bassiana*) did not effectively control thrips on onion (37). Hexacide (Rosemary oil) applied at daybreak was generally less phytotoxic to bentgrass compared to mid-day applications (47). Black cutworm egg hatch was not effected but 2^{nd}-4^{th} instar larva were controlled. Sod webworm was not controlled. Capsyn (Capsaicin) plus Nufilm provided some control of plum curculio but did not have residual activity (58).

BIOFUNGICIDES

Serenade (*Bacillus subtilis*) and Armicarb (Potassium Bicarbonate) in rotation programs allowed for at least a 50% reduction in the use of Nova (Myclobutanil) for control of

[*] The numbers in parenthesis are the first page number relating to the individual research report cited in this summary .

Peach Rusty Spot (60). Bees were effective in vectoring spores of Serenade, but did not decrease mummy berry or improve yield of blueberry (71). When Serenade was applied in blueberry as a spray, it was as effective as Indar (Febuconazole) (78) in controlling mummy berry. Serenade rotated with Indar was also effective in controlling mummy berry (78), but did not control *Alternaria* or *Anthracnose* fruit rot (79). Serenade provided early season control of white mold of lima bean while Sonata (Bacillus pumilus) did not (80). Serenade, Sonata and most conventional fungicides did not improve lima bean yield, but Endura (Boscolid) did (80) . Sonata and Serenade did not control downy mildew on lima bean (81). Serenade and Sonata controlled white mold in snap beans(82). Sonata, Serenade and all conventionals resulted in similar snap bean yields and all were better than the control. In potato, Sonata rotated with conventional products provided some control of white mold, early blight and late blight. All treatments improved potato yields compared to the control (83).

Biophos (Dipotassium phosphonate and phosphate) and Vital (Potassium phosphate) treatments resulted in significantly less black rot of pansy and was similar to Cleary 3336 (Thiophanate methyl) (85). In the ornamental Calibrachoa-million bells, Biophos controlled *Pythium* and *Phytophthora* (86). Biophos provided good control of powdery mildew in Gerbra daisy, but Heritage (Azoxystrobin) was superior(90). Biophos did not control *Phytophthora* root rot in vinca (91). *Phytophthora capscici* (Squash crown and fruit rot) were not controlled by FNX -100 (Dipotassium phosphate) or ABM 127 *Gliocladium virens* in the spring but FNX-100 enhanced control obtained by conventional products in the fall (92).

In pumpkin, powdery mildew, *Xanthamonas*, virus and marketable fruit number were similar with treatments of Milsana (*Reynoutria sachalinensis*) or Serenade alone or in combination with conventional fungicides (95). Most Milsana and Kaligreen (Potassium bicarbonate) treatments alone or with conventional fungicides controlled powdery mildew in pumpkin while Serenade did not (100). Most treatments including Pre-stop (*Gliocladium catenulatum*) or Milsana were similar to conventional fungicides in controlling *Botrytis* in greenhouse tomato. Serenade and BAS-516 (Pyraclostrobin and Boscolid) were similar to the control (101). Milsana alone or in rotation with Elevate (Fenhexamid) controlled powdery mildew and *Phomopsis* leaf blight similar to Pristine (Pyraclostrobin and Boscolid) in strawberry (106).

Messenger (Harpin protein) did not control *Ramularia* leaf spot in artichoke as well as Rally (Myclobutanil) (107). *Phytophtora* root rot ratings in avocado treated with Messenger and Aliette (Fosethyl-Al) were similar, but only Messenger increased yields compared to the control (114).

Oxidate (Hydrogen dioxide) did not control *Anthracnose* fruit rot or gray mold in strawberry (128). Bio-Save (*Pseudomonas syringae)* , Tsunami (Peroxyacetic acid) and Storox (Hydrogen dioxide) did not provide postharvest control of *Fusarium* in sweet potato while Pristine and Scholar (Fludioxonil) did (129). *Rhizopus* soft rot was not

controlled by Tsunami or Storox, but Bio -Save had some activity in sweetpotato(130). *Cercospora* leaf spot in sugarbeet was reduced by Bac-J (Bacillus mycoides) in moderate, but was not reduced in *Cercospora* susceptible sugarbeet cultivars(131). BioYield (*Paenobacillus macerans and Bacillus amyloliquefaciens)* provided good control of damping off in ornamentals (134).

EcoGuard (*Bacillus licheniformis*) had some early season activity against powdery mildew and *Rhizoctonia* in bedding plants, but was not active on Botrytis (149). In ginseng, Endorse (Polyoxin-D) performed favorably against *Botrytis* and *Alternaria* and appeared to be a good rotational tool with Quadris (Azoxystrobin) (167). In general Eco Guard was not effective in controlling vegetable diseases alone but may be useful in rotation(174).

BIONEMATICIDES

Dominator, liquid compost factor , castor oil and DiTerra (Myrothecium verrucaria) provided variable suppression of nematodes in grapes (188).

Easter lilys grown in nematode infested soil produced more bulblets when treated with Neem or Thimet (Phorate), but not Quillaja (Quillaja saponaria) or DiTera (195). Quillaja treatment resulted in larger bulb size. Tomato yields increased with Quillaja extract and were greater than with Telone (1,3-dichloropropane and chloropicrin) (196).

MeloCon (BioAct) (*Paecilomyces lilacinus*) protected plants as well as Vapam (Metam sodium)soil fumigant against root knot nematodes in tomato and better than the untreated control (200). While not significant, results were consistent in that tomato fruit numbers and weights from MeloCon treated plots were greatest in every case. Cucumbers were intolerant of the nematodes present in this study that neither the Vapam soil fumigant nor MeloCon treatment were able to help cucumbers overcome the damage.

PLANT GROWTH REGULATORS

AuxiGro (Glutamic acid) did not improve blueberry yields (206). AuxiGro tended to reduce bitter pit in apples, but did not impact total yield, size or color(208). AuxiGro did not impact any component of cranberry yield(211)

Title:	Pheromone-based strategy for control of western poplar clearwing moth
Common name of Biopesticide:	Checkmate WPCM-F & Checkmate WPCM-M
Chemical:	(Z,E) – 1,13-Octadecadienol (14.02%) (Z,Z) – 1,13-Octadecadienol (3.55%) Other ingredients (82.43%)
Commodity and Site:	Hybrid poplar; eastern Washington and eastern Oregon.
Target Species:	Western Poplar Clearwing moth (*Paranthrene robinae*)
Principal Invesigators:	Dr John J. Brown, Professor Dr. Douglas B. Walsh, WA State IR-4 SLR Department of Entomology Washington State University

Background: Over 45,000 acres of hybrid poplar (*Populas trichocarpa x P. deltoides*) are currently under cultivation in the Pacific Northwest, contributing to the economy of northeast Oregon near Boardman and eastern Washington near Patterson, Wallula, and Ice Harbor Dam. Projections are for another 50,000 acres to go into production within several years in Oregon, Washington and British Columbia[2].

Poplar fiber improves the over-all quality of softwood paper. Trees grown at lower elevations are accessible year-round, water is readily available from the Snake and Columbia River systems above and below their confluence, and rotation for pulp can be as short as 7 years. However, the world market for paper pulp is saturated, prices for hard white shavings-pulp have decreased from $520 (1995) to below $170 (2001) per ton (*Pulp & Paper Week*, 8/6/2001), and the July 2003 '*Pulp & Paper International*' described the current situation as, "the first net decline in (the pulp & paper) industry's history…". Companies managing their plantings for paper pulp cannot tolerate borrowing insects to the point of endangering the life of the tree, weaken limbs, or defoliation to an extent that maximum growth is not realized.

One company (Potlatch Corp.) has converted their operation near Boardman, OR from pulp to saw timber. This lengthens their crop rotation to 12 years and adds substantial costs to the production cycle by adding cultural practices including the pruning each tree to 24 feet. Poplar has some desirable milling properties that will allow these larger logs to be veneered. A shift in pest management practices is now required because insect pests that burrow galleries into the heartwood, vector diseases, or damage dominant terminal shoots can no longer be tolerated as they were when production was specifically for pulp.

Insects have always posed a major threat to this monoculture, but concern is multiplied when rotation is lengthened by 71% and clear heartwood, rather than 'chips' are the desired end product. Retail stores that will market home products made from poplar are requiring that the tree be managed under the guidelines of the Forest Stewardship Council (FSC>http://www.fscoax.org/<), which prohibits the use of World Health Organization Type 1A

and 1B and chlorinated hydrocarbon pesticides.

Our first year (2001) was a monitoring year during which we determined the important economic insect pests of poplar plantings[3]. Data were collected weekly from April through September from light traps, pit-fall traps, pheromone baited traps, and tree-to-tree visual monitoring. We determined that our principle pests were three heartwood burrowing insects, two Lepidoptera, and one Coleoptera species.
During 2002, Potlatch followed recommended control measures in the literature using Lorsban® 4E every two-weeks. Pheromone baited traps recorded a temporary one-week reduction in male clearwing moth capture, but trap capture increased again the following week and the application of a broad-spectrum pesticide was repeated. Trap capture was identical for 16,000 acres treated with chlorpyrifos (Figure #1).
We obtained the first Regional Section 18 for an unregistered sex pheromone on 29 May 2003, and treated approximately 8,500 acres of newly planted and one-year old trees. In summary, our treatments were completely successful in regards to shutting down trap capture of male moths. At this point 1,800 'sentinel' trees still need to be evaluated after leaf fall (Mid-November). We do know that Potlatch saved 83% of their pest control costs between 2002 when they used Lorsban® compared to 2003's use of pheromone for clearwing control.

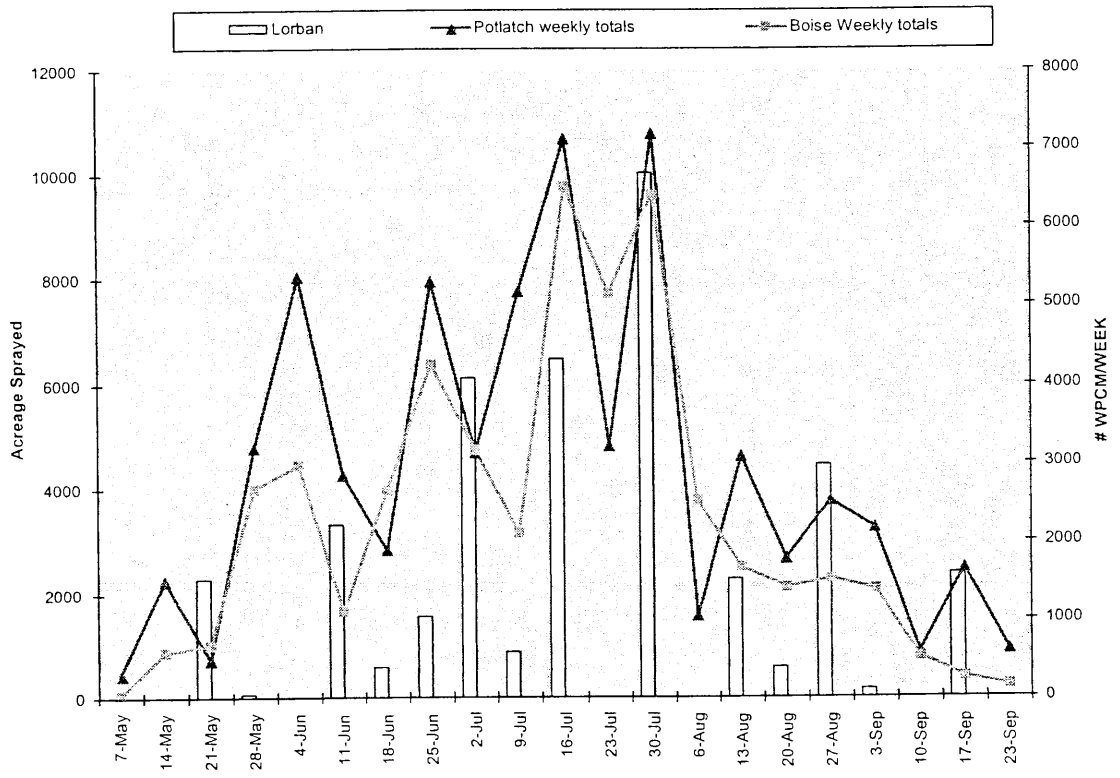
Current literature:

2. Cowles, R.S., J. G. Millar, E.J. Perry, and others (1996) Identification of the sex pheromone of the western poplar clearwing moth (Lepidoptera:Sesiidae) *Environmental Entomology* **25**: 109-113.
3. Chastagner, G. and Joseph Hudak (1999) Crop Profile for Hybrid Poplars in Washington and Oregon, pp12.
4. Brown, J. et. al. (2001) Integrated pest management in western poplar plantings. Poster D0726 Entomological Society of America, San Diego, CA.
5. Brown, J. J. et. al (2001) Progress report to Potlatch and Boise 40pp.
6. Kittelson, N. et al. (2002) Western poplar clearwing moth control in western US. Poster D0726 Entomological Society of America, Hollywood, FL.
7. Brown, J. et al. Regional Section 18 for use of WPCM-F and WPCM-D, issued May 29, 2003.
8. Brown, J. et. al. Crops at Risk. Sesiidae species taken advantage of a hybrid poplar monoculture. Invited Symposium talk 0681, Tuesday Oct 28, 2003. Entomological Society of America, Cincinnati, OH.
9. USDA (1985) Insects of Eastern Forests. Miscellaneous Publications #1426, 608pp.
10. Barry, M. W. (1979) Sex pheromone mediated behavior and biology of the peachtree borer, (Say). (Thesis Ohio State University 1978, Ann Arbor Michigan micro-film.
11. Snow, J. W. (1986) The pheromone permeation technique as a control for the peach tree borer. In Stone fruit tree decline workshop proceeding: Clemson U., (Zehr, E. I. Editor) pp 94-96. USDA/ARS publisher.

Field data supporting this proposal: This western poplar clearwing moth developed into the number one economic pest in poplar planting at both Potlatch's Oregon and Boise's Oregon and Washington locations in 2002. We had 92 delta traps baited for clearwing in 2001 within the Potlatch plantings and captured 95 moths between July 10 and August 7, 2001. In 2002 we monitored that same area, with the same number of traps, with more efficient 'bucket traps' and captured 17,087 male moths[4] during same time period! In response to such high population pressure hybrid poplar producers applied chlorpyriphos (Lorsban™ 4E, Dow Agrosciences,

Indianaplolis, IN) at a rate of 4 lb active ingredient per acre. In 2002 we estimate that over 44,000 lbs of chlorpyriphos were applied by hybrid poplar producers specifically for control of the clearwing moth. Boise elected to spray their plantings with endosulfan in 2002. Regardless if endosulfan or chlorpyrifos was used the male clearwing moth capture was identical for these two growing areas. (Figure #1). We have no evidence that treatment with these broad-spectrum insecticides diminished this year's trap capture, the number was reduced to 13,331. The reduction was do to a portion of the area was treated with pheromone in a mating disruption effort.

Figure #1. Comparison of number male clearwing moths captured in Potlatch's using chlorpyrifos to the number captured in Boise's poplar plantings where they used endosulfan between May 7 and September 3, 2002.



Results from 2002 & 2003:

August 30, 2002: Realizing that repeated applications of these broad-spectrum insecticides was not going to solve the clearwing moth problem, we contacted Suterra Corporation, Bend, Oregon to help us develop a 'Checkmate®' mating disruption strategy to control the pest. Potlatch, Boise, Suterra, WSU, and EPA (Sandy Halstead, Region X) representatives met at the Potlatch Headquarters near Boardman, OR on August 30, 2002. We presented information that we had collected concerning the biology of the clearwing moth that suggested it was an excellent candidate for mating disruption strategy. Our evidence included:

1. The poplar clearwing male moths are extremely attracted to pheromone-baited traps. Simply using one trap every 160+ acres captured over 100,000 male moths in 2002.

2. Pheromone-baited traps located 1.75 miles away from any poplar tree in sage or alfalfa fields still captured moths. An Experimental Use Permit would be of little use with such a mobile pest.

3. Female poplar clearwing moths are 'short-lived.' Moths captured in the field seldom live more than one-day, and those captured as over-wintering larvae and reared-out to adults died within 2 to 3 days.

4. We were able to 'shut-down' traps baited with 10 times the normal concentration of female pheromone by placing one pheromone septum on every ten trees.

5. The literature and consultation with experts suggests that this family of moths is the easiest to control with mating disruption strategy.[6 7] Jay Brunner, (Director of the WSU Tree Fruit Research and Extension Center, Personal Conversation) suspects mating disruption will prove so effective that flow-able pheromone application will not be required every year because the population will be suppressed.

September 26, 2002: Sandy Halstead arranged a teleconference between Suterra (Richard Fresh), WSU researchers (John J. Brown & Douglas Walsh), and several members of the EPA's BioPesticide group. The conversation ended with a lot of enthusiasm toward going forward with a full registration in 2003.

November 14, 2002: We submitted a proposal to the IR-4 BioPesticide program requesting $14,000 to support time-slip help to monitor our effort to use 'Checkmate' sex pheromone for the western clearwing moth control.

January 15, 2003: Suterra Corporation personnel met with WSU researchers and reported that Shin Etsu the company responsible for manufacturing the sex pheromone had completed the chemistry information required by EPA and said that information was in Shin Etsu's New York offices.

January 29, 2003: We submitted a request for a Section 18 to both David Priebe (Oregon Department of Agriculture) and Michael Norman (Washington State Department of Agriculture). Mr. Priebe and Norman decided to combine their efforts and request a Regional Section 18 that would allow us to treat poplar planting in both states.

February 28, 2003: Suterra called to say that Shin Etsu would not be able to produce the 44 kg of pheromone that we had ordered. They would be able to produce 11 Kg if we ordered it immediately.

Altered proposal for 2003: We had to make some alterations from our proposal of a year ago because of the limited amount of pheromone manufactured by Shin Etsu Corporation in Japan.

We had proposed using three different application strategies for 44 Kg of pheromone. Newly planted trees where to be protected with stationary membrane dispensers, two and three year old trees up to 8 meters tall where suppose to be protected with puffer type dispensers, and we were going to use the flowable formulation to protect mature trees 8 to 30 meters tall. Shin Etsu was only able to synthesize 11 Kg of pheromone for us in 2003 and we decided to concentrate our 11

Kg on newly planted and one-year old trees and use only the membrane dispensers and flowable formulation.

We had proposed to treat with three concentrations: high 5 g, medium 1g, low 0.5g per acre/season. The membrane dispenser where to be loaded with 24 mg sex pheromone and replaced in mid-season so that the concentration of pheromone in membranes would equal the high 5 gram/acre/ season rate in the flowable formulation. With the reduced amount of pheromone available, we changed our three concentrations of flowable to high 3 g, medium 1 g, and low 0.5 g/acre/season. We determined through rate of release information that the membrane dispensers may not need replacement mid-way through the season, so our number of membranes/acre was adjusted to match the high flowable rate of 3 g/acre/season.

April 26, 2003: We started to capture male clearwing moths in our traps. Moth capture was exceeding the record amount caught in 2002. There was tremendous pressure to obtain a Section 18 that would allow us to utilize the $25,000 of sex pheromone that we had Potlatch , Boise, and Suterra purchase.

May 19, 2003: We initiated Suterra's Experimental Use Permit by treating half of three units, 80 of 157 acres were treated with 3 g/acre/season rate, and membrane dispenser were placed in160 of 320 acres of poplar trees in two other blocks in Oregon. There were three times as many male moths captured in 2003 before application than caught in 2002 in the same area, and in 2002all 450 acres were sprayed with Lorsban® mid-May and early June. Application of pheromone to just half this area completely shut down the traps baited with 1 mg of female sex pheromone (Figure #2).

May 29, 2003: Our Regional Section 18 was issued and we scheduled our first treatment for June 2. Within one week of the first application to approximately 9,000 acres, the male clearwing moth capture decreased by 85% over the entire 32,000 acre planting area. Trap capture in traps baited with 1 mg were completely shut down within the pheromone

Figure #2. Effect of treating 240 acres under an Experimental Use Permit on May 19, 2003. This figure represents the male moth capture in 2002, the amount of chlorpyrifos sprayed over the entire 450 acres in 2002, and the male moth capture in 2003.

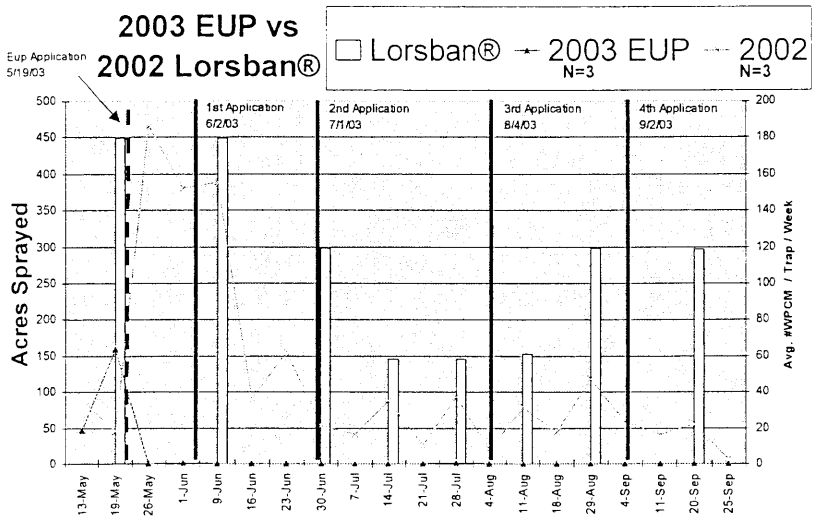
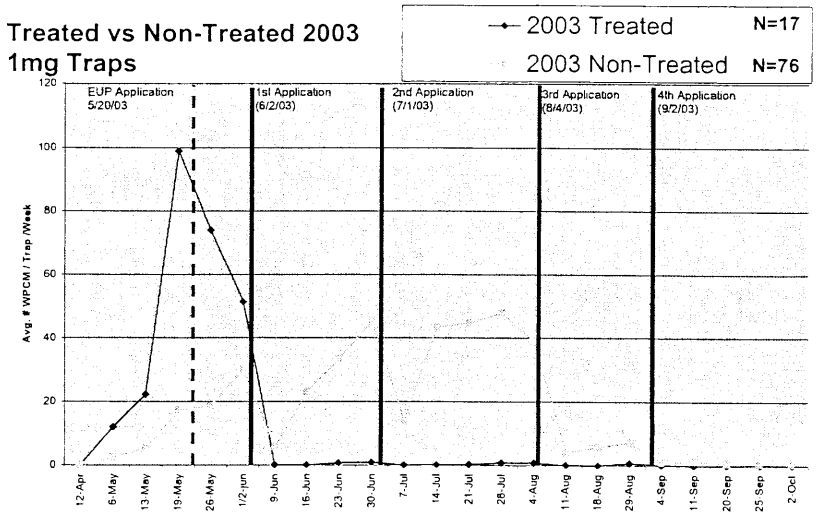


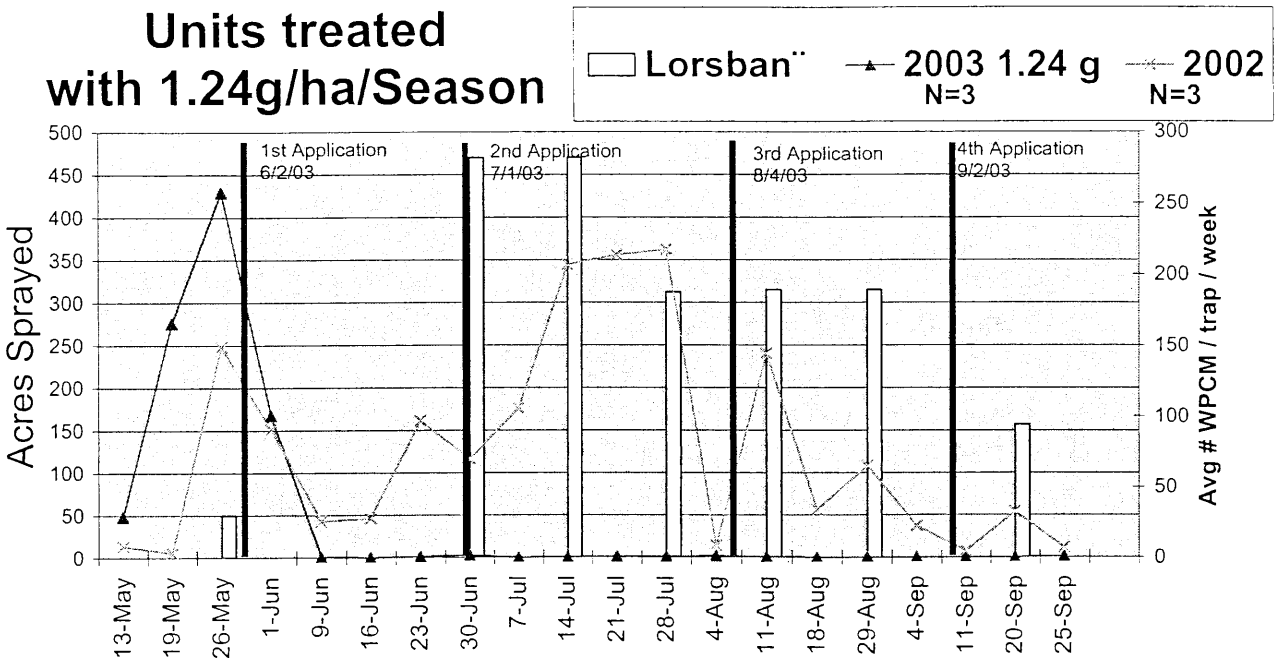
Figure #3. First capture of a male clearwing moth occurred in April 2003, by mid-May populations where exceeding those recorded in 2002. Over 35,000 male, and we assume an equal number of female moths eclosed before we obtained a Section 18 and were allowed to apply Checkmate WPCM pheromone.



treated areas, and we did not capture another moth in traps within blocks of trees where the membrane dispenser where placed! However, the delay of the Section 18 until late May allowed over 35,000 male, and we assume an equal number of female moths to eclose, mate, and colonize new plantings before we were able to apply the Checkmate WPCM pheromone (Figure #3).

June through September 2003: Figure #4 represents the total shut-down of traps baited with 1 mg pheromone septum in blocks treated with 0.5 grams WPCM-Checkmate /acre/season [1.24 g/ha/season]. These blocks were treated four times with with 0.125 g/acre delivered in 5 gallons of water, along with 8 oz of Nu-Film 17 on June 2, July, August, and September. We had similar results from the membrane dispensers and higher concentrations of the flowable formulation sex pheromone to the results depicted in Figure #4.

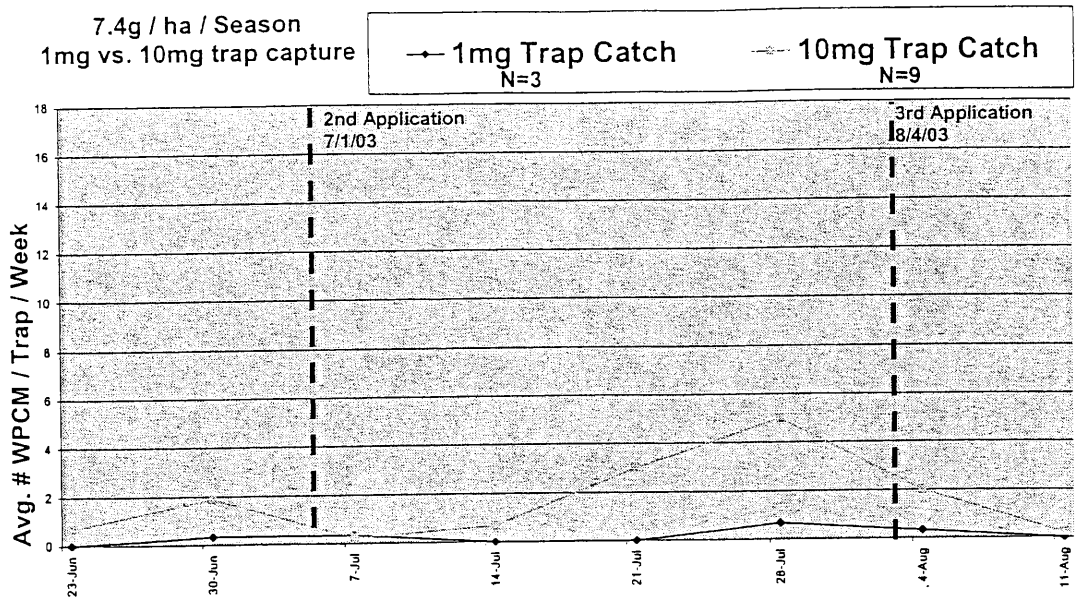
Figure #4. Capture of male Clearwing moths in traps baited with 1 mg sex pheromone in 2002 and 2003. These three blocks represent a total of460 acres, in 2002 the entire area was sprayed with Lorsban® June 30 & July 14, 2/3 of the area received 3 more Lorsban® treatments in July & August, and 160 acres was treated a seventh time in September. In 2003 no Lorsban® was used, and the area was treated four times with 0.31 g/ha, for a total of 1.24 g/season.



July and August 2003: When the flowable pheromone started to dissipate the pheromone traps baited with 10 mg of sex pheromone started to capture more moths (Figure #5) necessitating another application of flowable formulation. This condition was not evident in the traps baited with 1 mg pheromone lures.

October 28, 2003: National meeting of the Entomological Society of America, Symposium on Sesiidae, Cincinnati Ohio: Information form a Sesiidae symposium in Cincinnati in October 2003, suggests that other Sesiidae pests, the dogwood borer, raspberry crown borer, and grape root borer mate once (David Neilson), and mating disruption strategy has been successful on the current borer (David James). Even if mating disruption of Sesiidae moths just delays mating, the number of eggs laid, percentage that hatch, and overall fecundity is reduced in the grape root borer (Patricia Pritchard).

Figure #5. Male clearwing moths captured in traps baited with 1 or 10 mg of female sex pheromone in blocks treated with 7.4g/ha/Season.



Alternate controls: **Collectively Potlatch and Boise sprayed over 44,000 pounds of Lorsban® in 2002 with no effect beyond one week. Some areas received as many as seven treatments of Lorsban®. The week following spray applications moth capture rates rebounded. Boise's use of endosulfan for other pests in 2002, had no effect on male clearwing moth capture. At the end of the 2002 season we knew that these broad spectrum insecticides did not control the number of moths emerging in that season, but we held out hope that the 2002 sprays might influence moth population in 2003. This did not happen, moth emergence in 2003 before pheromone application exceeded the number captured the previous year (Figure #3).**

Potential hazards: The non-toxic 18 carbon alcohol[1] used in these pheromone based strategies replaced the six sprays of Lorsban® (rat oral LD_{50} = 135 mg/kg) that were used in 2002. We reduced the amount of Lorsban® use by 44,000 pounds in one year!

Management of oriental beetle, *Exomala orientalis* (Waterhouse) (Coleoptera: Scarabaeidae) by pheromone-mediated mating disruption in multiple crops

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During 2003, we conducted field experiments in blueberries and nurseries. The following is a brief summary of work pertaining to each crop system.

Blueberries: We have compared the efficacy of red rubber septa and reservoir-type macrodispensers in commercial blueberry fields. In addition, we also evaluated a new prototype sprayable pheromone formulation (Suterra LLC, Portland, OR) in 2-3 year old nursery blueberry fields.

Evaluation of dispensers in commercial blueberry fields

Methods: We evaluated rubber septa and reservoir type dispensers at rates per ha lower than tested in 2002. The three treatments evaluated in commercial blueberries during 2003 field season for mating disruption efficacy were 1) Reservoir-type macrodispensers (ChemTica, Costa Rica) at the rate of 20 dispensers per acre each loaded with 1.0 g of (Z)-tetradecen-2-one per dispenser, 2) red rubber septa at the same rate per acre each loaded with 0.1 g AI per septa, 3) untreated control. There were four replicates. In each plot 4 Japanese beetle sex pheromone traps (Trécé, Salinas, CA) baited with 300 ug of (Z)-tetradecen-2-one were deployed in such a way that the bottom of the collection jar of the trap was touching ground. Traps were checked twice each week. Due to limited availability of adult beetles, we could place virgin females in only one of the four replicates (40 females per treatment). Virgin females were left in the field for two nights, and following field retrieval were placed individually in 30 ml cups with moist sand. Adults were checked twice each week to monitor the fertility status of oviposited eggs. Additional details on trap and dispenser deployment, and placement of tethered virgin females can be garnered from Fig. 1.

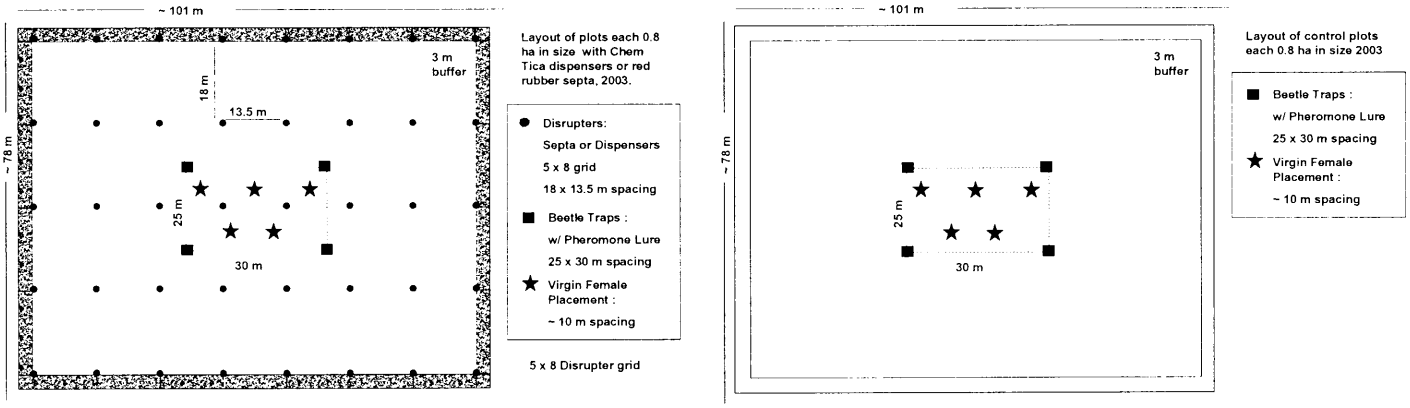

Fig. 1. Plot layout in blueberries treated with reservoir-type dispensers, red rubber septa, and untreated control plots. Plot size, dispenser distribution, and trap deployment in nursery plots was similar.

Results: Male oriental beetle captures among various treatment plots were not significantly different prior to placement of disrupters (F = 0.56; d.f = 2, 9; P = 0.589). Trap captures were significantly lower in plots treated with Chem Tica dispensers or rubber septa compared to trap captures in untreated control plots (F = 75.20; d.f. = 2, 9; P = 0.0001). The pheromone trap captures remained low in plots treated with Chem Tica dispensers or rubber septa throughout the adult flight compared to trap captures in untreated control plots (Fig. 2). The Disruption Index (DI) was calculated as DI = C-T/C *100 where C = trap captures in control, T = trap captures in treatment. The DI was > 98% in both plots treated with rubber septa or reservoir-type dispensers. The DI were comparable in both treatments despite the fact that reservoir-type dispensers had nearly 10X more pheromone compared to rubber septa (Table 1).

Table 1. Oriental beetle sexual communication disruption in highbush blueberries, 2003.

Treatment	Disrupters / ha	Loading (g) / Disrupter	Beetles/Trap (Mean ± SEM)		DI [3] (%)	Virgin Females[4]	
			Pre-Treatment[1]	Post-Treatment[2]		% Mated	N
Control	~	~	46.9 ± 8.1 NS	340.8 ± 41.7 a	~	76.9	13
Dispensers	50	1.0	22.7 ± 5.4 NS	6.6 ± 1.8 b	98.1	5.9	17
Rubber septa	50	0.1	37.8 ± 12.7 NS	2.3 ± 0.6 b	99.3	0.0	15

[1] June 29th through July 2nd, NS = Not significantly different; [2] July 2nd through August 14th, Means within a column followed by a different letter are significantly different (Fisher's Protected LSD, P = 0.05); [3] DI = [C - (T/C)]*100; [4] $P < 0.0001$, Chi-Square Test = 27.41.

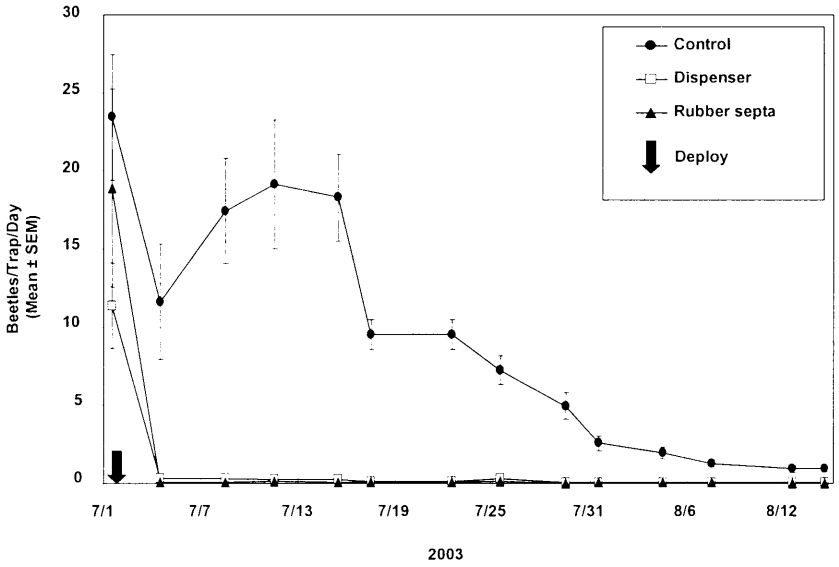

Fig. 2. Male beetle captures per trap per day in plots treated with reservoir-type dispensers, rubber septa, and in untreated control plots in blueberries, 2003.

In 2003, we placed tethered virgin females (40 females /plot) in only one of four replications; fewer than 50% of virgin females were recovered after two nights in the field. Bird predation and escape from tethers were significant factors affecting recovery. Significantly fewer virgin females were found to oviposit fertilized eggs that were recovered from the two disrupter treatments compared to females in the untreated control plot (Table 1). These studies indicate that sexual communication in oriental beetle can be disrupted by deploying retrievable dispensers releasing high rates of pheromone at lower densities than previously thought.

Evaluation of sprayable pheromone formulated by Suterra

Methods: Because of the delay in receiving the formulated pheromone, we chose to make a single application of the pheromone. Two treatments were evaluated: 1) high rate of pheromone at 30 g a.i. per acre, 2) low rate at 15 g a.i. per acre, and 3) untreated control. Pheromone was applied on July 18, 2004 in 40 gal per acre with a Myers 100 gal sprayer equipped with two shower-head nozzles that will deliver the spray simultaneously to both sides of a row. Four Japanese beetle traps baited with 300 ug of (Z)-tetradecen-2-one were deployed in such a way that the bottom of the collection jar of the trap was touching ground. There was a single replication per treatment and each plot was 2.5 acres in size.

Results:

Fewer beetles were captured in sprayable pheromone treated plots compared to untreated plot (Table 2). However, there were more than twice as many beetles captured in the high pheromone rate plot compared to the low rate plot. The disruption index was 73 and 88% for high and low rate treatments, respectively. Lack of replication made it difficult to discern dose-response. Based on trap shut-down, the low rate appears to be as effective as the high rate. Future work should compare the efficacy of Suterra formulation with 3M formulation.

Table 2. Average number of male oriental beetles captured in plots treated with Suterra formulation and untreated control plot, 2003

Treatment	Mean ± SEM	DI
Control	**279.8 ± 27.5**	**.**
Low	**32.5 ± 2.7**	**88.4**
High	**75.3 ± 9.8**	**73.1**

Nursery crops: In 2003, experiments were conducted at the Fruit and Ornamental Research Station, Cream Ridge, NJ. The three treatments evaluated in nursery were, 1) Reservoir-type macrodispensers (ChemTica, Costa Rica) at the rate of 30 dispensers per acre each loaded with 1.0 g AI per dispenser, 2) Two applications of 3M sprayable pheromone (MEC) at the rate of 15 g AI per acre per application, and 3) untreated control. There was a single replication per treatment. Reductions in male beetle captures in pheromone-baited Japanese beetle traps and larval density in sentinel host plants with tethered virgin females were used to assess the efficacy of communication disruption. Pheromone was applied on 7/1 and 7/15. We placed 20 juniper plants (*Juniperus* Sabina 'Aurea') per replicate tethered with 5 virgin females per pot. Potted plants were checked for oriental beetle grubs in October. Plants were watered twice each week to maintain moisture.

Results:

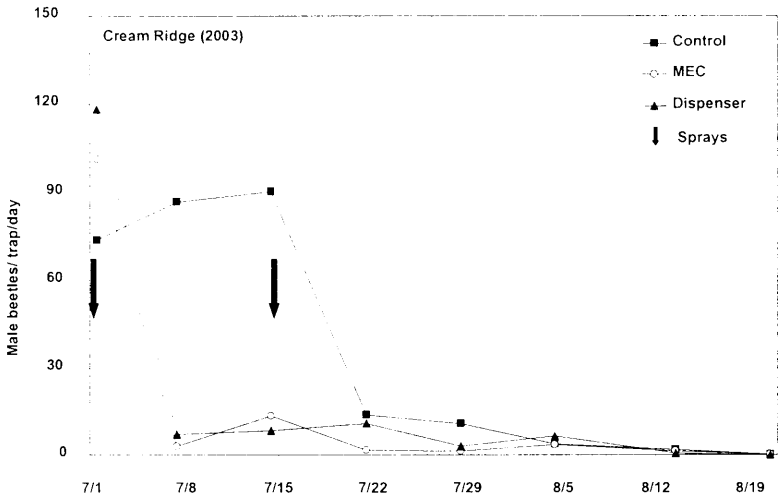

Fig. 3. Male beetle captures per trap per day in plots treated with reservoir-type dispensers, MEC formulation, and in untreated control plots in nursery crops, 2003.

Table 3. Oriental beetle sexual communication disruption in ornamental nurseries, 2003.

	Control	MEC	Dispenser
Beetles/Trap (Mean ± SEM)	**1454.25 ± 263.37**	**254.25 ± 89.27**	**174.75 ± 85.11**
DI (%)		**82.52%**	**87.98**
Larval Density Deployed females (n)	**2.28 ± 2.80 (n = 20)**	**0.29 ± 0.47 (n = 20)**	**0.65 ± 1.50 (n = 20)**

N = 4 traps per treatment
DI = (control – treatment) / control * 100

Trap captures were lower in plots treated with reservoir-type dispensers or MEC pheromone compared to trap captures in untreated control plots (Table 3). The adult captures remained low throughout the adult flight (Fig. 3). The Disruption Indices (DI) were similar in both treatments (Table 3). The larval density was also lower in plots treated with reservoir-type dispensers and MEC formulation compared to grub density in untreated control plots (Table 3).

Conclusions/Next Steps: These studies further confirm our previous data that mating disruption is a viable option for managing low populations of oriental beetle as part of an IPM program. The major bottleneck in commercializing this technology appears to be the registration of technical grade active ingredient. Bedukian Inc. is the sole manufacturer of this pheromone in US. Until Bedukian registers this pheromone with EPA, commercial products containing this pheromone can not be registered. Many researchers and commodity groups are impressing on Bedukian to go ahead with the registration of this ketone pheromone. Hopefully, in the very near future Bedukian will register the active ingredient, paving the way for the registration of commercial products in food and non-food crops. The efficacy of Suterra sprayable formulation and 3M formulation should be further evaluated in replicated field trials.

Testing Of New Codling Moth Granulosis Virus Products and Spinosad To Supplement Mating Disruption in Bartlett Pear Orchards

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ABSTRACT

Codling moth (*Cydia* (Laspeyresia) *pomonella*) (CM) mating disruption (MD) has become the standard practice in the California pear industry. Effective, environmentally acceptable alternative insecticides are needed to replace or complement the limited number of currently available materials that are used to supplement pheromone dispensers. The problem is particularly acute for organic growers or those transitioning to organic practices. Several materials were tested in 2003 in California Bartlett pear orchards in order to gain adequate efficacy data to support GV registration in California and provide an objective evaluation to supplement grower experience. Two were new formulations of CM granulosis virus (GV), Carpovirusine® (Sumitomo Corp., NY, NY) and Cyd-X® (Certis USA, Columbia, MD). The third was an organically acceptable formulation of spinosad, Entrust® (Dow AgroSciences, IN). Replicated trials, one single tree and three large-scale, were carried out in four counties. Treatments were compared to conventional grower standards Imidan® and Assail®, the organic standard, horticultural oil, MD alone, and at two sites, completely untreated controls. Test treatments were applied 3 – 11 times, depending on location. Data included weekly trap catches and percent damage throughout the season. In all four trials, CM damage was 70-90% less than using MD alone and 60-90% less than in completely untreated controls. Results varied with initial CM pressure, MD efficacy, and other non-treatment materials being applied for secondary pests. The test materials performed as well as the conventional insecticide program in one of the two conventional trials. Results thus showed that these new GV formulations, as well as Entrust, offer organic, as well as conventional growers, several new materials to supplement CM MD.

INTRODUCTION

Codling moth mating disruption (CM MD) has become the standard practice in the California pear industry. It must however, be supplemented by insecticides in at least some locations and years in order to maintain overall efficacy. The lack of effective supplements will likely render the technique ineffective over time due to CM population buildup in warm years or where sources of infestation exist.

Effective, environmentally acceptable alternative insecticides are needed to replace or supplement currently available materials in MD programs. Current materials are mainly broad-spectrum organophosphates that are being increasingly restricted and are becoming less effective due to resistance, and certain reduced risk materials (e.g. Confirm®, Intrepid®, Success® WP). The problem is particularly acute for organic growers or those interested in transitioning to organic practices. Besides limiting their own ability to control CM, the lack of effective options for organic growers increases pressure in neighboring non-organic orchards, thereby jeopardizing established and areawide control programs.

The most widely utilized organically approved insecticides currently used for CM control are oils of various types. Ryania was used until it was withdrawn by the manufacturer. Dr. Louis Falcon of UC Berkeley isolated and developed a codling moth granulosis virus (GV) for use as a biopesticide. His work was partially funded by the pear industry during the late 1970's and early 1980's. The product was used by a few organic growers, but was never fully developed commercially and eventually faded from use some years ago. A new GV product, Virosoft $^{CP4®}$ (Biotepp, Quebec, Canada), was tested in 2001, but failed due to inadequate formulation. Virosoft was apparently reformulated and sold under a different label in the Northwest in 2003 (unconfirmed report).

Several potentially useful non-GV were tested in 2002 and showed significant control in a single tree plot in Lake County when applied multiple times: kaolin clay (Surround®, Engelhard Corp., New Jersey) is widely used in the Pacific Northwest pre-bloom for pear psylla control, as well as to enhance fruit finish and reduce sunburn; an organic formulation of spinosad (Entrust® 80WP, Dow Agrosciences, Indiana) which was approved by EPA and OMRI for use in organic pome fruit orchards in 2003; and a relatively new pyrethrum formulation (PyGanic 1.4 EC, McLaughlin Gormley King Co., Minnesota), which failed to provide significant control.

In 2003, Entrust®, as well as two new GV products, Carpovirusine® (Sumitomo Corp., New York, NY) and Cyd-X® (Certis USA, Columbia, MD) were tested in Bartlett pear orchards in four locations in Northern California. Two orchards were conventionally farmed, one was certified organic, and one was in the third year of transition to organic. The purpose was to gain adequate efficacy data on selected available materials in order to support California registration and provide an objective evaluation to supplement grower experience.

The project was supported by the USDA IR-4 Program, Pear Pest Management Research Fund, and Gerber Products Company.

PROCEDURES AND RESULTS

Four replicated trials were carried out in mature Bartlett pear orchards in Mendocino, Sacramento, and Solano Counties. The first was a single tree trial comparing different rates of several test materials to standard insecticide and completely untreated controls. The other three were large scale grower-treated trials comparing Entrust, Carpovirusine and/or Cyd-X to oil and mating disruption (MD) alone. Data from a non-replicated, untreated control is included for one of the Mendocino County trials (Potter Valley).

I. **Single tree trial** (R.A. Van Steenwyk)

Site description: Hansen Orchard, Fairfield, Solano County, CA (conventional)
Mature trees, 25' x 25' spacing, 70 trees per acre
No mating disruption was applied in this orchard

Trial Design: RCBD, 4 single tree replications per treatment.

CM Pressure: Heavy

All timings were applied at semi-concentrate rate (200 gpa, 287 gal/tree) by hand held orchard sprayer operating at 250 psi.

Treatments and timings were:

Treatment	Rate lb(AI)/ac or GV part./ac	No. Appl.	Application Dates (Day-Degrees from 1st or 2nd Biofix)
1. Agri-Mek 0.15EC[a]	0.01465	1	18 April (140 from 1st biofix)
Imidan 70WP[b]	3.5	1	7 May (259 from 1st biofix)
Guthion 50WP	1.5	2	3 June (673 from 1st biofix) and 4 July (253 from 2nd biofix)
2. Carpovirusine[c]	7.6 X 10^{12}	11	30 April (207 from 1st biofix), 6 May (251 from 1st biofix), 13 May (316 from 1st biofix), 30 May (587 from 1st biofix), 9 June (758 from 1st biofix), 16 June (864 from 1st biofix), 1 July (192 from 2nd biofix), 8 July (319 from 2nd biofix), 16 July (503 from 2nd biofix), 22 July (660 from 2nd biofix) and 29 July (810 from 2nd biofix)
3. Cyd-X[c]	5.9 X 10^{12}	11	30 April (207 from 1st biofix), 6 May (251 from 1st biofix), 13 May (316 from 1st biofix), 30 May (587 from 1st biofix), 9 June (758 from 1st biofix), 16 June (864 from 1st biofix), 1 July (192 from 2nd biofix), 8 July (319 from 2nd biofix), 16 July (503 from 2nd biofix), 22 July (660 from 2nd biofix) and 29 July (810 from 2nd biofix)
4. Entrust	0.15	11	30 April (207 from 1st biofix), 6 May (251 from 1st biofix), 13 May (316 from 1st biofix), 30 May (587 from 1st biofix), 9 June (758 from 1st biofix), 16 June (864 from 1st biofix), 1 July (192 from 2nd biofix), 8 July (319 from 2nd biofix), 16 July (503 from 2nd biofix), 22 July (660 from 2nd biofix) and 29 July (810 from 2nd biofix)
5. Untreated	—		

[a] Treatments contained 0.25% Omni Supreme oil by volume.
[b] Treatment pH was adjusted to < 6.
[c] Treatments contained 0.0625% NuFilm-17.

Evaluation

Degree-days and trap catches: Degree-days were monitored using an automated CIMIS weather station located in Cordelia, CA. CM biofix is set when sunset air temperatures meet or exceed 62°F and there is a sustained moth flight. This temperature is the minimum required for CM oviposition. Flight activity of male CM was monitored with a pheromone trap placed high in the canopy of an untreated tree. The trap was placed on March 11 and inspected weekly from 19 March through 5 August.

CM Infestation: Control of CM was evaluated on August 5 by inspecting a maximum of 250 fruit per tree for CM infestation.

Secondary Pest Evaluation: Control of pear psylla (PP) nymphs, PP eggs, motile 2-spotted spider mite (TSSM) adults, TSSM eggs, motile European red mite (ERM) adults, ERM eggs, San Jose Scale (SJS) crawlers, Western predator mite (WPM) and pear rust mite (PRM) was evaluated by leaf-brushing 10 exterior and 10 interior leaves collected from each tree weekly from 13 May through 28 July. The plates with the contents from the brushed leaves were counted under magnification (20X) in the laboratory.

Results and Discussion:

Degree-days and trap catches: The overwintering CM flight began on 22 March. Biofix was set on 29 March. The overwintering flight was bimodal this year. The first peak of the overwintering flight occurred around 22 April at 165 DD. The air temperatures were unseasonably cool through early May which dramatically affected the early moth flight. The first peak often occurs at 300 DD after biofix. The second peak of the overwintering flight occurred around 27 May at 532 DD. The second peak often occurs at 650 DD after biofix. The first flight was completed by 22 June at 958 DD. The first flight is usually completed by 1,000 DD. The second biofix was set on 23 June. The peak of the second CM flight occurred approximately on 5 July at 272 DD after the 2nd biofix (Figure 1).

CM infestation: CM infestation in the untreated control was over 70%. Thus, this trial provided a stringent test of the experimental treatments. Although the Agri-Mek in the grower standard (GS) (Tr. #1) was applied mainly for its mite and psylla control, it also provided additional CM control when combined with Imidan and Guthion. The Entrust treatment (Tr. #4) was only slightly less effective than the GS. Both the GS and Entrust treatments had significantly less CM infestation than the Carpovirusine and Cyd-X GV treatments (Trs. #2 and 3) and the untreated control (Tr. #5). However, it should be noted that Entrust was applied at over 3.7 times the registered amount for the season. This high amount of Entrust was used for comparison purposes only (Table 1).

Although the Carpovirusine and Cyd-X GV treatments had high CM infestation levels, they still had significantly less CM infestation than the untreated control. Both GV treatments were applied with NuFilm-17 that likely increased their efficacy. The Cyd-X treatment showed slightly better CM control than the Carpovirusine treatment.

Secondary Pest Evaluations: The Agri-Mek plus Omni Supreme oil in the GS treatment (Tr. #1) was effective in suppressing most secondary pest flare-ups that are caused by organophosphate chemicals such as Imidan and Guthion. The other treatments also did not flare-up most of the

secondary pests and there was no significant difference between the number of PP nymphs or eggs, TSSM or ERM among any of the treatments. However, the GS had a slightly increased level of TSSM adults compared to the other treatments. The Cyd-X treatment (Tr. #3) had numerically more ERM adults and eggs than the rest of the treatments (Tables 2 and 3).

There was significantly more WPM in the untreated control than in the GS, Carpovirusine or Entrust treatments. The Cyd-X treatment had more than 3 times the number of WPM than the other organic treatments. The PRM was elevated in all the treatments compared to the untreated control. The extremely high number of PRM in the Entrust treatment is mainly due to one heavily infested replicate that greatly inflated the entire Entrust treatment's PRM mean population. All the treatments had significantly less SJS than the untreated control (Table 4).

II. Large scale trials

A. Site description: Hooper Vallette Orchard, Ukiah, Mendocino County, CA (conventional)
Mature trees, 20' x 20' spacing, 109 trees per acre

Trial Coordinator: Lucia Varela

Trial design: RCBD, 4 replications, 132 trees = 1.2 acres per plot (6 rows x 22 trees/row)
Data was taken from the center rows of each plot.

CM pressure: Moderate

Treatments applied by the grower using a commercial engine-driven air blast sprayer.

Treatments and timings were:

The entire orchard was treated with CheckMate CM-F sprayable CM pheromone (Suterra LLC, Bend, OR), 20 gms./acre, applied April 14, May 14, June 14, and July 14 (4 applications).

1) [1]MD plus Cyd-X @ 3 oz./100 gal./acre, applied May 12, 20, and 27 (1st generation), July 7, 14, 21 (2nd generation) (6 applications)
2) [2]MD plus Carpovirusine, 1 liter/264 gal./acre, applied May 12, 20, and 27 (1st generation), July 7, 14, 21 (2nd generation) (6 applications)
3) MD plus Assail @ 3 oz./acre, applied on June 14 (1B peak) (1 application)
4) MD alone

[1,2] Both GV treatments were applied with Nufilm 17 (Miller Chemical & Fertilizer Co., Hanover, PA) @ 16 oz./100 gal.

Evaluation

Degree-days and trap catches: One trap each of 1x low and 10x high were placed in the center of each plot and monitored weekly. Degree-days were monitored using an automated CIMIS weather station located in Hopland, CA.

CM infestation: 1000 fruit per replicate (500 top and 500 bottom) were sampled on July 3-17 (1061-1337 °D, 1st generation larvae) and August 7 (1803 °D, late 1st and 2nd generation larvae). The following categories were counted: emerged from egg but no sting (July sample only), sting but no worm, dead worm (July sample only), live worm, damage but worm gone (August sample only). This was done to detect GV activity as it is necessary for the larvae to ingest the GV in order to introduce it into the gut system and multiply.

Results

Degree-day and trap catches: Biofix was on March 27. Trap catches indicate two generations occurred in the orchard (Figure 1). The 1B peak occurred on June 8 (700 °D). The 2B peak occurred on August 17 (2150 °D) (Figure 2).

Egg and larval infestation: First generation damage was very low, never exceeding 0.05% in any plot, and there was no significant difference between treatments. Second generation damage (worm gone) reached 1.0% in the MD alone plot, but was only .1-.2% in the GV plots, statistically equal to the grower standard. There were, however, significantly more stings in both the GV treatments and the MD alone treatment (Tables 5 and 6).

B. Site description: Peck Ranch, Courtland, Sacramento County, CA (transition organic)
18' x 20' spacing, 121 trees/acre

Trial Coordinator: Chuck Ingels

Trial design: RCBD, 3 replications, 88 trees per plot=.83 acres per plot (8 rows x 11 trees per row)
Data was taken from the center of each plot.

CM pressure: High

All treatments applied by grower using a commercial engine driven sprayer @ 200 gpa

Treatments and timings were:

The entire orchard treated with Isomate Twin Tubes @ 200 per acre

Prior to initial replicated treatments, the entire orchard was treated with kaolin clay (Surround®, Engelhard Corp., NJ), 50 lbs. on March 25, 25 lbs. on April 15 and 23; oil (Gavicide Super 90, (Western Farm Service, Fresno, CA) 1 gal./acre on May 16 and 22. MD was Isomate Twin Tube dispensers applied @ 200/acre.

1) MD alone (through June 25 then oversprayed with oil due to high CM pressure).
2) MD plus oil @ 2 gal/acre, applied May 29, June 7, June 13, June 20, June 27, July 5, and July 12 (7 applications).
3) [1]MD plus Cyd-X @ 6 oz./acre applied May 29, June 7, June 13, June 20, June 27, July 5, and July 12 (7 applications).
4) [2]MD plus oil, then Entrust plus 1% oil @ 3 oz./acre applied May 29, June 7, and July 12 (3 applications).

[1] Cyd-X was applied with Nufilm 17 @ 16 oz./acre.

[2] Prior to May 29, 1% oil was applied on the same dates as above treatments to avoid damage while waiting for Carpovirusine to become allowable by OMRI for organic use which failed to occur in time for the 2003 season.

Evaluation

Degree-days and trap catches: Degree-days were calculated using an automated CIMIS weather station west of Lodi, CA. Male flight was monitored by placing traps with 1x and 10x lures high in trees in the orchard.

CM infestation: 1000 fruit per tree (500 top and 500 bottom) were sampled on June 23 (1030 °D, 1st generation larvae) and 2000 (1000 top and 1000 bottom) on July 18 (1576 °D, late 1st and 2nd generation larvae). 300 fruit remaining on the trees were sampled after harvest on September 20 to assess overwintering potential.

Results

Degree-days and trap catches: Biofix occurred later than normal on March 28. Cold, rainy weather prevailed through April and early May, delaying subsequent flights (Figure 3).

Egg and larval infestation: First generation damage in plots treated with oil, Cyd-X and Entrust was significantly lower than in MD alone plots (no stings were found). At this time, the MD alone plots were oversprayed with oil to avoid unacceptable damage. Second generation damage averaged 7.9% in the MD alone/oil overspray plots at harvest, while damage in MD plus season-long oil, Cyd-X and Entrust was over 50% less. (Tables 7 and 8).

C. Site description: Todd Boynton Orchard (certified organic)
20' x 20' spacing, 108 trees/acre

Trial Coordinator: Rachel Elkins

Trial design: RCBD, 3 replications, 108 trees per plot=1 acre per plot (9 rows x 12 trees per row)
Data was taken from the center rows of each plot

CM pressure: High

All treatments applied by the grower using a commercial engine-driven air blast sprayer.

Treatments and timings were:

The entire orchard was treated with Isomate Twin Tube pheromone dispensers @ 36/acre plus Suterra puffers @ 1.5/acre located in outside the plot in surrounding orchards.

Prior to initial replicated treatments, the entire orchard was treated with Surround @ 25 lbs./acre applied every other row on March 31, April 9, April 14, April 19, April 30, May 6, May 19, May 26, June 4, June 14, and June 21 (total of 5.5 applications of 50 lbs./acre) to control pear slug.

1) MD alone
2) [1] MD plus 415 oil applied @ 2.5 gal./acre July 2, July12, July 24, and August 4 (4 applications)
3) [2] MD plus Entrust, applied @ 2.5 oz./acre July 2, July 12, July 24, and August 4 (4 applications)
4) [3]MD plus Cyd-X, 3 oz./acre, applied July 2, July 12, July 24, and August 4 (4 applications)
5) Untreated control – one set of completely untreated Bartlett pear trees provided comparison data.

[1] Oil @ 3 gal./acre also included on August 4 to all treatments to control spider mites.
[2] Entrust® also applied @ 1 oz./acre on July 12 in all treatments to control pear slug.
[3] Cyd-X applied with Nufilm 17 @ 16 oz./acre.

Evaluation

Degree-days and trap catches: Degree-days were monitored using an automated Adcon weather station located in the trial orchard. One set each of 1x low, 1x high, 10xH and DA traps were hung in each block and monitored weekly.

CM infestation:

1) 600 fruit per replicate were sampled on July 14 (947 °D, 1st generation). Varying numbers of fruit (due to lack of fruit in orchard) per plot were sampled again on August 7 (1450 °D, late 1st and 2nd generation). An unreplicated post-harvest sample of fruit remaining on trees was taken in mid-September to assess overwintering potential.

Results

Degree-day and trap catches: Biofix was fixed on May 12, nearly two months later than normal due to unseasonably cold spring weather (Figure 4).

Egg and larval infestation: There were no significant first generation treatment differences. There was a trend toward significant difference (p=.07) between MD alone and Cyd-X for the August 7 pre-harvest sample. Damage ranged from 7.2% in the MD alone to 2.3% in the Cyd-X plots. Damage in the unreplicated untreated control was 34% (Table 9).

DISCUSSION

Carpovirusine and Cyd-X both controlled codling moth to some extent in all four trial locations. Level of control at harvest ranged from about 60 to over 90% versus completely untreated controls, and from about 70 to 90% versus mating disruption alone. Entrust exhibited about this level of control as well, faring even better when applied at rates above the label limit. The organic standard, oil, also reduced CM damage versus controls. The GV treatments controlled CM as well as a standard insecticide program in the one location it was used, however these treatments had a higher incidence of fruit stings.

Entrust and oil have the added benefits of being useful for controlling secondary pests. Entrust, a formula of spinosad, controls obliquebanded leafroller, and in the case of the Potter Valley location in 2003, pear slug. Oil suppresses pear psylla and mites. The need to control secondary pests with a limited range of available products resulted in both organic sites being oversprayed with Surround, Entrust, and oil at various times during the season (see above sections). Despite these variations at each site, a pattern of codling moth control was clearly established.

All the test materials were applied 3 -11 times. Since this was an unseasonably cool, prolonged spring, even more treatments may be needed in a "normal" or warm season. Cost, therefore, becomes a factor when deciding whether to use GV or Entrust. Growers, however, gain several new tools to incorporate into a codling moth program, either for full-season use or as a rotation material with other broad-spectrum or reduced-risk materials.

One aspect of GV untested in 2003 was the hypothesis that GV will "carry over" to subsequent seasons within the bodies of pupating larvae. This remains to be shown in California, but if proven, has the potential to drive down CM populations over time.

There are several relatively new possibilities for supplemental CM control in organic pear orchards. Future testing should look at various combinations in combination with MD to develop a true integrated pest management that manages CM while ensuring a good overall pest/predator balance.

ACKNOWLEDGEMENTS

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Fig. 1 – Seasonal Flight Activity of Codling Moth Captured in a Pheromone Trap Placed High in the Tree Canopy at Fairfield, CA - 2003

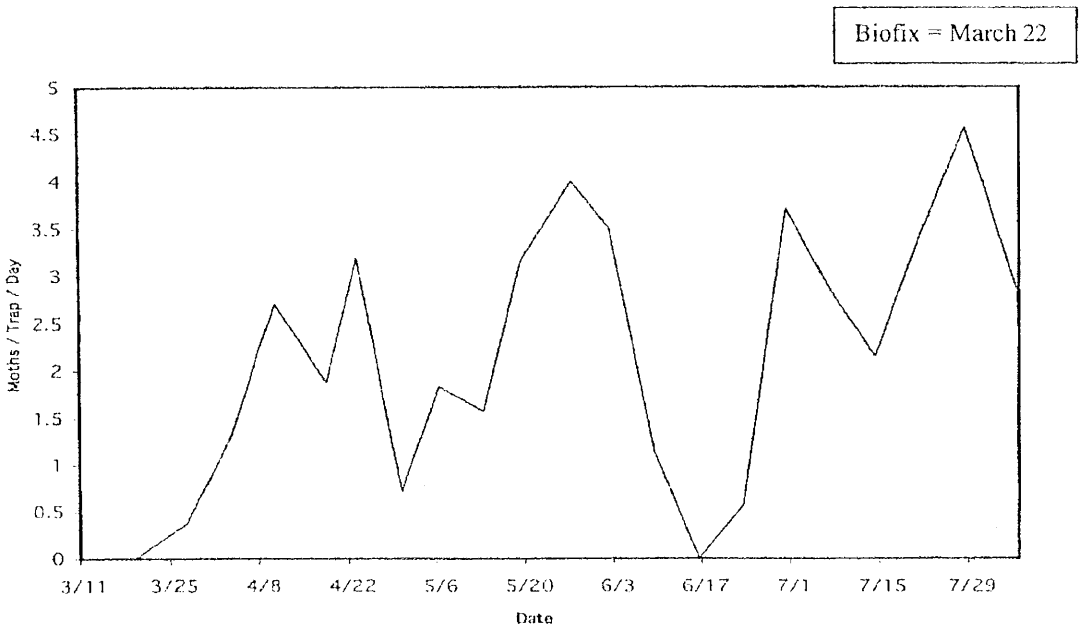


Fig. 2 – Seasonal Flight Activity of Codling Moth Captured in a Pheromone Trap Placed High in the Tree Canopy at Ukiah Valley, CA - 2003

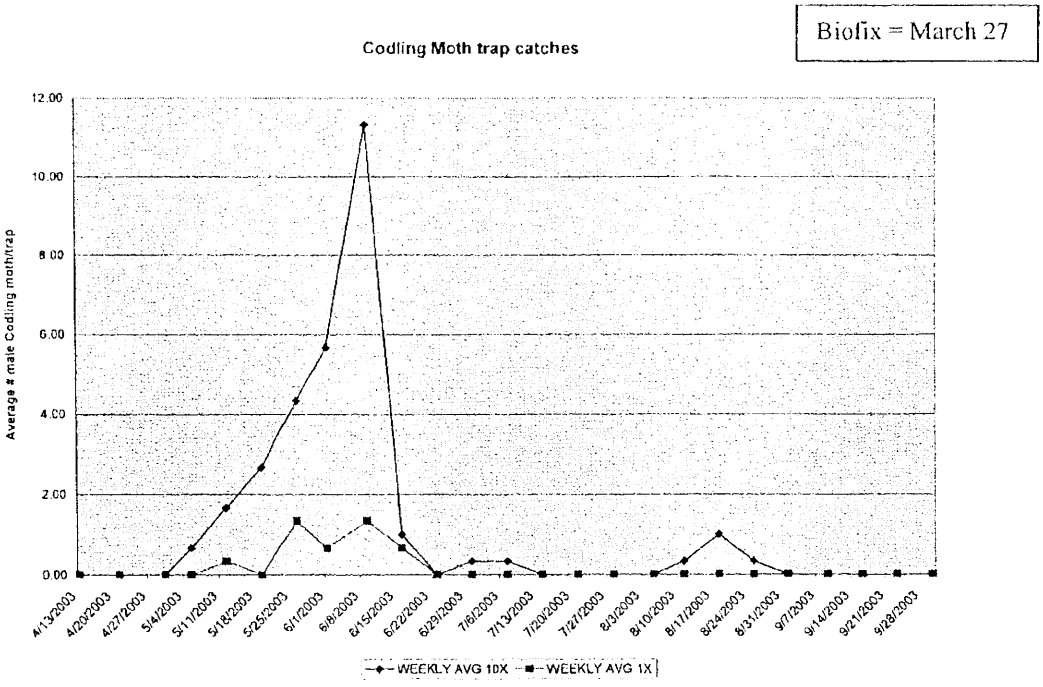


Fig. 3 – Seasonal Flight Activity of Codling Moth Captured in a Pheromone Trap Placed High in the Tree Canopy at Sacramento, CA - 2003

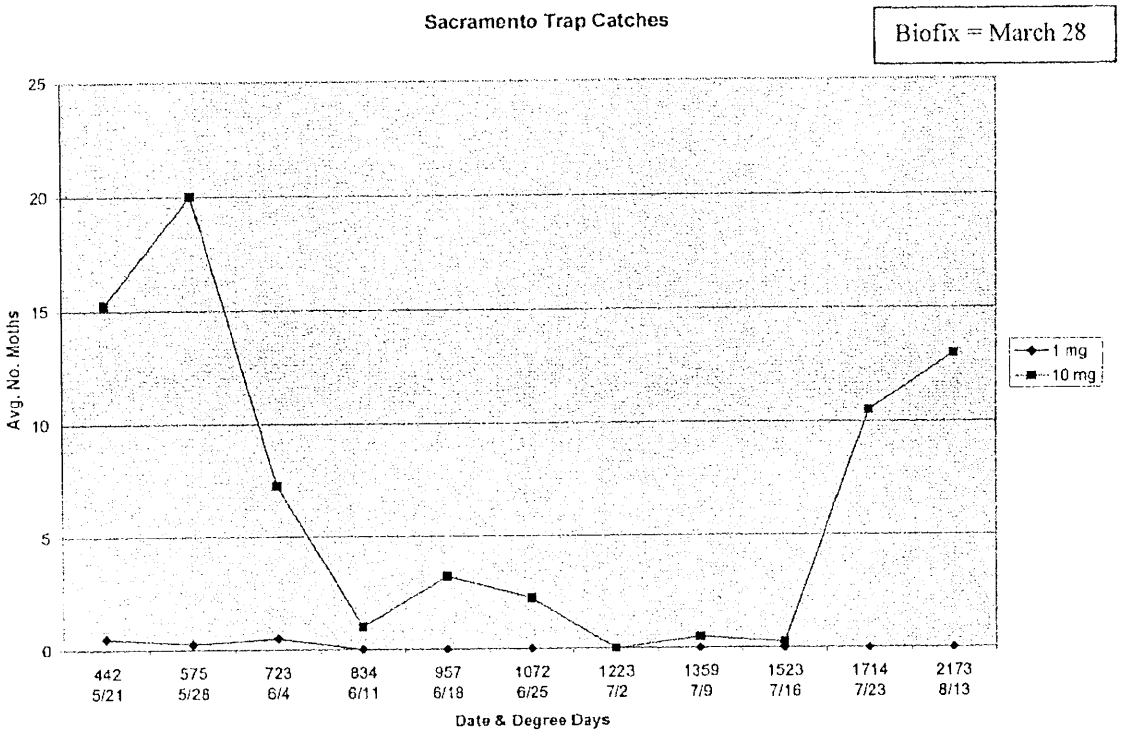


Fig. 4 – Seasonal Flight Activity of Codling Moth Captured in a Pheromone Trap Placed High in the Tree Canopy at Potter Valley, CA - 2003

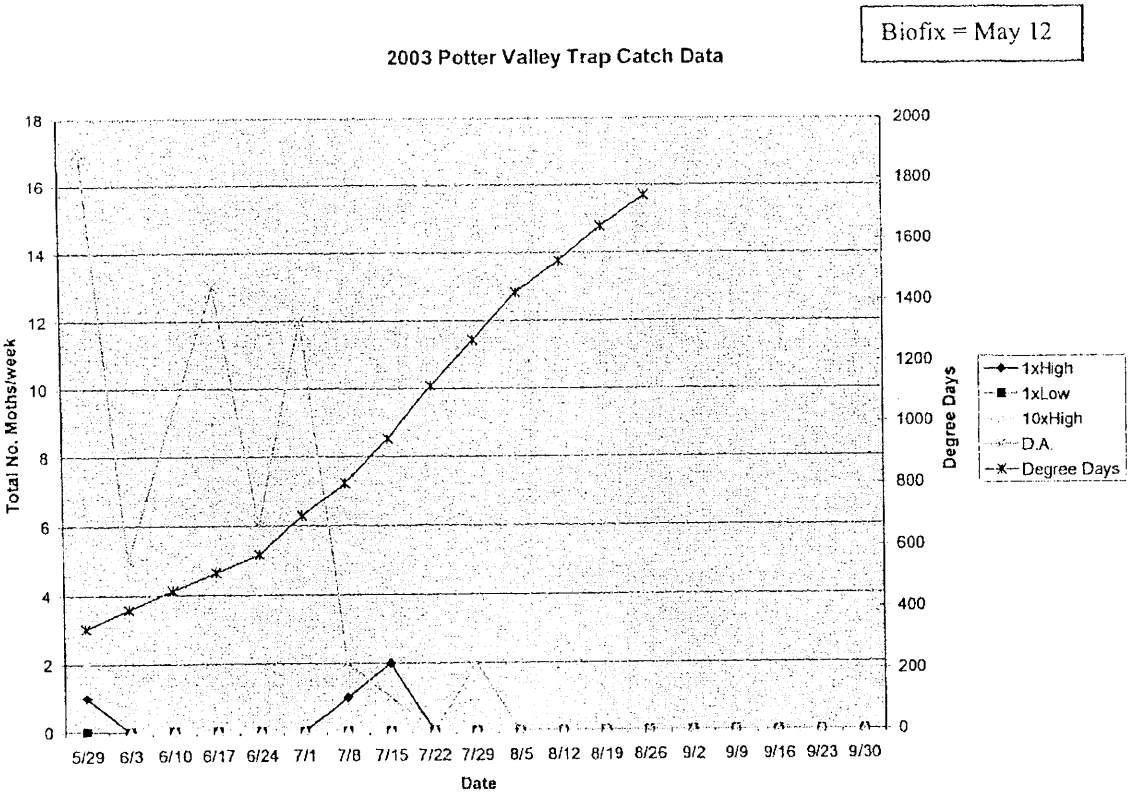


Table 1. Mean Percent Codling Moth-Infested Fruit Inspected at Commercial Harvest in Fairfield, CA - 2003.

Treatment	Rate lb (AI)/ac or GV part./ac	No. Appl.	Mean[a] Percent Infested Fruit at Commercial Harvest
1. Agri-Mek 0.15EC[b]	0.01465	1	3.7 a
Imidan 70WP[c]	3.5	1	
Guthion 50WP	1.5	2	
2. Carpovirusine[d]	7.6×10^{12}	11	30.5 b
3. Cyd-X[d]	5.9×10^{12}	11	26.9 b
4. Entrust	0.15	11	3.9 a
5. Untreated	–	–	70.2 c

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$). Data analyzed using an arcsin transformation.
[b] Treatments contained 0.25% Omni Supreme oil by volume.
[c] Treatment pH was adjusted to < 6.
[d] Treatments contained 0.0625% NuFilm-17.

Table 2. Mean Total Number of Pear Psylla Nymphs and Eggs in Fairfield, CA – 2003.

Treatment	Rate lb (AI)/ac or GV part./ac	No. Appl	Mean[a] Total per 20 Leaves PP Nymphs	PP eggs
1. Agri-Mek 0.15EC[b]	0.01465	1	133.3 a	39.0 a
Imidan 70WP[c]	3.5	1		
Guthion 50WP	1.5	2		
2. Carpovirusine[d]	7.6×10^{12}	11	112.5 a	70.5 a
3. Cyd-X[d]	5.9×10^{12}	11	150.0 a	60.8 a
4. Entrust	0.15	11	119.8 a	43.8 a
5. Untreated	–	–	141.5 a	67.3 a

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$).
[b] Treatments contained 0.25% Omni Supreme oil by volume.
[c] Treatment pH was adjusted to < 6.
[d] Treatments contained 0.0625% NuFilm-17.

Table 3. Mean Total Number of TSSM and ERM Mites and Eggs in Fairfield, CA – 2003.

Treatment	Rate lb (AI)/ac or GV part./ac	No. Appl.	Mean[a] Total per 20 Leaves			
			TSSM		ERM	
			Mites	Eggs	Mites	Eggs
1. Agri-Mek 0.15EC[b]	0.01465	1	4.8 a	4.8 a	1.5 a	56.5 a
Imidan 70WP[c]	3.5	1				
Guthion 50WP	1.5	2				
2. Carpovirusine[d]	7.6×10^{12}	11	0.3 a	3.5 a	1.8 a	111.5 a
3. Cyd-X[d]	5.9×10^{12}	11	0.8 a	3.3 a	7.5 a	273.0 a
4. Entrust	0.15	11	1.3 a	6.3 a	5.8 a	208.5 a
5. Untreated	–	–	0.5 a	6.8 a	2.3 a	169.3 a

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$).
[b] Treatments contained 0.25% Omni Supreme oil by volume.
[c] Treatment pH was adjusted to < 6.
[d] Treatments contained 0.0625% NuFilm-17.

Table 4. Mean Total Number of Western Predatory Mites, Pear Rust Mites and San Jose Scales in Fairfield, CA – 2003.

Treatment	Rate lb (AI)/ac or GV part./ac	No. Appl.	Mean[a] Total per 20 Leaves		
			WPM	PRM	SJS
1. Agri-Mek 0.15EC[b]	0.01465	1	0.3 a	151.5 a	13.3 a
Imidan 70WP[c]	3.5	1			
Guthion 50WP	1.5	2			
2. Carpovirusine[d]	7.6×10^{12}	11	1.8 a	178.5 a	33.0 a
3. Cyd-X[d]	5.9×10^{12}	11	6.5 ab	375.0 a	40.0 a
4. Entrust	0.15	11	2.0 a	1712.0 a	48.3 a
5. Untreated	–	–	8.8 b	43.5 a	163.5 b

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$).
[b] Treatments contained 0.25% Omni Supreme oil by volume.
[c] Treatment pH was adjusted to < 6.
[d] Treatments contained 0.0625% NuFilm-17.

Table 5. Mean Percent Codling Moth Infested Fruit Inspected After the First Generation, Ukiah, CA – 2003

Treatment	% infestation/1000 fruit [a]			
	Emerged from egg, no sting	Sting No worm	Dead worm	Live worm
MD plus Cyd-X[b]	.00	.02	.00	.01
MD plus Carpovirusine[c]	.02	.05	.01	.02
MD plus Assail	.00	.01	.00	.02
MD alone	.00	.00	.00	.00

[a] There was no significant difference between treatments (Fisher's protected LSD, $p \geq 0.05$). Data analyzed using an arcsin square root transformation.
[b, c] Treatments applied with 16 oz. NuFilm-17.

Table 6. Mean Percent Codling Moth Infested Pear Fruit Inspected Prior to Commercial Harvest after the 2nd generation, Ukiah, CA – August 7, 2003

Treatment	% infestation/1000 fruit [a]		
	Sting – no worm	Live worm	Worm gone
MD plus Cyd-X[b]	0.4	0.0	0.1 a
MD plus Carpovirusine[c]	0.3	0.1	0.2 a
MD + Assail	0.0	0.1	0.0 a
MD alone	0.4	0.2	1.0 b

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $p \geq 0.05$). Data analyzed using an arcsin transformation.
[b, c] Treatments contained 0.0625% NuFilm-17.

Table 7. Mean Percent Codling Moth Infected Fruit After the 1st Generation, Courtland, CA – 2003

Treatment	Rate	No. Appl.	% Damage[a]	
			Tree (July 23)	Ground (July 1)
MD plus oil	2 gal.	7	0.2 a	1.4
MD+oil+Entrust	3 oz.	7+3	0.2 a	1.0
MD+Cyd-X[b]	6 oz.	7	0.1 a	1.7
MD alone, then oil	-	3	0.8 b	2.3

[a] means followed by the same letter within a column are not significantly different (Fishers protected LSD, $P \leq .05$).
[b] 16 oz. Nufilm 17 applied with Cyd-X.

Table 8. Mean Percent Codling Moth Infected Fruit at Harvest, Courtland, CA – 2003

Treatment	Rate	No.Appl.	% Damage[a] Tree (July 18)	PH (Sept. 20)
MD plus oil	2 gal.	7	2.5 a	10.0
MD+oil then Entrust	2 gal. + 3oz.	7 + 3	1.6 a	10.2
MD+Cyd-X[b]	6 oz.	7	2.0 a	6.4
MD alone, then oil	2 gal.	3	8.1 b[c]	14.6

[a] Means followed by the same letter within a column are not significantly different (Fishers protected LSD, P≤.05).
[c] No. strikes significantly higher in lower fruit
[b] Cyd-X applied with 16 oz. Nufilm 17

Table 9. Mean Percent Codling Moth-Infested Fruit, Potter Valley, CA -- 2003

Treatment	Rate	No.Appl.	% Damage[a] 1st Gen. (July 14)	Harvest (Aug. 7)
MD plus 415 oil [b]	2.5 gal.	4	0.5	4.0 ab
MD plus Entrust [c]	2 oz.	4	0.8	3.7 ab
MD plus Cyd-X [d]	3 oz./16 oz.	4	1.0	2.3 a
MD alone	-	-	0.7	7.2 b
Untreated Control	-	-	3.8	34.0 -

[a] Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, P≤0.05). Data analyzed using an arcsin square root transformation.
[b] 3 gal. 415 oil applied to all treatments on August 4 to control spider mites.
[c] 1 oz. Entrust® applied to all treatments on July 12 to control pear slug.
[d] Cyd-X applied with 16 oz. Nufilm 17.

Progress Report— January 2004

Grant through Biopesticide Program IR-4
April 1, 2003-May 31, 2004

Improving Mass Production of the Gypsy Moth Pathogen *Entomophaga maimaiga*

Ann E. Hajek
Department of Entomology
Cornell University

As an introduction, there is very real demand for availability of *Entomophaga maimaiga* for release for gypsy moth control. We have determined that the resting spore stage is the stage to use for release. This obligate pathogen is difficult to grow; we can grow it in vivo but we've now developed methods for in vitro production of resting spores. However, a problem with laboratory production is spore dormancy. We've discovered a way to get in vivo-produced resting spores to germinate without going dormant. With this background, we proposed the following objectives for this project.

Original Objectives

1. Evaluate dormancy of in vitro-produced resting spores of *Entomophaga maimaiga*
2. Develop methods to ensure prevention of dormancy for in vivo-produced resting spores
3. Develop methods for mass production of non-dormant *Entomophaga maimaiga* resting spores

This study was funded for $15,000 and not the full amount requested which was $20,152. Therefore, all of the original objectives cannot be satisfied completely. Also, this grant has several more months before it ends and I expect to make more progress over that time. To date, our major efforts have been directed toward Objective 2. I will describe in detail our methods and results below.

2. Develop methods to ensure prevention of dormancy for in vivo-produced resting spores

Effect of light on dormancy. In nature, resting spores are produced in later instar gypsy moth larvae. We've found that some fungal isolates are much more prone to make resting spores than others and resting spores are produced at higher temperatures. Resting spores are normally made within late instars and they take several days to a week to mature to their thick-walled, environmentally resistant state. We feel that conditions when resting spores are maturing affect whether they become dormant or not. We conducted studies to determine the effect of light on whether resting spores become dormant. We injected gypsy moth larvae with protoplasts of an isolate of *E. maimaiga* (01JP412-2) known to produce abundant resting spores. Five-six days after larval injection (by which time

larvae would have just died), we placed individual cadavers in 29.6 ml plastic cups containing 1.5% water agar in constant dark or photoperiods of 14:10 or 15.5:8.5 (light: dark) at 20 C for 16 days, during which time resting spores would mature. After this period, we dissected five cadavers from each treatment to observe maturation of resting spores. For all treatments, resting spores from virtually all cadavers checked were visually mature, at the C5 stage. We soaked five cadavers of each treatment in water and divided the suspension between 3 deli cups of sterile soil for 29 days at 15 C. We then exposed gypsy moth larvae to the soil for 4 day periods and then reared the exposed larvae at 20 C to detect infections. This was repeated with the same soil cups 43 and 57 days after the cadaver suspension was added to soil cups and this entire procedure was repeated so that a second set of cadavers were assayed at 28 days.

We had been looking for an all or nothing response; we hypothesized that resting spores might need a specific photoperiod during maturation to go into dormancy. We tested this using the extreme of no light during resting spore maturation versus two photoperiods. Contrary to our hypothesis, we found abundant infections in all light treatments, with no clear pattern indicating more infections occurred for any specific treatment. Therefore, our light treatments had not caused the fungal resting spores spores to go into dormancy.

Effect of moisture on dormancy. Our second hypothesis has been that moisture levels present while resting spores are maturing will initiate dormancy. We've conducted three different experiments to test this hypothesis.

Our largest experiment involved injecting late instar larvae with protoplasts two different isolates of *Entomophaga maimaiga* from central New York (00NY1-1-2, 94NY1-4A). Because we've also found that fungal isolate makes a difference in resting spore dormancy, we hypothesized that infection by conidial showers or the generation of infection after a resting spore infection (primary infection in the field) might have an effect. Therefore, in this experiment, we also included treatments of larvae exposed to showers of conidia from these same isolates (conidial showers from cadavers of injected insects) and a treatment of larvae infected by exposure to conidial showers from cadavers of larvae exposed to resting spores. We also included a treatment with larvae co-injected with both strains (an idea based on results from other systems in the scientific literature). After injection or inoculation, larvae were reared either in the laboratory (25 C, 14:10) on artificial diet or in the field in bags on branches of oak trees. 23-25 days after injection, cadavers were checked visually for resting spore maturity. Nine of the 12 treatments did not produce enough mature resting spores and were thus could not be used for bioassays. To conduct bioassays, we used a very similar procedure as that described above, with cups of sterile soil and suspensions of cadavers containing resting spores added to cups with gypsy moth larvae then added to cups for 4 day intervals at 15 C. The first bioassays were conducted just after cadavers were collected in the field and were then repeated twice at 2 week intervals. Remaining cadavers were stored on water agar at 4 C and, after one month of cold, bioassays were repeated three times with only six of the treatments (mature resting spores were not present in cadavers from the other treatments).

We had expected an all or nothing response, that dormant resting spore would not yield infections but treatments where resting spores were not dormant would result in

infections. We found no infections until the very last bioassays with the cadavers that had been at 4 C for one month for only one treatment; perhaps these resting spores had been dormant and dormancy had been broken by that time. What we had expected was at least some infection in the first bioassays to demonstrate that some treatments had not gone into dormancy. Unfortunately, for some treatments (especially conidial showers), many of the cadavers did not produce resting spores so we could not evaluate all treatments. Interestingly, we expected from previous studies that resting spores from the laboratory treatment with injected larvae would not go into dormancy. However, this treatment was not maintained according to previous methods that stopped dormancy initiation; infected insects and then cadavers with resting spores were kept at 25 C for a total of 3 weeks before bioassays or cold storage. The resulting resting spores might not have been viable or perhaps this warmer temperature during resting spore maturation caused these resting spores to become dormant. This is clearly an interesting result from this study and we will continue investigations of temperature.

The second experiment was an extension of the first, using dried cadavers or cadavers of recently dead late instars collected in the field in mid-July (naturally infected), storing them individually on water agar or dry in the laboratory. We conducted bioassays in a similar way (exposing larvae to resting spore suspensions on sterile soil) to determine whether any infections occurred. Soil suspensions were placed in cups of soil one month after cadaver collection and cups of soil then remained at 15 C for 2 months before bioassays. No infections occurred. Although the time interval was long before bioassays were conducted, previous studies in our laboratory demonstrated that we would have seen infection in non-dormant treatments and no infection in cups with dormant resting spores. Therefore, placing recently dead field-infected late instars on water agar at constant temperatures in the laboratory did not prevent dormancy.

We also conducted a study to examine individual resting spores on water agar in petri dishes to visualize germination for treatments where gypsy moths would be exposed to moisture for different periods after injection with protoplasts of two different isolates (00NY1-1-2, JP4-12-2). Larvae within 24 hours of death were placed under 6 treatments of exposure to 60% RH for 24 h periods at varying intervals after larval death with the remainder of the time at 100% RH. Eighteen days after injection of larvae, germination was evaluated with three plates for 3 cadavers for each treatment on 1.5% water agar at 20 C in the dark. Germination was checked every 2 days for 2 weeks. The 00NY1-1-2 isolate was discontinued in this study because enough resting spores were not formed in cadavers. Germination was only seen for resting spores of JP4-12-2 held at 60% RH constantly after host death but percent germination was low.

IR-4 Progress Report – June 14, 2004

Improving Mass Production of the Gypsy Moth Pathogen *Entomophaga maimaiga*

Ann E. Hajek, Dept. Entomology, Cornell University

Studies Conducted Spring 2004 and Plans for Summer 2004

I consider that there have been two major barriers to the ability to mass produce *E. maimaiga* as a biopesticide. We have focused on the resting spores as the stage that should be mass produced, based on results from our studies. First, we needed to be able to produce resting spores *in vitro* and we have developed the methodology and media for this (Kogan & Hajek 2000). Second, we needed to deal with the resting spore survival and dormancy so that we would be assured that resting spores would be able and ready to germinate when released in the field. We have learned how to keep resting spores alive (Hajek et al. 2001) but the ability to manipulate resting spore dormancy eluded us. Each year in the field the resting spores produced in July are dormant and the next spring some come out of dormancy and germinate, while others remain dormant; so, once resting spores are dormant, it can be a very long time before they germinate naturally. We conducted many studies trying to figure out how to break resting spore dormancy. During our studies, we learned that we could altogether prevent dormancy and this seemed like such a terrific alternative that we began pursuing this avenue instead. However, we realized that we needed to understand exactly what conditions are necessary to prevent resting spore dormancy, so that once resting spores were mass produced, small changes in production conditions did not result in dormant resting spores. Also, we clearly needed to conduct studies with *in vitro*-produced resting spores to make sure that dormancy could be prevented in them the same way that dormancy is prevented in *in vivo*-produced resting spores. The following experiments have been and are being conducted to address these latter issues that must be clarified before mass production would be possible.

Each of the assays that are being conducted requires at least 2.5 months from set-up until the end of the bioassay:

Grow fungal protoplasts to infect larvae	5 days
Inject larvae to produce resting spores and larvae die	5-7 days
Resting spores mature	14 days
Period of time before infection begins abundantly	ca. 45 days

Therefore, these experiments cannot be completely in a brief time frame.

1. Effect of temperature during resting spore maturation on initiation of resting spore dormancy. Bioassays conducted only with isolate ARSEF 6162 of the gypsy moth pathogen *Entomophaga maimaiga*, the isolate displaying lack of initiation of resting spore dormancy previously. Resting spores were produced in late instar gypsy moth larvae, allowing resting spores to mature after insect death and then placing resting spores on soil, as per standard methods (see Hajek et al. 1999, 2001). After insect death different

groups of cadavers were placed at 15, 20 and 25 C during resting spore maturation (approximately 14 days). After this maturation interval, for most treatments resting spores were washed with mercuric chloride and then rinsed thoroughly to kill any microbial contaminants. Resting spores were placed on soil in bioassay cups at 15 C at which time the density of resting spores and level of resting spore maturation was also quantified. Resting spores on soil then remained at 15 C through the time when bioassays were conducted. At varying intervals after resting spores were placed on soil, fourth instar gypsy moth larvae were exposed to resting spores for 4 day periods and then placed at 20 C for 10 days and checked daily for larval death and conidial production. At least 10 days later, cadavers of any larvae dying were dissected to detect production of resting spores within cadavers.

First replicate. This study was initiated in 3 March 2004; 22, 32, 47 and 54 days after resting spores were placed on soil, healthy larvae were placed in soil cups for 4 day periods. Infection was abundant for cups containing resting spores matured at 15 C but was meager or did not occur at all for resting spores maturing at 20 or 25 C (Table 1).

Table 1. Percent infection among gypsy moth larvae exposed to *Entomophaga maimaiga* (ARSEF 6162) resting spores after placing resting spore-producing cadavers at varying temperatures for two weeks after insect death during resting spore maturation

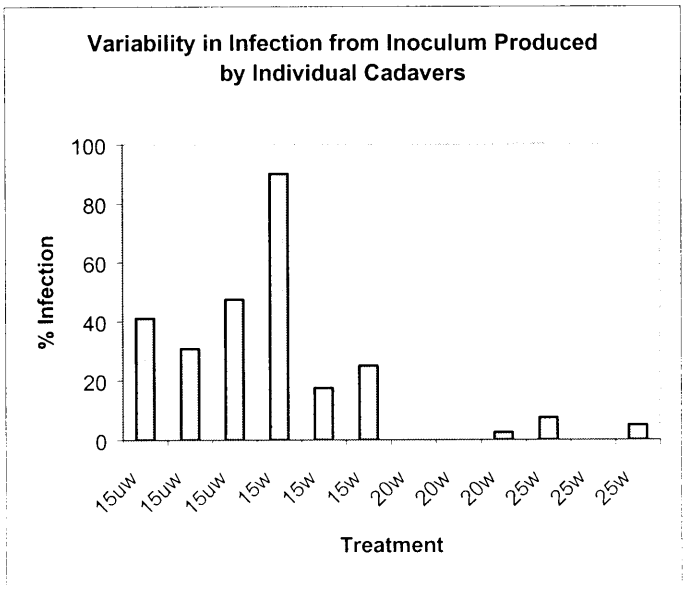
	Interval after resting spores placed on soil			
Temp during resting spore maturation*	22 days	32 days	47 days	54 days
15 C no $HgCl_2$	18.6 ± 18.6	16.7 ± 12.0	76.7 ± 14.5	46.7 ± 21.9
15 C $HgCl_2$ wash	36.7 ± 17.6	33.3 ± 28.5	56.7 ± 21.9	50 ± 25.2
20 C $HgCl_2$ wash	0	0	0	3.3 ± 3.3
25 C $HgCl_2$ wash	6.7 ± 6.7	0	10 ± 5.8	0

*2 week interval after host death

Infection was slightly higher in cups where resting spores had been washed with mercuric chloride so this became a standard procedure for subsequent assays.

Within each treatment, infection was quite variable among cups (see Figure 1), suggesting that for different cadavers, the numbers of resting spores germinating was quite different; this could be in part due to different densities of resting spores on the soil but there is also the potential that resting spore germination varied by cadaver, regardless of resting spore number in a cadaver.

Fig. 1. Total infection in bioassay cups among gypsy moth larvae exposed to *Entomophaga maimaiga* (ARSEF 6162) resting spores after placing resting-spore producing cadavers at varying temperatures for two weeks after insect death for resting spore maturation*



*w = washed with $HgCl_2$; uw = not washed with $HgCl_2$

Second replicate. Based on these results, this study is being replicated. We found a low level of infection among resting spores matured at 20 and 25 C and we found variability among cadavers in the levels of infection and this first bioassay only tested resting spores from three different cadavers for each treatment. For these reasons, this study is presently being replicated using 6 cadavers per maturation temperature, and washing all resting spores with mercuric chloride before they are placed on soil.

Field confirmation. Resting spores produced in the field never germinate directly after being produced. We hypothesize that this is due, in part, to warmer temperatures in the field in late June and early July when 5th+ instars that would produce resting spores would naturally die of *E. maimaiga* infections. To confirm our laboratory findings, we will collect gypsy moth larvae from high density populations with a history of *E. maimaiga* infections and will place collected larvae at 15, 20 or 25 C. Additional field-collected larvae will be kept in a field insectary to die and ambient temperature and RH will be monitored at this field site. We will try to collect enough larvae so that at least 6 larvae from each treatment are infected with *E. maimaiga*. We will evaluate subsequent dormancy of resting spores by 1. visually rating resting spore maturation stage, and by 2. exposing gypsy moth larvae in bioassay cups using optimal standard procedures. We hypothesize that resting spores from *E. maimaiga* maintained in the field insectary and the majority of those resting spores matured at 20 and 25 will not germinate while resting spores at 15 C during their maturation will germinate.

2. Effect of fungal isolate on ability to avoid dormancy when *E. maimaiga* is matured at 15 C after host death. The isolate that has been used to study infectivity of *Entomophaga maimaiga* without dormancy was isolated from soil collected in Japan in 1998. It will be much more difficult to register this isolate for use as a biopesticide in the U.S. than a U.S. isolate. Also, we know that there are numerous biological properties that vary by isolate for *E. maimaiga*. Therefore, these bioassays are presently being conducted to compare the ability to not go into dormancy for 6 different isolates: 2 from Massachusetts, 1 from New York State, 1 from Northeastern China, 1 from Japan (the original isolate used in Experiment 1) and 1 from the Russian Far East. For each isolate, resting spores from 6 cadavers are being bioassayed separately, except the Chinese isolate which did not produce spores abundantly so 7 cadavers were merged for one bioassay cup and three additional bioassay cups contained resting spores from individual cadavers. These studies are only being conducted at 15 C.

3. Conducting bioassays without soil and confirming which fungal cells are germinating. Using similar procedures, only the Japanese isolate is being tested at 15 C, with 10 cadavers. Resting spores produced from individual cadavers are processed as described above and are then added to sterile non-compressed felt in bioassay cups. Bioassays will be conducted after 30 days. In addition, after infections have begun, cells will be washed from 4 of the cups where infection has occurred. These cells will be added to sterile water agar and cells will be watched daily to confirm the type of cells germinating to cause infection. This study will hopefully identify a more standardized substrate for bioassays than soil and will confirm that resting spores are actually the cells that are germinating. This close attention to fungal cells should also help us to understand which of the various maturation stages of fungal cells are germinating without dormancy. This might sound very elementary but resting spores are so difficult to work with that such studies have really never been undertaken and no one has previously identified that dormancy of entomophthoralean resting spores can be avoided through specific manipulations.

4. Interaction between temperature and drying in initiating dormancy. In the field in central New York State, resting spores are produced in late instars in late June or early July. Temperatures are somewhat warmer at that time. However, we've seen through experiments thus far that some germination occurs when resting spores mature at 20 and 25 (although very limited), but we have never found any infection from resting spores in the field at this time. We hypothesize that the drying that occurs when resting spores mature within cadavers of gypsy moth larvae hanging on trees interacts with temperature to initiate dormancy. Studies are presently being initiated to hold resting spores at 15 C when they are maturing but simultaneously expose them to different levels of humidity for the 2 week period during which they mature: on water agar (free water), over solutions maintaining either 90% or 55% RH or over silica gel (0% RH). We hypothesize that we will only find infection from the treatment where resting spores are exposed to high levels of moisture during maturation.

5. Lack of initiation of dormancy for *in vitro*-produced resting spores. Resting spores will be produced *in vitro*, following published protocols and using 5 isolates known to produce abundant resting spores *in vitro* (see Kogan & Hajek, 2000) plus the Japanese isolate that we know can be manipulated to avoid dormancy. Previous studies with *in vitro*-produced resting spores did not evaluate whether resting spore production was affected by different temperatures. Therefore, the effect of temperature on resting spore production by different isolates must be studied first and avoidance of dormancy when resting spores are matured at different temperatures will be evaluated afterward.

Effect of temperature on *in vitro* resting spore production. Resting spores will be produced in 2 ml of media in standard 25 cm^2 cell culture flasks. Triplicate flasks for each isolate (6 total) will be placed at 15, 20 and 25 for 21 days, after which resting spores produced in each flask will be counted.

Effect of resting spore production and maturation temperature on avoidance of dormancy. Resting spores will be harvested by passing cell culture media with fungal cultures through a 63 micron sieve and collecting fungal cells on a 20 micron sieve 14 or 21 days after cultures are initiated. Based on results from Experiment 3 above, we will hopefully know that sterile non-compressed felt is appropriate as a substrate for bioassays. Resting spores will be placed on felt (a substrate with ample aeration surface area but which can stay very moist) and, at varying intervals, bioassays will be conducted. In addition, activity of fungal cells will be observed microscopically to evaluate activity.

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Kogan, P.H. and A.E. Hajek. 2000. *In vitro* formation of resting spores by the insect pathogenic fungus *Entomophaga maimaiga*. J. Invertebr. Pathol. 75: 193-201.

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Efficacies of Selected Insecticides on Onion Thrips in South Texas

T.-X. Liu

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The objectives

To determine the efficacies of selected insecticides for management of onion thrips, *Thrips tabaci*, and/or western flower thrips, *Frankliniella occidentalis* on onions in south Texas.

Materials and Methods

Table 1. Materials and applications

Insecticide	Rate lb ai/ac	Company	Application Dates
1 Novaluron 0.83 EC	12 oz	Uniroyal	3/11, 3/25, 4/7
2 Novaluron 0.83 EC	16 oz	Uniroyal	3/11, 3/25, 4/7
3 Lannate*	2 pts	Du Pont	3/11, 3/25, 4/7
4 Knack 0.86 EC* pyriproxyfen	10 oz	Valent	3/11, 4/24
5 Dinotefuran	25 g ai	Valent	3/11, 3/25, 4/7
6. Repel	1 qt	UAS America	3/11, 3/25, 4/7
7 Mycotrol	1 qt	Emeral Bio	3/11, 3/25, 4/7
8 Warrior* 1 EC	3.84 oz	Syngenta	3/11, 3/25, 4/7
9 Repel + Dinotefuran	1 qt + 25 g ai	-	3/11
10 Repel + Mycotrol	1 qt + 1 qt	-	3/11, 3/25, 4/7
11 Repel + Knack	1 qt + 10 oz	-	3/11, 3/25, 4/7
12 Warrior 2x Knack 2 x	3.84 oz + 10 oz		3/17, 3/25, 4/2, 4/7
13 Untreated		-	

***Local standard**

Field Trial

Onion plants (variety 1015Y) were directly seeded in two rows on 10 in centers on 40 in beds on 10 October 2001. Experimental plots were two beds wide and 14-20 ft long, and were separated by two rows of sorghum (windbreaks) across the rows and 2 ft alleys down the rows. All plots were arranged in a randomized complete block design with 4 replications.

Insecticide Application

All insecticides as shown in Table 1 were applied using a tractor-mounted sprayer at 100 psi and 30 gpa with 3 TX7 hollow cone nozzles per row (1 on top and 2 on drops).

Knack was applied twice on 11 March and 2 April.

Repel + Dinotefuran were applied only once on 11 March.

Warrior 2x and Knack 2x: Warrior was applied twice on 17 and 25 March, and Knack was applied twice on 2 and 7 April, respectively.

All other insecticides were applied trice, on 11 and 25 March and 7 April.

Thrips sampling

Adults were collected from across the test field to determine the species composition. All thrips were counted and recorded on each of 5 randomly selected plants from each plot on each sampling date. Thrips were sampled on 10, 18, and 24 March, 1, 7, 15, and 22 April.

Damage Evaluation.

At termination on 25 April, onion plants from 10 ft long from each of 5 beds (10 rows) were collected. Thrips damage on foliage was evaluated based on the 5 categories: 0, no damage; 1, minor damage (1-20% leaves whitefish and damaged); 2, minor-moderate damage (21-40% leaves whitish and damaged); 3, moderate damage (41-60% leaves whitish and damaged); 4, moderate-heavy damage (61-80% leaves whitish and damaged); and heavy damage (100% leaves whitish and dead). These onions were then graded and weighed.

Data Analysis.

Numbers of thrips per plant from each of the 10 plants from each plot were subjected to analysis of variance (ANOVA), and the means were separated using the least significant difference test (LSD) at $P = 0.05$ (SAS Institute 2002).

Results and Discussion

Thrips populations were high throughout the mid to late onion growing season. Generally, thrips densities were lower on the onion plants treated with all insecticides over the season, although the thrips densities were exceeded the economic threshold in all insecticide treatments.

Thrips (Tables 1-3).

Thrips adults. There were significant differences in overall numbers of adult thrips on onion plants (Table 1) between the insecticide treatments and untreated control, and among the insecticide treatments. However, there were no clear cut which insecticides had better control. Generally, plants treated Repel and/or Mycotrol had more adults than others, whereas plants treated with Knack, Lannate, Dinotefuran, and Novaluron 16 oz had slightly fewer adult thrips.

Thrips immatures. Thrips populations built up from early March, increased rapidly from mid March to late April. In general, the treatments, Lannate, Novaluron, Repel + Knack, and Knack, had fewer immature thrips nymphs than other insecticide treatments. Plants treated with Repel had the greatest numbers of immature thrips.

All Thrips. Because of the high proportion of thrips nymphs, the overall thrips populations had the similar trend as those of immatures (Tables 1 and 2). Data in Table 2 show that thrips populations were high throughout the season, reached the highest points in early and mid April until the end of the season in late April.

Although all insecticide-treated plants had significant fewer thrips as compared with those on untreated plants, the thrips densities were still far exceed the economic threshold (5 thrips per plant). Again, plants treated with Repel, Repel + Mycotrol, Warrior followed Knack had the more thrips than other treatments. Lannate, Novaluron, Knack and Repel-Knack had the least thrips.

Onion Size and weight (Tables 3-5).

There were more larger-onions from the insecticide-treated plots than from untreated plots (Tables 3-4). Only 21% onions were "large" onions in the untreated plots, whereas generally more than 50% (2 exceptions) onions were "large" in insecticide-treated plots. Generally, lower percentages (7% or lower) of "small" onions were found in the insecticides-treated plots, whereas >16% were "small" in the untreated plots (Table 5).

4

Foliage Damage (Table 6).

Plants treated with Lannate had the least damage, followed by Novaluron, Mycotrol, Repel-Mycotrol, Warrior and Dinotefuran. Untreated plants had the highest damage ranking, followed by Repel-Knack, Repel-Dinotefuran and Repel.

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Table 1. Mean numbers of thrips (adults and immatures) on onion plants after applications of selected insecticides (Spring 2003, Weslaco, Texas)

Treatments	Adults		Immature		All thrips	
	Mean	SE	Mean	SE	Mean	SE
Dinotefuran 25 g	11.8	bc 1.0	66.0	de 2.7	77.8	cd 3.4
Knack 10 oz	10.5	c 0.8	62.6	de 2.7	73.1	de 3.1
Lannate 2 pts	10.7	bc 0.7	52.4	e 2.5	63.1	e 2.9
Mycotrol 1 qt	14.5	ab 1.1	64.9	cd 2.6	79.4	cd 3.3
Novaluron 12 oz	13.4	bc 1.0	62.4	de 2.4	75.8	cde 2.9
Novaluran 16 oz	11.8	abc 0.9	58.0	de 2.3	69.8	de 2.8
Repel 1 qt	13.1	abc 1.1	79.9	b 3.2	93.0	bc 3.8
Repel + Dinotefuan	12.0	bc 0.8	76.1	bc 3.4	88.0	bc 3.8
Repel + Knack	12.1	abc 1.0	61.0	de 2.4	73.2	bcd 2.9
Repel + Mycotrol	15.8	a 1.5	66.6	cd 2.5	82.4	bcd 3.4
Warrior 3.84 oz	11.9	bc 0.8	67.1	cd 3.3	79.0	cd 3.7
Warrior 2x, Knack 2x	13.0	abc 0.9	68.4	cd 3.1	81.4	bcd 3.6
Untreated Control	13.0	abc 0.9	101.9	a 4.6	117.9	a 5.3

*Means in the same column followed by the same letters do not differ significantly at P = 0.05 (Tukey, SAS Institute 2002).

Table 2. Mean numbers of all thrips (adults and immatures) on onion plants after applications of selected insecticides (Spring 2003, Weslaco, Texas)

Treatments	3/10/03		3/18/03		3/24/03		4/01/03		4/07/03		4/150/3		4/22/03	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Dinotefuran 25 g	44.8	3.2	30.2	2.9	44.3	4.6	90.6	8.3	104.2	8.0	132.2	11.6	98.3	6.0
Knack 10 oz	34.5	2.8	48.2	5.0	51.2	3.9	88.6	8.5	90.6	7.0	109.8	12.5	88.6	7.1
Lannate 2 pts	36.9	2.8	33.5	3.4	34.2	4.0	74.2	7.8	85.7	6.7	128.6	7.9	48.6	3.9
Mycotrol 1 qt	41.3	3.7	65.7	5.5	55.9	5.4	117.5	9.0	94.6	7.0	129.6	11.3	51.2	4.1
Novaluron 12 oz	55.1	5.0	63.9	4.5	66.6	7.0	93.5	7.7	76.8	6.6	119.3	11.5	55.6	4.6
Novaluron 16 oz	54.5	4.3	39.8	4.6	52.3	5.7	105.9	6.6	81.5	8.4	97.9	9.6	56.7	4.9
Repel 1 qt	56.1	4.7	54.1	4.8	60.6	7.1	124.5	8.9	99.7	7.5	131.2	13.0	125.3	10.8
Repel + Dinotefuran	36.7	3.3	42.3	4.5	59.3	5.3	91.1	6.2	95.3	6.5	170.4	11.7	121.1	9.3
Repel + Knack	46.3	3.8	44.5	4.1	54.3	4.5	123.7	9.2	90.7	10.4	74.7	6.0	78.1	5.6
Repel + Mycotrol	60.8	6.4	44.8	3.5	55.3	6.8	134.2	11.4	102.0	6.7	113.5	8.0	66.7	7.0
Warrior 3.84 oz	54.0	3.9	37.9	2.8	33.8	3.8	71.4	6.8	89.9	6.4	172.4	13.3	93.7	7.0
Warriot 2x Knack 2 x	.	.	.	.	39.6	3.4	68.2	6.0	103.6	6.1	108.6	9.9	86.8	7.9
Untreated Control	45.3	3.3	80.9	8.5	44.3	3.1	149.3	7.6	101.6	6.4	206.6	13.6	138.4	15.7

*Means in the same column followed by the same letters do not differ significantly at P = 0.05 (Tukey, SAS Institute 2002).

Table 3. Mean numbers of small, medium and large onions after applications of selected insecticides (Spring 2003, Weslaco, Texas)

Treatment	Small onions		mediumn onions		largen onions	
	Mean	SE	Mean	SE	Mean	SE
Dinotefuran 25 g	1.50	0.96	14.75	1.31	20.25	4.82
Knack 10 oz	1.00	1.00	14.75	2.69	22.00	4.30
Lannate 2 pts	2.75	1.60	14.25	5.79	21.00	1.47
Mycotrol 1 qt	1.50	0.96	14.75	3.35	17.25	4.03
Novaluron 12 oz	1.75	1.03	18.00	4.26	23.25	1.75
Novaluron 16 oz	2.25	0.85	15.00	2.48	17.00	1.08
Repel 1 qt	3.00	3.00	16.50	3.80	14.50	2.99
Repel + Dinotefuran	0.50	0.50	11.25	3.35	19.25	2.66
Repel + Knack	1.00	1.00	14.50	4.25	20.25	1.55
Repel + Mycotrol	3.75	2.39	19.25	4.77	15.75	0.95
Warrior 3.84 oz	2.75	1.89	17.25	2.43	24.00	3.39
Warrior 2x, Knack 2x	3.00	2.12	12.75	3.20	19.50	2.63
Untreated Control	7.25	3.09	4.81.00	5.12	11.50	5.63

Table 4. Mean weight (kg) of small, medium and large onions after applications of selected insecticides (Spring 2003, Weslaco, Texas)*

Treatment	Small onions		Medium onions		Large onions	
	Mean	SE	Mean	SE	Mean	SE
Dinotefuran 25 g	0.25	0.14	b 2.75	0.48	a 8.50	2.02
Knack 10 oz	0.13	0.13	b 3.25	0.48	a 7.25	1.49
Lannate 2 pts	0.25	0.14	b 2.38	0.94	a 9.00	0.00
Mycotrol 1 qt	0.25	0.14	b 2.75	0.48	a 6.25	1.44
Novaluron 12 oz	0.25	0.14	b 3.00	0.71	a 7.75	0.25
Novaluron 16 oz	0.38	0.13	b 3.00	0.41	a 7.25	0.48
Repel 1 qt	0.13	0.13	b 2.75	0.48	a 5.00	1.29
Repel + Dinotefuran	0.13	0.13	b 2.25	0.63	a 8.00	0.82
Repel + Knack	0.13	0.13	b 2.75	0.85	a 7.25	0.48
Repel + Mycotrol	0.25	0.14	b 3.75	0.75	a 6.50	0.50
Warrior 3.84 oz	0.25	0.14	b 3.00	0.41	a 9.50	1.50
Warrior 2x, Knack 2x	0.25	0.14	b 2.75	0.48	a 7.75	0.63
Untreated Control	0.38	0.13	b 3.75	0.85	a 8.25	1.89

*Means in the same column followed by the same letters do not differ significantly at P = 0.05 (Tukey, SAS Institute 2002).

Table 5. Mean percent (%) of small, medium and large onions after applications of selected insecticides (Spring 2003, Weslaco, Texas)

Treatment	Small onions		Mediumn onions		Large onions	
	Mean	SE	Mean	SE	Mean	SE
Dinotefuan 25 g	4.91	ab 3.04	41.69	b 5.28	53.40	a 8.16
Knack 10 oz	3.57	b 3.57	38.92	b 4.70	57.50	a 7.26
Lannate 2 pts	5.57	b 3.34	33.38	b 8.50	61.05	a 10.64
Mycotrol 1 qt	4.70	b 3.07	43.65	b 8.77	51.65	a 11.14
Novaluron 12 oz	3.57	b 2.21	40.74	b 5.58	55.69	a 5.96
Novaluron 16 oz	5.87	ab 2.07	43.07	b 2.64	51.06	a 4.51
Repel 1 qt	5.88	ab 5.88	48.76	b 7.79	45.36	a 10.57
Repel + Dinotefuran	1.85	b 1.85	34.65	b 4.77	63.49	a 4.47
Repel + Knack	1.89	a 1.89	38.09	b 4.57	60.02	a 6.18
Repel + Mycotrol	7.13	ab 4.47	48.14	b 3.23	44.73	a 7.02
Warrior 3.84 oz	6.76	ab 4.16	38.69	b 1.97	54.55	a 4.14
Warriot 2x, Knack 2x	6.49	a 4.51	34.31	a 3.19	59.20	a 6.94
Untreated Control	16.16	a 8.16	56.85	b 3.05	41.28	a 9.12

*Means in the same column followed by the same letters do not differ significantly at P = 0.05 (Tukey, SAS Institute 2002).

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Table 6. Mean foliage damage ranking of onion plants after applications of selected insecticides (Spring 2003, Weslaco, Texas)*

	Foliage Damage	
	Mean	SE
Dinotefuran 25 g	cde 3.8	0.3
Knack 10 oz	bcd 4.0	0.0
Lannate 2 pts	f 2.0	0.0
Mycotrol 1 qt	e 3.0	0.6
Novaluron 12 oz	e 3.0	0.0
Novaluron 16 oz	e 3.0	0.0
Repel 1 qt	abc 4.3	0.3
Repel + Dinotefuran	abc 4.3	0.5
Repel + Knack	ab 4.8	0.3
Repel + Mycotrol	cde 3.8	0.5
Warrior 3.84 oz	de 3.3	0.6
Warrior 2x, Knack 2x	abc 4.3	0.3
Untreated Control	a 5.0	0.0

*Means in the same column followed by the same letters do not differ significantly at P = 0.05 (Tukey, SAS Institute 2002).

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IR-4 ORNAMENTAL DATA REPORTING FORM

(Please type or print)

1. INVESTIGATOR (Name, Address, Phone#): Parwinder Grewal and Kevin Power, Department of Entomology, OARDC/OSU, 1680 Madison Ave, Wooster, Ohio 44691
LOCATION OF TRIAL: OSU Turfgrass Research Center, Columbus, Ohio
TRIAL TYPE:(check one) x FIELD ___CONTAINER ___GREENHOUSE
INTERIORSCAPE

2. PESTICIDE: Insecticide
COMMON NAME: Rosmary oil FORMULATION:oil/water/lecithin
BATCH NO.: E 1721 PRODUCT: Hexcide
EPA REG. NO. NA MFG: EcoSMART Technologies

3. USE INFORMATION:

	COMMON NAME	SCIENTIFIC NAME
PLANT: Turfgrass	Bentgrass	Agrostis palustris
PEST(S): Insect	Black Cutworm	Agrotis ipsilon
PEST(S): Insect	larger sod webworm	Pedisia trisecta

PLOT SIZE see below EXPERIMENTAL DESIGN completely randomized OF REPS 3 & 4

4. APPLICATION PARAMETERS:
TYPE OF APPLICATION (aerial, ground, foliar, drench, ppi, chemigation, broadcast, directed, other)
ground hand held single nozzle boom broadcast application
NO. OF APPLICATIONS 1 APPLICATION TYPE CO_2 charged system
NOZZLE TYPE/SIZE T-Jet Flat fan NOZZLE PRESSURE 7-12psi see methods
DELIVERY RATE 20 & 40 gal/acre see tables CALIBRATION DATE 9/15 & 16 2003

5. APPLICATION SUMMARY:

APPL.DATE	RATES (quarts/A)*	Event/pest target
9/17/2003 am	1, 2, 4, & 4	Phytotoxicity test
9/17/2003 am	1, 2, & 4	Target black cutworm egg hatch
9/17/2003 am	1, 2, & 4	3rd to 4th instar black cutworm
9/17/2003 pm	1, 2, 4, & 4	Phytotoxicity test
9/24/2003 am	1, 2, & 4	sod webworm larvae

*Be sure to provide units

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8. NARRATIVE SUMMARY OF METHODS AND RESULTS:

Experiment I: Phytotoxicity Evaluation, Daybreak Application

The experiment was located at the Ohio State University's Turfgrass Research Facility in Columbus, Ohio. The plots, established on a creeping bentgrass range measuring 1½ by 2 ft, were completely randomized and replicated three times. At daybreak on September 17, treatments were applied at spray volumes equivalent to 20 and 40 gallons per acre with a CO_2 pressurized sprayer using a single flat fan nozzle. The 20 gallon/acre treatments were applied using a T-Jet XR8003VS nozzle operating at 7 psi and a metronome set to assist the applicator in maintaining a 1.9 mph walk. One of the 40 gallon/acre treatments was applied as was the 20 gallon/acre treatment with a second pass immediately over the plot to simulate spray overlap. The second 40 gallon/acre treatment was applied using a T-Jet XR8005VS operating at 12 psi and a metronome set set to assist the applicator in maintaining a 0.7 mph walk speed.

Field conditions at the September 17, treatment date were: Turf - level, 100 % creeping bentgrass 3/8 in height, dew present, no thatch. Soil - moist; 53° F at 2 in. depth. Weather - clear 55° F, no wind

Phytotoxicity data taken at 1, 7, and 14 DAT were based on the subjective evaluation of three raters using a damage rating scale where 0 = no damage and 5 = 100% damage (brown turf). Analysis of Variance was used by plot totals and means separated by LSD test at alpha=0.05.

Experiment II: Phytotoxicity Evaluation, Mid-day/full sun Application

The experiment was located at the Ohio State University's Turfgrass Research Facility in Columbus, Ohio. The plots, established on a creeping bentgrass range measuring 1½ by 2 ft, were completely randomized and replicated three times. At noon and full sun on September 17, treatments were applied at spray volumes equivalent to 20 and 40 gallons per acre with a CO_2 pressurized sprayer using a single flat fan nozzle. The 20 gallon/acre treatments were applied using a T-Jet XR8003VS nozzle operating at 7 psi and a metronome set to assist the applicator in maintaining a 1.9 mph walk. One of the 40 gallon/acre treatments was applied as was the 20 gallon/acre treatment with a second pass immediately over the plot to simulate spray overlap. The second 40 gallon/acre treatment was applied using a T-Jet XR8005VS operating at 12 psi and a metronome set set to

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assist the applicator in maintaining a 0.7 mph walk speed.

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Field conditions at the September 17, treatment date were: Turf - level, 100 % creeping bentgrass 3/8 in height, dry, no thatch. Soil - moist; 74° F at 2 in. depth. Weather - sunny 80°, 5-7 mph wind

Phytotoxicity data taken at 1, 7, and 14 DAT were based on the subjective evaluation of three raters using a damage rating scale where 0 = no damage and 5 = 100% damage (brown turf). Analysis of Variance was used by plot totals and means separated by LSD test at alpha=0.05.

Experiment III: Efficacy against black cutworm at egg hatch

The experiment was located at the Ohio State University's Turfgrass Research Facility in Columbus, Ohio. The plots, established on a creeping bentgrass range measuring 1½ by 2 ft, were completely randomized and replicated four times. Three steel cylinders measuring 8 inches tall by 8 inches in diameter were inserted into each plot. On September 17, treatments were applied using a CO_2 pressurized sprayer at 12 psi and a single XR8005VS flat fan nozzle. The applicator used a metronome set to maintain a 1.9 mph walk speed was 1.9 mph and a metronome set for the applicator to maintain a 1.9 mph walk in order to deliver a spray volume equivelant to 40 gallons of spray per acre. There was no posttreatment irrigation. After the sprays had dried, sections of cheese cloth containing an average of 16 eggs were placed in each of the cylinders after the sprays had dried. The cylinders were covered with 20 mesh vinyl screening and secured with rubber bands. The screens remained on the cylinders for the duration of the study.

Field conditions at the September 17, treatment date were: Turf - level, 100 % creeping bentgrass 3/8 in height, dew present, no thatch. Soil - moist; 53° F at 2 in. depth. Weather - clear 55° F, no wind

Efficacy data taken October 2, 15 DAT. Screens were remover from the cylinders and and a soap and water drench was applied. Data were based on the number of black cutworm larvae surfacing. The plot means were subjected to an Analysis of Variance and means separated by LSD test at alpha=0.05.

Experiment IV: Efficacy against black cutworm at 2nd to 4th instar stage

This experiment was applied concurrently with the egg hatch timing experiment above. The methods and field conditions were the same with the exception that each cylinders was infested with six second and third instar black cutworm larvae after sprays had dried.

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Experiment V: Efficacy against sod webworm

The experiment was located at the Ohio State University's Turfgrass Research Facility in Columbus, Ohio. Plots measuring 3 by 5 ft consisting of creeping bentgrass were completely randomized and replicated four times. On September 25, treatments were applied using a CO_2 pressurized sprayer operating at 19.5 psi with a hand held three nozzle boom using XR8005VS nozzles. The applicator used a metronome set to maintain a 1.9 mph walk in order to deliver a spray volume equivelant to 40 gallons of spray per acre. There was no posttreatment irrigation.

Field conditions at the September 25, treatment date were: Turf - level, 100 % creeping bentgrass 1/2 in height, dry, no thatch. Soil - moist; 60° F at 2 in. depth. Weather - clear 54° F, no wind

Efficacy data taken 7 DAT on October 2. A soap and water drench was applied to the center square yard of each plot and the number of caterpillars surfacing within one hour was recorded. The total sod webworms and black cutworms from each plot were separately subjected to an Analysis of Variance and means separated by LSD test at alpha=0.05.

9. GOOD RESEARCH PRACTICE STATEMENT:

I acknowledge that I have read and followed the IR-4 Research protocol and completed this trial following good agricultural practice, or reported any deviations (note any changes from authorized protocol in narrative).

SIGNATURE Parwinder Grewal **DATE** 12/11/2003

PRINCIPAL INVESTIGATOR

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PHYTOTOXICITY REPORT FORM

Experiment I: Phytotoxicity Evaluation, Daybreak Application

TREATMENT	RATE PRODUCT Quart PER ACRE	SPRAY VOLUME PER ACRE	REP.	PHYTO RATE #1 1 DAT AM TMT*	PHYTO RATE #2 7 DAT AM TMT*	PHYTO RATE # 3 14 DAT AM TMT*
CONTROL	0	20	1	0	0	0
CONTROL	0	20	2	1	1	0
CONTROL	0	20	3	0	0	0
CONTROL	0	MEAN		0.3a	0.3a	0a
HEXCIDE	1	20	1	1	1	0
HEXCIDE	1	20	2	2	2	0
HEXCIDE	1	20	3	0	0	0
HEXCIDE	1	MEAN		1.0a	1.0a	0a
HEXCIDE	2	20	1	1	0	0
HEXCIDE	2	20	2	3	2	0
HEXCIDE	2	20	3	1	0	0
HEXCIDE	2	MEAN		1.7a	0.7a	0a
HEXCIDE	4	20	1	0	0	0
HEXCIDE	4	20	2	0	2	0
HEXCIDE	4	20	3	0	0	0
HEXCIDE	4	MEAN		0a	0.7a	0a
HEXCIDE	2 x2	20	1	1	0	0
HEXCIDE	2 x2	20	2	1	5	0
HEXCIDE	2 x2	20	3	0	0	0
HEXCIDE	2 x2	MEAN		0.7a	1.a7	0a
HEXCIDE	2	40	1	9	10	0
HEXCIDE	2	40	2	6	10	1
HEXCIDE	2	40	3	7	10	0

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HEXCIDE	2	MEAN		7.3b	10b	0.3a

* Total of three raters, 0=no injury, 5=complete kill./ Means followed by the same letter are not significantly different. LSD at p= 0.05.

PHYTOTOXICITY REPORT FORM
Experiment II: Phytotoxicity Evaluation, Mid-day/full sun Application

TREATMENT	RATE PRODUCT Quart PER ACRE	SPRAY VOLUME PER ACRE	REP.	PHYTO RATE #1 1 DAT PM TMT*	PHYTO RATE #2 7 DAT PM TMT*	PHYTO RATE # 3 14 DAT PM TMT*
CONTROL	0	20	1	0	0	0
CONTROL	0	20	2	2	1	0
CONTROL	0	20	3	0	0	0
CONTROL	0	MEAN		0.7a	0.3a	0a
HEXCIDE	1	20	1	1	0	0
HEXCIDE	1	20	2	1	1	0
HEXCIDE	1	20	3	1	0	0
HEXCIDE	1	MEAN		1.a0	0.3a	0a
HEXCIDE	2	20	1	0	0	0
HEXCIDE	2	20	2	2	0	0
HEXCIDE	2	20	3	0	1	0
HEXCIDE	2	MEAN		0.7a	0.3a	0a
HEXCIDE	4	20	1	6	8	0
HEXCIDE	4	20	2	5	6	1
HEXCIDE	4	20	3	6	5	0
HEXCIDE	4	MEAN		5.7b	6.3b	0.3a
HEXCIDE	2 x2	20	1	6	4	0
HEXCIDE	2 x2	20	2	2	6	0
HEXCIDE	2 x2	20	3	5	2	0

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HEXCIDE	2 x2	MEAN		4.3b	4.0b	0a
HEXCIDE	2	40	1	4	4	0
HEXCIDE	2	40	2	0	5	0
HEXCIDE	2	40	3	0	4	0
HEXCIDE	2	MEAN		1.3a	4.3b	0a

* Total of three raters, 0=no injury, 5=complete kill./ Means followed by the same letter are not significantly different. LSD at p= 0.05.

EFFICACY REPORT FORM

Experiment III: Efficacy against black cutworm at egg hatch

TREATMENT	RATE Product/ acre	REP	Black Cutworm 15 DAT*			
CONTROL**	0	1	0			
CONTROL	0	2	1			
CONTROL	0	3	0			
CONTROL	0	4	4			
CONTROL	0	MEAN	1.3a			
HEXCIDE	1 quart	1	0			
HEXCIDE	1 quart	2	0			
HEXCIDE	1 quart	3	1			
HEXCIDE	1 quart	4	0			
HEXCIDE	1 quart	MEAN	0.3a			
HEXCIDE	2 quart	1	1			
HEXCIDE	2 quart	2	0			
HEXCIDE	2 quart	3	0			
HEXCIDE	2 quart	4	0			
HEXCIDE	2 quart	MEAN	0.3a			
HEXCIDE	4 quart	1	1			

PR.NO.:	A
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HEXCIDE	4 quart	2	0			
HEXCIDE	4 quart	3	0			
HEXCIDE	4 quart	4	0			
HEXCIDE	4 quart	MEAN	0.3a			
TALSTAR	0.5 lbai/a	1	0			
TALSTAR	0.5 lbai/a	2	0			
TALSTAR	0.5 lbai/a	3	0			
TALSTAR	0.5 lbai/a	4	0			
TALSTAR	0.5 lbai/a	MEAN	0a			

* Total cutworms in three 8 inch in diameter cages per plot. Means followed by the same letter are not significantly different. LSD at p= 0.05.

EFFICACY REPORT FORM

Experiment IV Efficacy against black cutworm at 2nd to 4th instar stage

TREATMENT	RATE Product/ acre	REP	Black Cutworm 15 DAT*			
CONTROL**	0	1	10			
CONTROL	0	2	6			
CONTROL	0	3	4			
CONTROL	0	4	6			
CONTROL	0	MEAN	6.5a			
HEXCIDE	1 quart	1	1			
HEXCIDE	1 quart	2	2			
HEXCIDE	1 quart	3	3			
HEXCIDE	1 quart	4	2			
HEXCIDE	1 quart	MEAN	2.0b			
HEXCIDE	2 quart	1	0			

PR.NO.:	A
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HEXCIDE	2 quart	2	1			
HEXCIDE	2 quart	3	4			
HEXCIDE	2 quart	4	2			
HEXCIDE	2 quart	MEAN	1.8b			
HEXCIDE	4 quart	1	8			
HEXCIDE	4 quart	2	2			
HEXCIDE	4 quart	3	1			
HEXCIDE	4 quart	4	1			
HEXCIDE	4 quart	MEAN	3.0b			
TALSTAR	0.5 lbai/a	1	0			
TALSTAR	0.5 lbai/a	2	0			
TALSTAR	0.5 lbai/a	3	0			
TALSTAR	0.5 lbai/a	4	0			
TALSTAR	0.5 lbai/a	MEAN	0b			

* Total cutworms in three 8 inch in diameter cages per plot. Means followed by the same letter are not significantly different. LSD at p= 0.05.

EFFICACY REPORT FORM

Experiment V Efficacy against sod webworm

TREATMENT	RATE Product/ acre	REP	sod webworm 7 DAT*	black Cutworm 7 DAT*		
CONTROL**	0	1	0	1		
CONTROL	0	2	4	1		
CONTROL	0	3	1	0		
CONTROL	0	4	1	0		
CONTROL	0	MEAN	1.5a	0.5a		
HEXCIDE	1 quart	1	1	0		
HEXCIDE	1 quart	2	0	0		

PR.NO.:	A
TRIAL:	
DATE:	

HEXCIDE	1 quart	3	0	0		
HEXCIDE	1 quart	4	1	0		
HEXCIDE	1 quart	MEAN	0.5a	0a		
HEXCIDE	2 quart	1	1	0		
HEXCIDE	2 quart	2	0	0		
HEXCIDE	2 quart	3	7	1		
HEXCIDE	2 quart	4	0	0		
HEXCIDE	2 quart	MEAN	2.0a	0.3		
HEXCIDE	4 quart	1	1	0		
HEXCIDE	4 quart	2	5	0		
HEXCIDE	4 quart	3	1	0		
HEXCIDE	4 quart	4	1	0		
HEXCIDE	4 quart	MEAN	2.0a	0a		
TALSTAR	0.5 lbai/a	1	1	0		
TALSTAR	0.5 lbai/a	2	0	0		
TALSTAR	0.5 lbai/a	3	1	0		
TALSTAR	0.5 lbai/a	4	0	0		
TALSTAR	0.5 lbai/a	MEAN	0.5a	0a		

* Total cutworms in 1 sq yd/plot. Means followed by the same letter are not significantly different. LSD at p= 0.05.

Evaluating the Effectiveness of Capsaicin for Control of the Plum Curculio (PC), *Conotrachelus nenuphar* (Herbst), For Use in Organic Apple Production

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Final Report

Insecticides were applied to mature apple trees at the Trevor Nichols Research Complex in Fennville, MI (Indigo Block) at a rate of 100 GPA with an FMC 1029 airblast sprayer. Treatments were arranged in a completely randomized design of two tree plots. Applications of materials were made on 29 May (Petal fall).

The purpose of the field-based bioassay was to evaluate the lethal and sub lethal "oviposition / feeding deterrence" effects of Capsaicin-based compounds with and without the addition of commercial insecticide "stickers" on PC adults. The treatments were sprayed in the field, then the bioassay was conducted in the laboratory. Each replicate was set up using 5 laboratory reared (southern strain) mated female PC adults, and one apple fruit clusters, with a total of ten fruit and ten leaves. These shoots were collected from field treated trees 4 hours after the applications. The shoots were placed in water soaked vans® floral foam in clear plastic 1-qt. containers and the foam covered with sealing wax, to preserve the integrity of the fruit and foliage. Holes were punched in each container's lid to reduce condensation of water vapor in the "bioassay chambers". Four replicated chambers were loaded per treatment. The mortality of beetles was recorded after 4 days of exposure. The number of fruit feeding and oviposition stings were also recorded at that time.

The only treatment that had significant lethal effects was the Capsyn plus Nufilm sticker. The fact that that Capsyn alone did not cause mortality suggests that either the Nufilm itself was toxic to the beetle or that it maintained the lethal potential of the Capsyn. Since it is not likely that Nufilm is directly toxic to curculio, I presume that it some how enhanced the activity of the Capsyn. Given that there was not any precipitation in the 4 hours between field application and biossay set-up, the only factor that could have caused the degradation of activity of the Capsyn alone is UV/sunlight. If this was the case, then the level of Capsaicin needed to provide control of curculio for any length of time would require a much higher application rate in the field than what was tested. This would probably be cost-prohibitive. This is supported by the fact that in the residual timings, 7 day post application, none of the treatments showed control better than the untreated check. None of the treatments had statistically different feeding and/or oviposition deterrent effects compared to the untreated check. My conclusions are that Capsaicin itself has only limited potential as a pest control tool for the plum curculio, but that Nufilm and other stickers should continue to be studied for their potential to enhance the performance of Biopesticides.

Table 1. Response of Plum Curculio adults to capsaicin field-based bioassay treatments.

	Treatment	Amt. Form / Acre	4 Hour Residue - 4 Day Exposure		
			Live.(%)	Ovip./Fruit	Feeding/Fruit
1	UTC		100 a	10.08 ab	2.88 ab
2	Miller Hot Sauce	0.8 gal/a	95 a	12.9 a	2.45 ab
3	Miller Hot Sauce	0.8 gal/a	95 a	8.48 ab	2.28 ab
	Nufilm 17	1 pt/a			
4	Miller Hotsauce	0.8 gal/a	100 a	10.2 ab	1.58 b
	Wilbur Sticker	1 gal/a			
5	Capsyn	1 gal/a	100 a	12.73 a	1.75 b
6	Capsyn	1 gal/a	75 b	6.58 b	3.83 a
	Nufilm17	1 pt/a			
7	Capsyn	1 gal/a	85 ab	12.1 a	2.25 ab
	Wilbur Ellis Sticker	1 gal/a			

Means followed by same letter do not significantly differ (P=.05, LSD)

Integration and Enhancement of Biocontrol Strategies for Management of Peach Rusty Spot

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Rusty spot of peach, caused by the apple powdery mildew pathogen *Podosphaera leucotricha*, is found throughout the U.S. and is a serious disease on susceptible cultivars (4). Direct crop loss occurs through fruit infection, which results in necrosis of epidermal cells and cracking by harvest. In NJ, an average crop loss of $204/A was calculated in 1997 by an IPM survey (5).

Research conducted during 2000 and 2001 screened three biological control agents and six biorational products known to control powdery mildews (2). None of these biopesticides provided control equivalent to the standard fungicide, myclobutanil. However, some materials yielded enough control to warrant examination in integrated disease control programs.

During this study on moderately susceptible 'Jerseyglo' peach, the best biological control agent (Serenade 10WP) and the best biorational material (Armicarb 85SP) were deployed in integrated programs with myclobutanil (Nova 40W). The overall goal was to reduce the usage of myclobutanil by at least 40-50% while maintaining commercially acceptable control. In addition, several integrated Serenade / Nova treatments were examined for efficacy on the highly susceptible cultivar 'Autumnglo'. Different rates of Nova were combined with Serenade to determine if myclobutanil can be further reduced.

MATERIALS AND METHODS

Materials and Methods. The experiment was conducted during the spring and summer of the 2003 growing season. The tests were conducted in a 7-year-old 'Jerseyglo' peach tree block and an 8-year-old 'Autumnglo' peach tree block, both grafted on 'Lovell' rootstock. Trees in both blocks, located at the Rutgers Agr. Res. & Ext. Center, were planted on a 25' x 25' spacing.

Treatments in each block were replicated four times in a randomized complete block design with single-tree plots. Treatment trees were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.1 mph was used for applications.

Recent research on the temporal analysis of rusty spot epidemics has revealed the key phenological stages during which disease develops (1, 3). Given that information, applications are normally made from petal fall until second cover. Unlike previous years, a third cover application was made because of the possibility of the epidemic

being delayed due to the later than normal bloom and the abnormally cool weather early in the season. Applications for the 'Jerseyglo' were made on the following dates and tree growth stages: 29 Apr (PF, petal fall); 7 May (SS, shuck split); 15 May (1C, first cover); 27 May (2C, second cover); and 10 Jun (3C, third cover). Applications for the 'Autumnglo' were made on the following dates and tree growth stages: 30 Apr (PF); 7 May (SS); 15 May (1C); 27 May (2C); and 10 Jun (3C). Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. Weather conditions were very unfavorable for rusty spot development during 2003. 'Autumnglo' peach, a highly susceptible cultivar, had only a maximum of 19% fruit infection on nonsprayed control trees; in contrast, 90% fruit infection occurred in 2002.

The low incidence of rusty spot is likely due to cool weather around petal fall and shuck split and extended periods of wet weather from after the 1C to the last assessment on 20 June. A total of 20 days with rain ≥0.10 in occurred from bloom on 17 Apr to the last assessment on 20 Jun, with 15 of those rain periods occurring after 15 May.

Rainfall impact on spray residue was minimal for the first two applications, but greater thereafter. The number of rain periods (≥0.10 in) following each spray were: PF, 0; SS, 2; 1C, 5; 2C, 5; and 3C, 5.

Assessment. A total of ten disease assessments were performed for the 'Jerseyglo' and nine for the 'Autumnglo' to track disease progression during the epidemics. Data for the 'Jerseyglo' were recorded on days 135 (15 May), 143 (23 May), 147 (27 May), 150 (30 May), 154 (3 Jun), 157 (6 Jun), 161 (10 Jun), 164 (13 Jun), 168 (17 Jun), and 171 (20 Jun). 'Autumnglo' data were recorded on days 135 (15 May), 140 (20 May), 143 (23 May), 147 (27 May), 150 (30 May), 154 (3 Jun), 157 (Jun 6), 160 (9 Jun), 164 (13 Jun), 168 (17 Jun), and 171 (20 Jun). During each assessment, a total of 40 fruit were arbitrarily selected from each treatment tree. The total number of lesions was counted on each fruit. From these data, disease incidence was calculated as proportion of infected fruit and disease severity as number of lesions / fruit.

Analysis. For the tests in each block, areas under the disease incidence (AUDIC) and disease severity (AUDSC) curves were calculated for each replicate of each treatment in the experiment. Separate analyses of variance were performed for each of these four dependent variables using the GLM procedure of the Statistical Analysis System v8.2 (SAS Institute, Cary, NC). AUDIC and AUDSC treatment means were compared using the Waller-Duncan *k*-ratio *t* test ($P \leq 0.05$; $k = 100$).

RESULTS AND DISCUSSION

Jerseyglo. Onset of the rusty spot epidemic occurred at about day 147 or 27 May (Fig 1). Disease increased on the non-sprayed trees in a near linear fashion between days 147 and 166 until leveling off. At the peak of the epidemic, incidence and severity of rusty spot on nontreated trees was 17% and .21 lesions / fruit, respectively. Typically

disease incidence reaches >40% fruit infection on this cultivar in favorable years.

Each of the Nova / Serenade application schedules reduced rusty spot incidence and severity throughout the epidemic (Fig 1). Disease levels in the alternating and block treatments ranged from 10% to 14% fruit infection and .14 to .16 lesions / fruit at the peak of the epidemic. The Nova / Serenade mixture had the same incidence and severity of disease as the nontreated in the assessment taken at the peak of the epidemic, but it had a lower incidence and severity throughout the earlier assessments. All of the Nova / Armicarb integrated treatments had a slight effect on reducing disease incidence and severity, ranging from a maximum of 13% to 16% fruit infection and .17 to .20 lesions / fruit respectively.

Based on analysis of area under the disease progress curves (AUDPC), all Nova / Serenade and Nova / Armicarb treated fruit had significantly less disease incidence than non-sprayed fruit (Table 1). The disease severity in the Nova /Serenade reverse block, the Nova / Serenade mixture, and the Nova / Armicarb alteration were not significantly different than that of the nonsprayed block; however, the severity for the rest of the integrated treatments was significantly different than that of the nonsprayed (Table 2). There was no significant difference of disease incidence or severity between the standard and any of the integrated treatments.

Based on the AUDIC results (Table 1), percent disease control was 57% for the standard Nova schedule and 33 to 52% for the integrated treatments. This atypically low level of control may be due to loss of residues during the frequent rainfalls after first cover.

Autumnglo. The rusty spot epidemic for 'Autumnglo' occurred about day 150 to 164, reaching a maximum of 19% and .25 for incidence and severity respectively (Fig 2). Serenade alone only slightly reduced incidence and severity, but the Serenade integrated with Nova was much more effective in controlling the disease. The integrated programs had maximum disease levels ranging from 4-9% and .04 - .11 for incidence and severity respectively.

Based on analysis of AUDPC, all treated fruit had significantly less disease than nontreated fruit (Tables 3 and 4). Trees receiving just Serenade had significantly less infected fruit than on the nonsprayed trees, but a higher amount of diseased fruit than any of the integrated programs. Of the integrated programs, the fruit in the block treatment had significantly more disease incidence and severity than fruit from any of the other integrated treatments. Fruit from all the other integrated treatments were not significantly different in disease incidence and severity than those from the standard treatment, with the exception of the disease incidence of the fruit treated with the 20% Nova mixture.

In contrast to 'Jerseyglo', percentage control in the 'Autumnglo' block was higher. The Nova standard provided 88% disease control, while the integrated treatments ranged from 46 to 81%. Those treatments having the systemic Nova in their 1C-3C sprays provided the best control.

CONCLUSIONS

1. Integration of the biological control product Serenade or the biorational material Armicarb allowed at least a 50% reduction in the fungicide component.

2. Relative to the standard, no increase in disease was observed when implementing most of the integrated approaches (the exceptions were the block program with Serenade and 20% Nova mixture in the 'Autumnglo' block).

3. All the integrated treatment programs showed improvement over the non-sprayed. In the 'Jerseyglo' block, there was no significant difference between any of the integrated treatments and the standard. Because of the extremely low levels of disease, the results may differ in a more typical year. All integrated treatments in the 'Autumnglo' block did not differ significantly from the standard with the exception of the block treatment. Further studies will have to be done to see if the integration treatments differ in disease control during a year with a moderate to high amount of rusty spot.

4. When mixed with a half rate of Serenade, the rate of Nova can be reduced up to 65% (1.75 oz/A) without a significant reduction of disease control compared to the standard. These reduced-rate treatments also showed that under low disease pressure, Serenade can also be reduced from 10 to 5 lb/A in the mixture.

5. Although all treatments, including the standard, significantly reduced disease levels below that of the non-sprayed, the percentage of disease control was atypically low. We suspect that frequent rain after 1C contributed to lower residues. We note that the reverse block treatment in the 'Autumnglo' orchard, which had the systemic Nova applied at 1C-3C, had significantly lower disease incidence and severity than the block program, which utilized Serenade during these cover sprays. In fact, all 'Autumnglo' treatments that had Nova applied at these timings performed the best.

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TABLE 1. Comparison of areas under peach rusty spot disease incidence curve (AUDIC) for eight different types of integrated biopesticide / fungicide treatment schedules on Jerseyglo trees

Biopesticide Type	Integration Type	Fungicide Treatment	Rate/A	Application Timing [1]	AUDIC [2]
Control Treatment					
---	---	Nonsprayed	---	---	2.1 a
Standard Treatment					
---	None	Nova 40W	5 oz	PF, SS, 1C, 2C, 3C	0.9 b
Serenade + Nova Integrated Treatments					
Biological Control Agent	Alternation	Nova 40W Serenade 10WP	5 oz 10 lb	PF 1C 3C SS 2C	1.0 b
	Block	Nova 40W Serenade 10WP	5 oz 10 lb	PF, SS 3C 1C, 2C	1.1 b
	Reverse Block	Nova 40W Serenade 10WP	5 oz 10 lb	1C, 2C PF, SS 3C	1.3 b
	Mixture	Nova 40W + Serenade 10WP	2.5 oz 5 lb	PF, SS, 1C, 2C, 3C	1.4 b
Armicarb + Nova Integrated Treatments					
Biorational Material	Alternation	Nova 40W Armicarb 85SP	5 oz 5 lb	PF 1C 3C SS 2C	1.4 b
	Block	Nova 40W Armicarb 85SP	5 oz 5 lb	PF, SS 3C 1C, 2C	1.0 b
	Reverse Block	Nova 40W Armicarb 85SP	5 oz 5 lb	1C, 2C PF, SS 3C	1.2 b
	Mixture	Nova 40W + Armicarb 85SP	2.5 oz 2.5 lb	PF, SS, 1C, 2C, 3C	1.0 b

[1] PF = 100% petal fall; SS = < 5% shuck split; 1C – 3C = first through third cover sprays.

[2] Means followed by the same letter are not significantly different according to the Waller-Duncan *k*-ratio *t* test ($P \leq 0.05$; $k = 100$); disease incidence calculated as proportion of fruit infected.

TABLE 2. Comparison of areas under peach rusty spot disease severity curve (AUDSC) for eight different types of integrated biopesticide / fungicide treatment schedules on Jerseyglo trees

Biopesticide Type	Integration Type	Fungicide Treatment	Rate/A	Application Timing [1]	AUDSC [2]
Control Treatment					
---	---	Nonsprayed	---	---	2.4 a
Standard Treatment					
---	None	Nova 40W	5 oz	PF, SS, 1C, 2C, 3C	1.1 b
Serenade + Nova Integrated Treatments					
Biological Control Agent	Alternation	Nova 40W Serenade 10WP	5 oz 10 lb	PF 1C 3C SS 2C	1.3 b
	Block	Nova 40W Serenade 10WP	5 oz 10 lb	PF, SS 3C 1C, 2C	1.2 b
	Reverse Block	Nova 40W Serenade 10WP	5 oz 10 lb	1C, 2C PF, SS 3C	1.6 ab
	Mixture	Nova 40W + Serenade 10WP	2.5 oz 5 lb	PF, SS, 1C, 2C, 3C	1.7 ab
Armicarb + Nova Integrated Treatments					
Biorational Material	Alternation	Nova 40W Armicarb 85SP	5 oz 5 lb	PF 1C 3C SS 2C	1.7 ab
	Block	Nova 40W Armicarb 85SP	5 oz 5 lb	PF, SS 3C 1C, 2C	1.2 b
	Reverse Block	Nova 40W Armicarb 85SP	5 oz 5 lb	1C, 2C PF, SS 3C	1.4 b
	Mixture	Nova 40W + Armicarb 85SP	2.5 oz 2.5 lb	PF, SS, 1C, 2C, 3C	1.2 b

[1] PF = 100% petal fall; SS = < 5% shuck split; 1C – 3C = first through third cover sprays.

[2] Means followed by the same letter are not significantly different according to the Waller-Duncan *k*-ratio *t* test ($P \leq 0.05$; $k = 100$); disease incidence calculated as proportion of fruit infected.

TABLE 3. Comparison of area under peach rusty spot disease incidence curve (AUDIC) for six different types of integrated biopesticide / fungicide treatment schedules on Autumnglo trees.

Biopesticide Type	**Integration Type**	**Fungicide Treatment**	**Rate/A**	**Application Timing [1]**	**AUDIC [2]**
Control Treatment					
----------	----------	Nonsprayed	----------	----------	2.6 a
Separate Standard Fungicide and Biocontrol Treatments					
----------	None	Nova 40W	5.0 oz	PF, SS, 1C, 2C, 3C	0.3 e
Biological Control Agent	None	Serenade	10.0 lbs	PF, SS, 1C, 2C, 3C	2.0 b
Nova + Serenade Integrated Treatments					
Biological Control Agent	Alternation	Nova 40W Serenade 10WP	5.0 oz 10.0 lb	PF 1C 3C SS 2C	0.7 de
	Blocked	Nova 40W Serenade 10WP	5.0 oz 10.0 lb	PF, SS 1C, 2C, 3C	1.4 c
	Reverse Block	Nova 40W Serenade 10WP	5.0 oz 10.0 lb	1C, 2C, 3C PF, SS	0.6 de
	Mixture, 20% Nova	Nova 40W + Serenade 10WP	1.00 oz + 5.0 lb	PF, SS, 1C, 2C, 3C	0.8 d
	Mixture, 35% Nova	Nova 40W + Serenade 10WP	1.75 oz + 5.0 lb	PF, SS, 1C, 2C, 3C	0.6 de
	Mixture, 50% Nova	Nova 40W + Serenade 10WP	2.50 oz + 5.0 lb	PF, SS, 1C, 2C, 3C	0.5 de

[1] PF = 100% petal fall; SS = < 5% shuck split; 1C – 3C = first through third cover sprays.

[2] Means followed by the same letter are not significantly different according to the Waller-Duncan *k*-ratio *t* test ($P \leq 0.05$; $k = 100$); disease incidence calculated as proportion of fruit infected

TABLE 4. Comparison of area under peach rusty spot disease severity curve (AUDSC) for six different types of integrated biopesticide / fungicide treatment schedules on Autumnglo trees

Biopesticide Type	Integration Type	Fungicide Treatment	Rate/A	Application Timing [1]	AUDSC [2]
Control Treatment					
----------	----------	Nonsprayed	----------	----------	3.1 a
Separate Standard Fungicide and Biocontrol Treatments					
----------	None	Nova 40W	5.0 oz	PF, SS, 1C, 2C, 3C	0.4 d
Biological Control Agent	None	Serenade	10.0 lbs	PF, SS, 1C, 2C, 3C	2.1 b
Nova + Serenade Integrated Treatments					
Biological Control Agent	Alternation	Nova 40W Serenade 10WP	5.0 oz 10.0 lb	PF 1C 3C SS 2C	0.8 d
	Blocked	Nova 40W Serenade 10WP	5.0 oz 10.0 lb	PF, SS 1C, 2C, 3C	1.5 c
	Reverse Block	Nova 40W Serenade 10WP	5.0 oz 10.0 lb	1C, 2C, 3C PF, SS	0.7 d
	Mixture, 20% Nova	Nova 40W + Serenade 10WP	1.00 oz + 5.0 lb	PF, SS, 1C, 2C, 3C	0.9 d
	Mixture, 35% Nova	Nova 40W + Serenade 10WP	1.75 oz + 5.0 lb	PF, SS, 1C, 2C, 3C	0.7 d
	Mixture, 50% Nova	Nova 40W + Serenade 10WP	2.50 oz + 5.0 lb	PF, SS, 1C, 2C, 3C	0.5 d

[1] PF = 100% petal fall; SS = < 5% shuck split; 1C – 3C = first through third cover sprays.

[2] Means followed by the same letter are not significantly different according to the Waller-Duncan *k*-ratio *t* test ($P \leq 0.05$; $k = 100$); disease incidence calculated as proportion of fruit infected

Fig. 1 - Rusty Spot Incidence on Jerseyglo

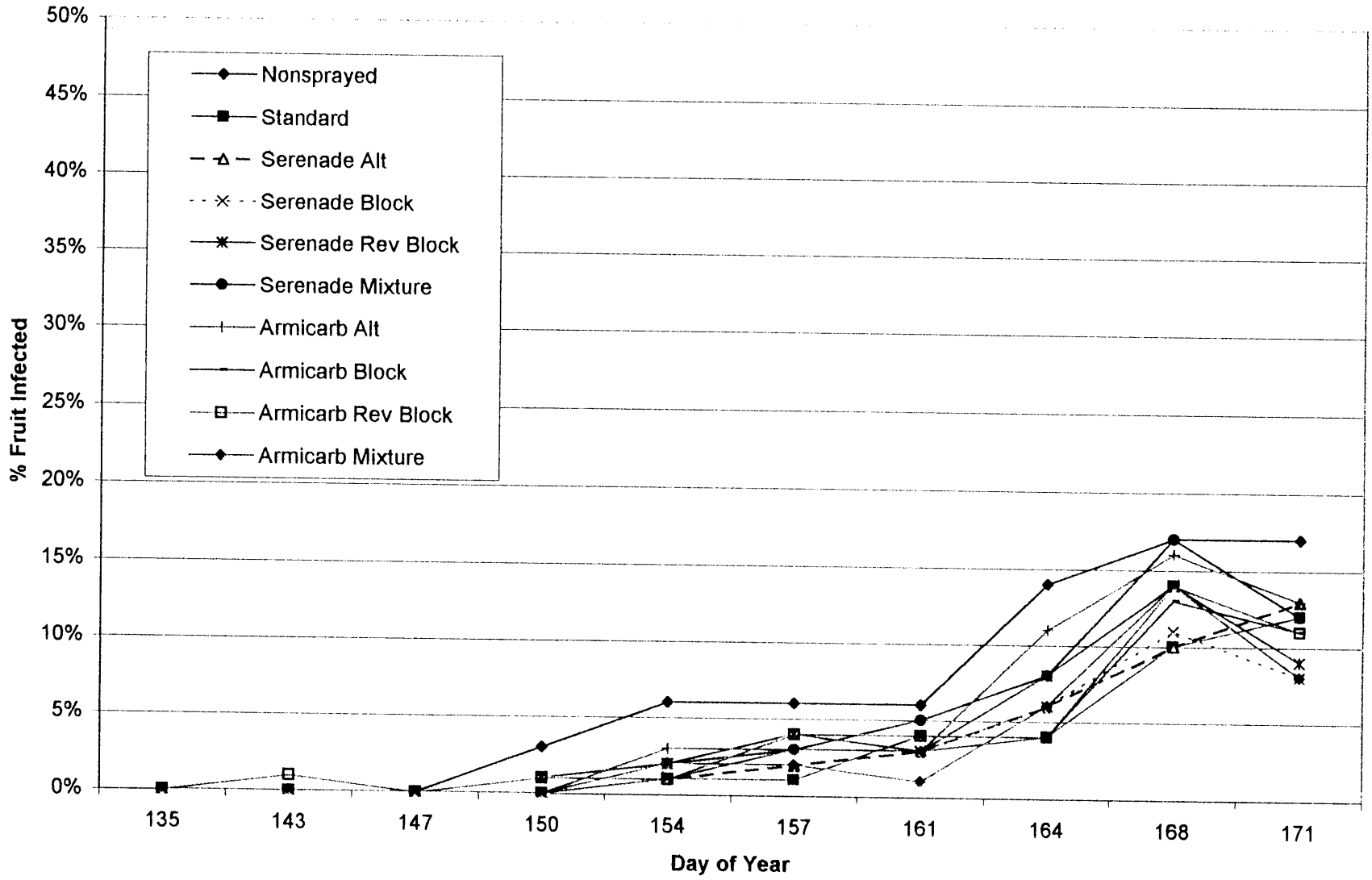
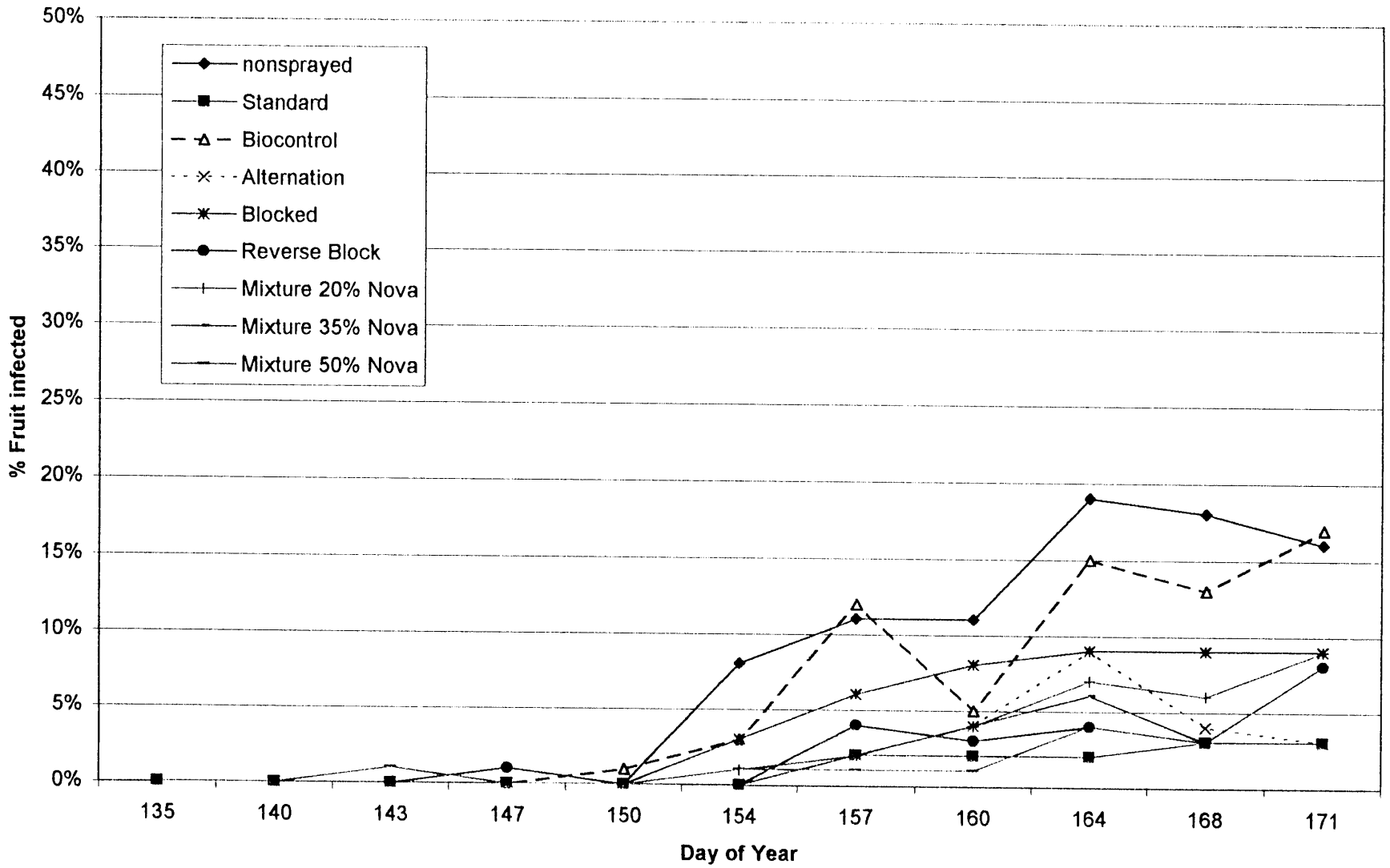


Fig. 2 - Rusty Spot Incidence on Autumnglo



IR-4 Biopesticide Program
Research Progress Report, 2003

Field Evaluation of a Pollinator-Delivered Biological Control Against Mummy Berry Disease of Blueberry

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Background:

Mummy berry, caused by the fungus *Monilinia vaccinii-corymbosi*, is considered the most important disease of blueberry in Georgia (Scherm *et al.* 2001) and other southern states. The main damage is due to the mummification of fruit which results from the infection of open flowers by fungal conidia via the stigma-style-ovary pathway. Fruit loads containing infected fruit above a near-zero tolerance are unfit for use, resulting in severe economic losses to producers (Scherm & Copes 1999).

The disease is currently controlled by a combination of pre-bloom and bloom sprays of fungicide (Scherm & Stanaland 2001). However, the number of labeled active ingredients is limited, and there is a high risk of fungicide resistance development in the pathogen population due to overuse of these compounds. In previous research, funded by the IR-4 Biopesticide Program in 2001 and 2002, we showed that that Serenade WP Biofungicide (Agraquest, Davis, CA), containing the biocontrol bacterium *Bacillus subtilis*, significantly reduces infection by *M. vaccinii-corymbosi* when applied to the stigmas of detached blueberry flowers in the laboratory (Scherm *et al.* 2004). In experiments with caged blueberry bushes in the field, we further documented that honey bees will vector the biocontrol product effectively from hive-based dispensers to open flowers (Dedej *et al.* 2002), leading to significant suppression of the incidence of mummified fruit in treated bushes (Scherm *et al.* 2002). With funding obtained by the IR-4 Biopesticide Program in 2003, we took this research one step further by (i) documenting the absence of negative effects of bee-vectored Serenade on pollination and fruit characteristics and (ii) determining bee-transmission of the biocontrol product in natural conditions (without cages to confine bees and exclude other insects).

Objectives:

1. Determine the risk of negative effects of bee-vectored Serenade on pollination and pollination-related fruit characteristics.
2. Evaluate honey bee transmission of the biocontrol product in commercial conditions (without cages) and monitor associated mummy berry suppression.

Methodology:

Objective 1. A three-pronged approach was used to evaluate the effects of stigma-applied Serenade on pollination and fruit set: (i) In the laboratory, detached flowers of 'Tifblue' rabbiteye blueberry (*Vaccinium ashei*) were treated with Serenade 1 or 0 days before manual application of 'Powderblue' pollen; 36 h after pollination, flowers were processed as described by Ngugi et al. (2002) to determine the number and growth rates of pollen tubes that entered the stylar canal. (ii) In the greenhouse, a similar experiment was carried out using attached flowers, again with application of Serenade 1 or 0 days before application of pollen. Fruit set, berry weight, and seed number (an indicator of the quality of pollination) were determined for each treatment. (iii) In the field at the UGA Horticulture Research Farm near Athens, screen cages containing two mature 'Climax' bushes, two

potted 'Tifblue' pollenizer plants, and one standard Langstroth bee hive with 0, 1600, or 6400 honey bees were established prior to bloom. The hives contained dispensers with or without Serenade (Fig. 1). As in the greenhouse trial, fruit set, berry weight, and number of seeds per fruit were determined for each treatment. All experiments were subjected to appropriate analysis of variance procedures.

Objective 2. Two bee hives, each with ca. 20,000 honey bees, were introduced into the center of a large rabbiteye blueberry planting near Alma (Bacon County) at the beginning of bloom in early March. Each hive was equipped with a Serenade dispenser which was checked regularly and replenished with the biocontrol product as needed.

Two 90-m-long sampling transects were established toward the West (within rows) and North (across rows) of the hives. Each transect included single-bush plots of cultivar 'Woodard' ca. 1, 4, 8, 12, 24, 36, 48, 72 and 90 m from the hives; the 1-m plot was not included in the across-row transect. On 6 days in late March and early April, bee activity was estimated in each plot by four 1-min counts (two in the morning, two in the afternoon). On the same days, population densities of *B. subtilis* were determined from 10 stigmas randomly collected among all open flowers per plot. Individual pistils were processed as described by Scherm *et al.* (2004) and population densities of the biocontrol agent expressed as colony-forming units (CFU) per stigma. Flowers from two caged plots (to exclude bees and other large insects) served as controls at each sampling date.

Results:

Objective 1. In laboratory experiments with detached flowers, application of Serenade, regardless of whether it was done 1 day before or simultaneously with pollination, did not affect the rate of pollen tube growth in any of three experimental runs compared with flowers receiving no biocontrol product ($0.104 \leq P \leq 0.826$; Fig. 2A). Similarly, application of the biocontrol product had no effect ($0.148 \leq P \leq 0.953$) on the number of pollen tubes that entered the stylar canal (Fig. 2B).

Across the three Serenade treatments and two experimental runs in the greenhouse, fruit set, fruit weight, and seed number averaged 58.8%, 1.83 g, and 44 seeds per fruit, respectively. Application of Serenade, regardless of whether it was done 1 day before or simultaneously with pollination, had no significant effect on fruit set or the number of seeds per fruit ($P > 0.05$). However, a marginally significant ($P = 0.048$) Serenade effect was noted in run 2 of the experiment. The average berry weight in this run was 1.85 g for flowers treated with the biocontrol product 1 day before pollination, 1.99 g for flowers receiving the biocontrol product and pollen simultaneously, and 1.93 g for flowers that were pollinated but received no Serenade. Based on means separation with Fisher's protected LSD test ($\alpha = 0.05$), fruit weights in the two Serenade application timings were significantly different from each other, but they were not different from those of the untreated control that received pollen only.

In the field experiment with caged bushes, increasing bee density per cage significantly increased fruit set, fruit weight, and seed number (Tables 1 and 2). While presence of Serenade did not affect fruit weight, it significantly reduced fruit set (by 11%) and seed numbers (by about 50%) (Tables 1 and 2). However, it should be noted that fruit weights and especially seed numbers were lower in this experiment than in the greenhouse experiments described above, indicating that pollination was marginal in the field cages, despite the relatively high bee density. This was likely due to the fact that potted pollenizer plants were considerably smaller and had fewer flowers than the mature 'Climax' plants from which fruit were collected, likely resulting in pollen limitation.

Objective 2. In the open-plot field trial in south Georgia, bee visitation rates ranged from 0 to 10 bees per bush and minute, with averages of 3.0 and 2.1 bees per bush and minute within and across rows, respectively. These bee activities were considerably lower than those observed in caged bushes at the research farm. Consequently, most flowers harbored no detectable populations of *B. subtilis*, the active ingredient of Serenade, indicating inadequate vectoring of the product. The highest *B. subtilis* population density measured on any one flower was 960 CFU per stigma, similar to the carrying

capacity of about 10^3 CFU per stigma deduced previously (Scherm *et al.* 2004). Because of the low transmission rate of *B. subtilis* to flowers in this trial, and due to the very low mummy berry disease pressure at the field site in 2003, no data on fruit mummification were collected.

Conclusions:

Over the past few years, we clearly documented that *B. subtilis*, the active ingredient of Serenade, shows significant activity against *M. vaccinii-corymbosi*, the mummy berry fungus, *in vitro* and on detached flowers in the laboratory (Scherm *et al.* 2004). After documenting basic efficacy, we explored honey bee transmission as a means of vectoring the biocontrol product to the stigmatic surface of newly opened flowers where the mummy berry fungus infects. This was based on the premise that conventional spray application will not deliver the biocontrol product reliably to blueberry flowers, given the very small surface of the stigma; the observation that flowers commonly face downward where the stigmatic surface is not easily reached by the spray; and the fact that new, susceptible flowers open daily during bloom, which would require very close spray intervals to prevent infection of newly opened flowers. Using caged bushes in an experimental blueberry planting, we showed that honey bees will indeed vector the biocontrol product effectively from hive-based dispensers to open flowers (Dedej *et al.* 2002), leading to significant suppression of the incidence of mummified fruit in treated bushes (Scherm *et al.* 2002). Unfortunately, a similar efficacy of the bee vectoring approach was not observed in commercial conditions when bee hives were placed in a large blueberry planting but where bee activity was not manipulated with screen cages. Despite the use of supplemental bees, the bee visitation rates per flower were apparently too low to result in consistent coverage of the stigmatic surfaces with biocontrol product. Furthermore when honey bees visited individual flowers, they often exhibited nectar-robbing behavior, i.e., they attempted to gain access to the nectar via holes in the sides of the corolla (generated previously by wild bee species such as carpenter bees). During such opportunistic behavior, honey bees do not land on or crawl over the stigmatic surface, thereby reducing the chance of delivering Serenade to the infection court.

Ending on a more positive note, the results presented here indicate that stigma-applied Serenade does not result in negative effects on pollination and pollination-related fruit quality characteristics. Although reductions in fruit weight and seed number were observed in the field trial, this result was likely an artifact associated with poor overall pollination in that trial. When pollination was adequate, as in the laboratory and greenhouse trials, no such negative effects were observed.

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Table 1. Analysis of variance to determine the effects of year, honey bee density, presence or absence of Serenade Biofungicide, and their interaction on fruit set, fruit weight, and seed number on 'Climax' rabbiteye blueberry in screen cages in the field

Source	df	Fruit set			Fruit weight			Seed number		
		Mean Square	*F*	*P* > *F*	Mean Square	*F*	*P* > *F*	Mean Square	*F*	*P* > *F*
Year (block) [a]	1	1347.8	15.4	0.0024	0.163	9.47	0.0105	35.7	2.84	0.1202
Bee density [b]	1	6076.9	69.4	< 0.0001	0.267	15.5	0.0023	361.9	28.8	0.0002
Serenade [c]	1	484.9	5.54	0.0382	0.014	0.82	0.3850	117.4	9.34	0.0109
Bee density × Serenade	1	139.6	1.59	0.2328	0.010	0.58	0.4612	37.9	3.02	0.1102
Error	11	963.1	---	---	0.189	---	---	138.2	---	---

[a] 2002 and 2003.

[b] Densities were 1600 or 6400 honey bees per 5.8-m^3 screen cage, each of which contained two mature 'Climax' bushes along with two potted 'Tifblue' pollenizer plants. Control cages without bees were not included in the analysis of variance.

[c] Serenade (*Bacillus subtilis* strain QRD132) was applied via bee hive-based dispensers (Fig. 1).

Table 2. Effects of honey bee density and presence or absence of Serenade on fruit set, fruit weight, and seed number on 'Climax' rabbiteye blueberry in screen cages in the field

Factor	Fruit set (%) [a]	Fruit weight (g) [a]	Seed number [a]
Bee density per cage [b]			
1600 bees	24.1 ± 4.54 b	1.09 ± 0.048 b	2.54 ± 0.623 b
6400 bees	63.1 ± 5.64 a	1.34 ± 0.066 a	12.0 ± 2.34 a
Serenade [c]			
Absent	49.1 ± 9.15 A	1.18 ± 0.091 A	10.0 ± 2.91 A
Present	38.1 ± 8.28 B	1.24 ± 0.055 A	4.58 ± 1.33 B

[a] Values are means and standard errors (n = 8). Values within the same column followed by the same letter are not significantly different according to Fisher's protected LSD (α = 5%).

[b] Screen cages were 5.8 m^3 in size and contained two mature 'Climax' bushes along with two potted 'Tifblue' pollenizer plants. Control cages without bees were not included in the analysis of variance.

[c] Serenade (*Bacillus subtilis* strain QRD132) was applied via bee hive-based dispensers (Fig. 1).

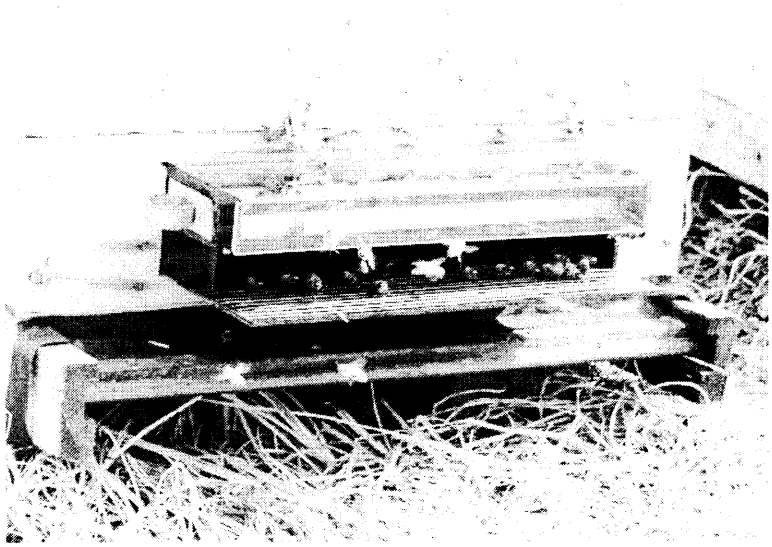

Fig. 1. Exit of a commercial bee hive equipped with a dispenser for the Serenade biocontrol product.

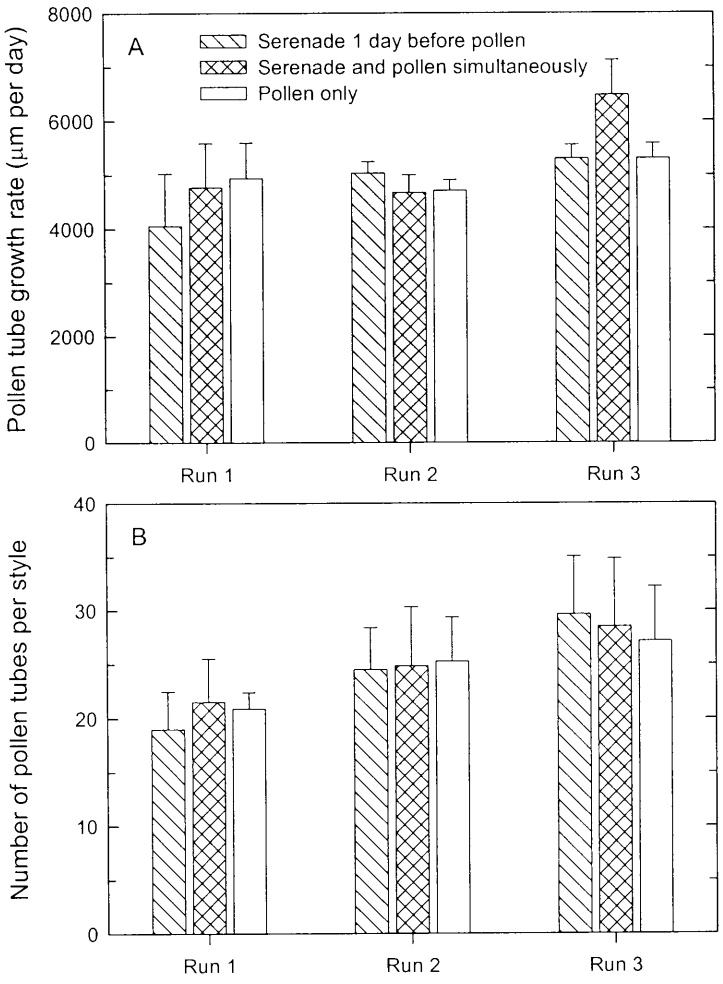

Fig. 2. Effect of dry-application of Serenade biocontrol product to detached 'Tifblue' blueberry flowers on growth rates (**A**) and numbers (**B**) of pollen tubes following application of 'Powderblue' pollen.

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Evaluation of fungicides for control of mummy berry in blueberries, 2003.

The experiment was conducted in a mature commercial blueberry planting in Grand Junction, MI. Bushes were spaced at 5 x 10 ft. Treatments were applied to 4-bush plots and were replicated four times in a randomized complete block design. Sprays were applied with an R&D Research CO_2 cart-styled sprayer equipped with six bottles (0.8 gal each), a twin gauge Norgren pressure regulator set at 55 psi, and a single XR TeeJet 8002VS nozzle on a 5-ft spray boom. Spray volume was 40 gpa. Spray dates and corresponding phenological stages were as follows: 28 Apr (green tip), 8 May (green tip), 14 May (very late green tip), 19 May (early pink bud), 28 May (bloom), 6 Jun (petal fall). Total rainfall between sprays was 2.42, 2.06, 0.53, 0.66, and 0.41 in., respectively. Dates of morning temperatures close to 32F were 27 Apr. The number of shoot strikes was assessed on the two center bushes of each plot on 30 May. Mummified berries on the ground were counted in a 6.5 x 6.5-ft section between the two center bushes of each plot on 30 Jul, just prior to the first harvest.

Mummy berry pressure was low in 2003. The reason for this is not entirely clear, but may be related to a dry period after bud break, which may have led to drying out of apothecia or a failure of pseudosclerotia to germinate. Most of the shoot strikes occurred fairly late. Very few frosts occurred, and only on two dates did the temperature get close to 32°F (3 and 13 May) This led to a difference in the timing of only one spray between the regular full spray schedule (1, 2, 4, 5, 6) and the 'frost-guided' schedule (1, 2, 3, 5, 6). In the absence of major frost events, the frost-guided schedule did not show any benefit over the regular schedule for Indar. In fact, it tended to be less effective. Under this schedule, Serenade performed similarly to Indar. On a regular schedule, Indar provided the best numerical control of mummy berry shoot strikes as well as the number of mummified berries per bush. Serenade alternated with Indar provided statistically equivalent control. The reverse program of Indar alternated with Serenade tended to provide poorer control, suggesting that timing of each of these products is important. Orbit alternated with Captan provided somewhat less control than Orbit alternated with Switch. Three sprays of TM-45002 or Elevate provided moderate control of shoot strikes, but Elevate was less effective than TM-45002 against fruit infection.

Treatment, rate/A	Application timing[z]	Number of shoot strikes per bush	Number of mummified berries per bush
Untreated		5.8 a[y]	18.8 a
Serenade	1, 2, 3, 5, 6	4.9 ab	10.3 b
Orbit 3.6EC 6 fl oz Captan 80WP 3 lb	1, 5, 4,	4.8 ab	8.8 b
Bravo Weatherstik 4 pt Indar 75WSP 2 oz Topsin M 70WSB 1 lb + Captan 50WP 5 lb	1, 2, 4, 5, 6	4.0 abc	9.5 b
Indar 75WSP 2 oz	1, 2, 3 5, 6	3.9 abcd	10.5 b
TM-45002 68WDG 5.25 lb	1, 3, 5	3.4 bcd	7.5 b
Orbit 3.6EC 6 fl oz Switch 62.5WG 14 oz	1, 5 4,	3.0 bcd	7.5 b
Indar 75WSP 2 oz Serenade 8 lb	1, 4, 6 2, 5	3.0 bcd	12.8 ab
Serenade 8 lb Indar 75WSP 2 oz	1, 4, 6 2, 5	2.9 bcd	7.3 b
Elevate 50WDG 1.5 lb	1, 3, 5	2.6 bcd	17.3 a
Bravo WeatherStik 4 pt Serenade 8 lb Topsin M 70WSB 1 lb + Captan 50WP 5 lb	1, 2, 4, 5, 6	2.3 cd	8.5 b
Indar 75WSP 2 oz	1, 2, 4, 5, 6	1.6 d	6.3 b

[z]Spray dates: 1 = 28 Apr (green tip), 2 = 8 May (green tip), 3 = 14 May (very late green tip), 4 = 19 May (early pink bud), 5 = 28 May (bloom), 6 = 6 Jun (petal fall).

[y]Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

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Evaluation of fungicides for control of fruit rots in blueberries, 2003.

The experiment was conducted in a mature commercial blueberry planting in Grand Junction, MI. Bushes were spaced at 5 x 10 ft. Treatments were applied to 4-bush plots and were replicated four times in a randomized complete block design. Sprays were applied with an R&D Research CO_2 cart-styled sprayer equipped with six bottles (0.8 gal each), a twin gauge Norgren pressure regulator set at 55 psi, and a single XR TeeJet 8002VS nozzle on a 5-ft spray boom. Spray volume was 40 gpa then 50 gpa on Jul 30. Spray dates and corresponding phenological stages were as follows: 28 Apr (green tip), 8 May (green tip), 14 May (very late green tip), 19 May (early pink bud), 28 May (bloom), 6 Jun (petal fall), and 30 Jul (pre-harvest). Total rainfall between sprays was 2.42, 2.06, 0.53, 0.66, 0.41, and 3.78 in., respectively. On 4 Aug and 12 Aug, healthy-looking berries were hand-harvested from the two center bushes of each plot (25 berries per bush, 50 per plot). Disposable gloves were used to pick berries and changed between plots to reduce cross-contamination. The berries were placed equidistantly on metal screens in aluminum trays and incubated at 72°F and 100% RH. After 10 days, berries were visually assessed for fungal sporulation.

Post-harvest disease pressure was low to moderate for Alternaria and extremely high for anthracnose fruit rot. The only significant differences were noted in Alternaria fruit rot incidence at the first harvest. This is probably due to the fact that most sprays were aimed at mummy berry control and therefore applied early in the season. A spray on July 30, less than a week before harvest, did not improve anthracnose control in any of the treatments, suggesting latent infections were already present. TM45002 and Indar (1, 2, 4, 5, 6) provided significant control of Alternaria post-harvest fruit rot. The two fungicide programs containing Bravo, and Switch alternated with Orbit, also provided significant control of Alternaria compared to the untreated check.

Treatment, rate/A	Application timing[z]	Alternaria fruit rot incidence (%) Harvest 1		Alternaria fruit rot incidence (%) Harvest 2		Anthracnose fruit rot incidence (%) Harvest 1		Anthracnose fruit rot incidence (%) Harvest 2	
Untreated		14.0	ab[y]	1.0	ns	98.5	ns	99.5	ns
Indar 75WSP 2 oz	1, 2, 3 5, 6	16.0	a	1.5		97.5		98.0	
Orbit 3.6EC 6 fl oz Captan 80WP 3 lb	1, 5, 7 4,	14.0	ab	4.0		88.0		94.0	
Indar 75WSP 2 oz Serenade 8 lb	1, 4, 6 2, 5	12.0	abc	4.0		98.5		99.5	
Elevate 50WDG 1.5 lb	1, 3, 5, 7	11.0	abc	4.5		100.0		97.0	
Serenade 8 lb	1, 2, 3, 5, 6	11.0	abc	3.5		97.0		99.5	
Serenade 8 lb Indar 75WSP 2 oz	1, 4, 6 2, 5	10.5	abc	3.5		100.0		98.0	
Orbit 3.6EC 6 fl oz Switch 62.5WG 14 oz	1, 5, 4, 7	7.0	bc	1.5		98.0		85.0	
Bravo Weatherstik 4 pt Indar 75WSP 2 oz Topsin M 70WSB 1 lb + Captec 4L 2 qt Cabrio EG 14 oz	1, 2, 4, 5, 6, 7	6.8	bc	4.0		98.0		96.0	
Bravo Weatherstik 4 pt Serenade 8 lb Topsin M 70WSB 1 lb + Captec 4L 2 qt Cabrio EG 14 oz	1, 2, 4, 5, 6, 7	6.5	bc	3.5		100.0		95.5	
TM-45002 68WDG 5.25 lb	1, 3, 5, 7	5.5	c	4.0		100.0		96.5	
Indar 75WSP 2 oz	1, 2, 4, 5, 6	5.5	c	3.0		98.5		99.5	

[z]Spray dates: 1 = 28 Apr (green tip), 2 = 8 May (green tip), 3 = 14 May (very late green tip), 4 = 19 May (early pink bud), 5 = 28 May (bloom), 6 = 6 Jun (petal fall), 7 = 30 Jul (pre-harvest).
[y]Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.1094$); ns = not significant.

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Evaluation of fungicides for control of white mold on lima beans near Harbeson, DE, 2003.

The experiment was conducted on a grower's field near Harbeson, DE that had a history of white mold disease. The experiment was arranged as a randomized complete block design with four replications. Plots were 12 ft wide and 40 ft long. The fordhook lima bean cultivar 'Sussex' was seeded in 30 in. rows on 27 Jun. Fungicides were applied on 6 Aug with a CO_2 backpack sprayer equipped with 4 nozzles spaced 18 in. apart. The sprayer delivered 45 gpa at 42 psi. Warrior T 1EC (3.2 oz/A) was applied to manage corn earworm (*Helicoverpa zea*) and Champ Formula 2 2.6F (1 qt/A) plus Penetrator Plus (8 oz/A) was applied to manage Downey Mildew (*Phytophthora phaseoli*) on 13 Aug. On 11 Sep Warrior T 1EC (3.8oz/A), and Champ Formula 2 2.6 F (1 qt/A) were applied to manage corn earworm and downy mildew, respectively. White mold severity was determined by counting the no. of infected pods in two rows, 39.4 in. in length, and infected pods on the soil surface surrounding the rows (in a 60 x 39.4 in. area) on 17 Sep. Plants in two 10-ft-row sections in the center of each plot were removed at the soil line by replicate, beginning on 25 Sep through 3 Oct. Pods were removed manually and pods infected with white mold were counted. Pods with no visible white mold were threshed and weighed. Yield (seed weight) was variable and higher on one end of the experimental area perpendicular to the direction of the replications. Therefore plot location was used as a covariate in analysis of yield, and yield was used as a covariate in analysis of infected pods on 17 Sep and at harvest.

White mold severity was high in the field. On 17 Sep, plots sprayed with Endura 70WG alone or in combination with Penetrator Plus had significantly fewer pods infected with white mold than nontreated plots. Endura 70WG plus HyperActive, Serenade 10WP, Switch 62WG at 11 and 14.1 oz/A and Omega 4SC had intermediate levels of pods infected with white mold that were not significantly different than the nontreated plots. There were no significant differences in the number of infected pods at harvest. Plots sprayed with Endura 70WG, alone, with HyperActive, or Penetrator Plus, and Pristine 38WG had significantly higher yield than nontreated plots. The active ingredient (a.i.) in Endura is boscalid. Pristine contains the a.i. boscalid and also pyraclostrobin. Yield in plots sprayed with Topsin M 70WP, Topsin M 4.5F, Switch 62WG and Omega 4SC was intermediate, and due to field variability, not significantly different than the nontreated plots.

Treatment and rate/A *	Infected pods/A 17 Sep		Infected pods/A at harvest	Yield T/A	
Endura 70WG 7 oz + Hyper Active 10.5 fl oz	9332	cd**	11258	0.79	a
Endura 70WG 7 oz + Penetrator Plus 2.7 pts	6652	d	13543	0.86	a
Endura 70WG 7 oz	7354	d	4875	0.86	a
Topsin M 70WP 2 lbs.	20570	ab	9536	0.71	ab
Topsin M 4.5F 3.1 pts.	15948	abcd	12826	0.71	ab
Serenade 10WP 6 lbs.	11242	bcd	10297	0.62	ab
Sonata F 8 pts	15895	abcd	14282	0.53	b
Switch 62WG 11 oz	10582	bcd	12166	0.68	ab
Switch 62WG 14.1 oz	11279	abc	9466	0.67	ab
Omega 4SC 8 fl oz	9321	bcd	11946	0.72	ab
Pristine 38WG/lb	18614	cd	15644	0.79	a
Serenade 10WP 4 lbs plus Topsin M 70WP 1 lb	26546	a	11872	0.54	b
Nontreated	19229	abc	12645	0.54	b
LSD ($P = 0.05$)	10,689		n.s.	0.24	

* Fungicides were applied on 6 Aug.

** Mean values in each column followed by the same letter are not significantly different at P=0.05 according to Fisher's protected least significant difference test.

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Fungicide trial for the control of downy mildew of baby lima bean, 2003.

Fungicides were tested for control of downy mildew of baby lima bean at the University of Delaware Experiment Station Farm in Newark, DE. The baby lima bean cultivar Eastland was planted on 9 July with a commercial four-row Monosem planter. Dual Magnum 7.62E (1.5 pt/A) and Pursuit 2SC (2.0 oz/A) were applied pre-emergence for weed control. The soil type was a Matapeake silt loam soil and 60 lbs of nitrogen were side-dressed after emergence on 6 Aug. Plots were arranged in a randomized complete block design with four replications. Each plot consisted of four rows, 20 ft long and spaced 30 in. apart. The three middle rows of each plot were sprayed and the border row prevented spray drift. The middle 10 ft of the center row of each plot was evaluated for percentage of infected pods, percentage of infected plants and yield. On 5 Sep and again on 12 Sep all plots were inoculated with a sporangial suspension of *Phytophthora phaseoli* race E in the evening using a backpack sprayer. The plots were misted nightly with a low pressure misting system equipped with low volume misting nozzles. The system was operated intermittently from dusk to dawn daily to increase humidity and favor infection. Supplemental irrigation was provided when needed throughout the growing season. Fungicides were applied on 3, 10, 17, and 24 Sep using a backpack CO_2 pressurized sprayer at 30 gal/A at 52 psi. Applications were made with a broadcast boom equipped with hollow cone nozzles (D4 disks, #45 cores). Two treatments included the adjuvants HyperActive 2.0 pt/100 gal and LI-700 2.0 pt/100gal plus Headline 2.09 F 6.0 fl oz. Both adjuvants work to improve the deposition, retention, wetting, and penetration of the fungicide on plant and pathogen surfaces. On 5 Oct, the middle ten feet of the center spray row were evaluated for percent plants infected. A plant was determined to be infected if any part (raceme, petiole or pod) had mildew. The plants were harvested on 7 Oct and the percentage of infected pods and yield were determined.

The disease severity in the field was very high this season, all plants in the control plots were infected. Ridomil Gold/Copper WP 2.0 lb. was the only treatment that significantly increased yield compared to the controls. Phostrol 4.0 pt, Phostrol 2.0 pt, and Champ DP 2.0 lb all performed well and were found to be significantly better than the controls for percent plant and percent pod infection. However, the yield data for this trial was highly variable and none of these treatments were found to be statistically higher than the control plots for yield. HyperActive 2.0 pt/100 gal and LI-700 2.0 pt/100gal did not improve the performance of the Headline 2.09 F 6.0 fl oz treatment. The two biological fungicides tested, Sonata AS 1.0 gal and Serenade WP 6.0 lb performed at the same level or significantly lower than the control plots for all factors. No phytotoxicity was observed for any of the treatments.

Treatment and rate/A	Incidence (%) of downy mildew		Yield
	Plants	Pods	(lb/A)
Control	100.0 a*	72.9 ab	487.8 de
Control	98.8 a	61.1 abc	670.8 bcde
Champ 2F 2.0 lb	100.0 a	44.7 bcd	1306.7 abcde
Cuprofixx Disperss DF 3.0 lb	100.0 a	37.4 cd	1676.9 abcd
Serenade WP 6.0 lb	100.0 a	80.9 a	505.3 cde
Headline 2.09 F 6.0 fl oz + LI-700 2.0 pt/100 gal	100.0 a	38.4 cd	1894.8 ab
Headline 2.09 F 6 fl oz + HyperActive 2.0 pt/100 gal	100.0 a	45.7 bcd	1526.1 abcde
Quadris 2.08 SC 9.2 fl oz	100.0 a	51.6 bc	1350.3 bcde
Sonata AS 1.0 gal	98.9 a	57.6 abc	422.5 e
Headline 2.09 F 6.0 fl oz	98.7 a	40.1 cd	1807.6 ab
Kocide 2000 DF 2.0 lb.	97.6 ab	40.4 cd	1589.9 abcde
Headline 2.09 F 9.0 fl oz	95.1 ab	44.6 bcd	1633.4 ab
Champ DP 2.0 lb.	82.3 b	20.6 de	1742.3 abc
Phostrol 2.0 pt.	58.2 c	21.6 de	1341.6 abcde
Phostrol 4.0 pt.	4.2 d	4.1 e	1916.5 ab
Ridomil Gold/Copper WP 2.0 lb.	0.0 d	2.7 e	2308.6 a

* Means followed by the same letter are not statistically different at P=0.05 (Tukey Multiple Comparison)

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Evaluation of Sonata-based products and fungicide programs for white mold control, 2003

Snap beans cv. Hi-style were planted Michigan State University Muck Soils Experimental Station, Bath, MI on 2 Jul into three-row by 25-ft plots (30-in. row spacing, 5-in. between seeds) replicated four times in a randomized complete block design with 5-ft between plots. The trial site was fertilized, prior to planting, with a 34:31:0 mix and received sulfur 5lb/A and zinc 2.2lb/A. Weeds were controlled with Dual 2 Magnum 0.87 pt/ A, Poast Plus 1.5 pt/A, Reflex 8 oz/A, and Basigran 14 oz/A. Insects were controlled with Sevin 80S (1.25 lb/A on 28 Jul), Thiodan 3EC (2.33 pt/A on 21 Aug) and Pounce 3.2EC (8 oz/A on 28 Jul). Plots were irrigated to supplement precipitation to about 1"/A/4 day period with overhead sprinkler irrigation and were cultivated immediately before sprays began. All fungicides in this trial were applied once on 6 Aug or twice on 27 Jul and 20 Aug with an ATV rear-mounted R&D spray boom delivering 25 gal/A (80 p.s.i.) and using three XR11003VS nozzles per row. A non-destructive white mold index was calculated by counting the number of stems from each sample of 50 stems, falling into class 0 = no visible symptoms; 1 = 1 - 5% of stem with visible sporulation; 2 = 6 - 10% of stem with lesions and sporulation; 3 = 11 - 50% of stems and foliage with lesions; 4 = 51 - 100% of stem, foliage or pods with lesions and internal sclerotia. Plots were rated visually for white mold on 28 Aug and 10 Sep. Plots (25-ft row) were harvested on 10 Sep and white-mold free pods only from individual treatments were weighed. Maximum and minimum air temperature (°F) were 92.1 and 64.4 (Jun), 92.5 and 72.5 (Jul), 88.7 and 68.6 (Aug) and 91.3 and 64.8. Maximum and minimum soil temperature (°F) were 82.0 and 70.8 (Jun), 84.6 and 74.2 (Jul), 84.3 and 74.2 (Aug) and 82.3 and 69.3 (to 10 Sep). Precipitation was 0.32" (Jun), 1.14" (Jul), 0.41" (Aug) and 0.0" (to 7 Sep).

White mold developed slowly during Aug then increased during Sep. Untreated controls reached mean index values of 2.25 and 3.25 by 56 and 70 days after planting (DAP), respectively. Taking 56 DAP as a key reference point all programs reduced white mold significantly compared to the untreated control. There were no significant differences among programs. Taking 70 DAP as a key reference point application programs with white mold indices less than 1.75 were not significantly different and only programs 1 and 15 were not significantly different form the untreated control. Only white mold free pods were harvested and all programs had significantly greater white mold-free yield than the untreated control. There were no differences among treatments. Phytotoxicity was not noted in any of the treatments.

Treatment and rate/acre	White mold[a] 56 DAP[c]		70 DAP		Marketable Yield[b] (lbs/A)	
1 Sonata 1SC 4.0 pt (A,C)[d]	0.75	b[e]	2.00	abc	5194	b
2 Sonata 1SC 8.0 pt (A,C,)	0.00	b	1.50	bcd	5106	b
3 Sonata 1SC 4.0 pt (B)	0.00	b	1.75	bcd	5250	b
4 Sonata 1SC 8.0 pt (B)	0.25	b	1.50	bcd	5069	b
5 Serenade 6WDG 4.0 lb + Topsin 75WDG 1.0lb (A,C)	0.00	b	1.50	bcd	5400	b
6 Serenade 6WDG 4.0 lb + Topsin 75WDG 1.0lb (B)	0.00	b	1.50	bcd	5256	b
7 Serenade 6WDG 2.0 lb + Topsin 75WDG 1.0lb (A,C)	0.75	b	1.75	bcd	5455	b
8 Serenade 6WDG 2.0 lb + Topsin 75WDG 1.0lb (B)	0.25	b	1.50	bcd	5956	b
9 Sonata 1SC 4.0 pt + Topsin 75WDG 1.0lb (A,C)	0.00	b	0.75	cd	4738	b
10 Sonata 1SC 4.0 pt + Topsin 75WDG 1.0lb (B)	0.00	b	1.00	bcd	5138	b
11 Topsin 75WDG 2.0lb (A,C)	0.50	b	1.25	bcd	5638	b
12 Topsin 75WDG 2.0lb (B)	0.25	b	1.75	bcd	4625	b
13 Topsin 75WDG 1.0lb (A,C)	0.50	b	1.75	bcd	5144	b
14 Topsin 75WDG 1.0lb (B)	0.25	b	1.00	bcd	5156	b
15 Sonata 1SC 4.0 pt + Biotune SC 0.3 pt (A,C)	0.75	b	2.25	ab	5185	b
16 Omega 5SC 0.33 pt (B)	0.00	b	1.00	bcd	5744	b
17 Omega 5SC 0.33 pt (A,C)	0.00	b	0.50	d	5250	b
18 Untreated	2.25	a	3.25	a	2375	a

[a] White mold *(Sclerotinia sclerotiorum)* index was calculated by counting the number of stems from each sample of 50 stems, falling into class 0 = no visible symptoms; 1 = 1 - 5% of stem with visible sporulation; 2 = 6 - 10% of stem with lesions and sporulation; 3 = 11 - 50% of stems with lesions; 4 = 51 - 100% of stem with lesions and internal sclerotia.

[b] Yield of bean pods without any visible white mold.

[c] Days after planting (2 Jul).

[d] Application dates: A= 23 Jul; B= 6 Aug; C= 20 Aug

[e] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

POTATO (*Solanum tuberosum* L.'Russet Norkotah')
White mold; *Sclerotinia sclerotiorum*
Late blight; *Phytophthora infestans*
Early blight; *Alternaria solani*
Gray mold; *Botrytis cinerea*

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Evaluation of Sonata-based products and fungicide programs for foliar disease control, 2003

Potatoes (cut seed) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 5 Jun into two-row by 25-ft plots (34-in row spacing) replicated four times in a randomized complete block design. The two-row beds were separated by a five-foot unplanted row. Plots were irrigated as needed with sprinklers and were hilled immediately before sprays began. All fungicides in this trial were applied on a 7-day interval from 23 Jun to 21 Aug (total 9 applications) from 1 Jul to 27 Aug with an ATV rear-mounted R&D spray boom delivering 25 gal/A (80 p.s.i.) and using three XR11003VS nozzles per row. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 20 Jun), Basagran (2 pt/A on 20 Jun and 15 Jul) and Poast (1.5 pt/A on 28 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 15 Jun), Sevin 80S (1.25 lb/A on 1 and 28 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 28 Jul). A white mold index was calculated by counting the number of stems from each sample of 50 stems, falling into class 0 = no visible symptoms; 1 = 1 - 5% of stem with visible sporulation; 2 = 6 - 10% of stem with lesions and sporulation; 3 = 11 - 50% of stems with lesions; 4 = 51 - 100% of stem with lesions and internal sclerotia. Plots were rated visually for white mold and percentage foliar area affected by early blight on 28 Aug and 11 and 25 Sep. A single evaluation of foliar late blight and Botrytis gray mold was made on 25 Sep. Vines were killed with Reglone 2EC (1 pt/A on 25 Sep). Plots (25-ft row) were harvested on 12 Oct and individual treatments were weighed and graded. Maximum and minimum air temperature (°F) were 92.1 and 64.4 (Jun), 92.5 and 72.5 (Jul), 88.7 and 68.6 (Aug) and 91.3 and 64.8. Maximum and minimum soil temperature (°F) were 82.0 and 70.8 (Jun), 84.6 and 74.2 (Jul), 84.3 and 74.2 (Aug) and 82.3 and 69.3 (to 7 Sep). Precipitation was 0.32" (Jun), 1.14" (Jul), 0.41" (Aug) and 0.0" (to 7 Sep). Plots were irrigated to supplement precipitation to about 1"/A/4 day period with overhead sprinkler irrigation.

White mold developed slowly during Aug then increased during Sep. Untreated controls reached mean index values of 3.8 by 112 days after planting (DAP). Taking 84 DAP as a key reference point application programs 1, 2, 3 and 10 reduced stem white mold significantly compared to the untreated control. All other programs were not significantly different from the untreated control or each other. Taking 98 DAP as a key reference point application programs 1, 2, 6, 8, 9 and 10 reduced stem white mold significantly compared to the untreated control. Programs 6, 9 and 10 had the lowest white mold index values (index = 1.0) but were only significantly different form those programs with index values > 2.3. All other programs were not significantly different from the untreated control or each other. Taking 112 DAP as a key reference point application programs 1, 2, 3, 6, 8, 9 and 10 reduced stem white mold significantly compared to the untreated control. Programs 6, 9 and 10 were not significantly different from each other (white mold index values < 2.0) and had significantly less white mold than programs with values > 2.5. Treatments 1 and 2 had significantly less white mold than treatments 4, 5 and 7. All other programs were not significantly different from the untreated control or each other. All programs had significantly less foliar early blight than the untreated control at both evaluation dates, 98 and 112 DAP. Treatments 8, 9 and 10 had significantly less early blight than treatment 7, 98 DAP, but were not significantly different from any other treatment. Taking 112 DAP as a key reference point, treatments 8, 9 and 10 had significantly less early blight than all programs with except 2. Late blight spread to the trial area from adjacent trials in which late blight was present about 90 DAP. Untreated control plots had an average of 30.0% foliar late blight 112 DAP. All programs had significantly less foliar late blight compared to the untreated control. Program 6 had the lowest percent foliar late blight (1.5%) which was significantly less than all other programs with > 6.8% foliar late blight. Programs 1 and 2 had significantly less foliar late blight than program 3 but no other programs were significantly different. Gray mold reached about 17% in the untreated control 112 DAP and all application programs reduced the gray mold foliar infection significantly compared to the untreated control but no programs were significantly different. Yield was not correlated with increasing severity of foliar early blight, white mold, late blight or gray mold and there was no significant difference among any treatments in terms of marketable or total yield. Phytotoxicity was not noted in any of the treatments.

Treatment and rate/acre	Stem white mold[a] 84 DAP[e]	98 DAP	112 DAP	Foliar early blight[b] (%) 98 DAP	112 DAP	Foliar late blight (%)[c] 112 DAP	Foliar gray mold (%)[d] 112 DAP	Yield (cwt/A) US1	Total
1 Quadris 2SC 0.38 pt + Bravo WS 2SC 1.5 pt (A,C) Bravo WS 2SC 1.5 pt (B,E,G,H) Sonata 1SC 4.0 pt (D,F)[f]	0.3 bc[g]	1.5 bcd	1.8 cd	2.5 bc	4.5 bc	6.0 cd	4.0 b	210	303
2 Quadris 2SC 0.38 pt + Bravo WS 2SC 1.5 pt (A,C) Bravo WS 2SC 1.5 pt (B,E,G,H) Sonata 1SC 8.0 pt (D,F)	0.3 bc	1.3 cd	1.5 cd	1.8 bc	2.5 cd	6.3 cd	3.3 b	232	307
3 Quadris 2SC 0.38 pt + Bravo WS 2SC 1.5 pt (A,C) Bravo WS 2SC 1.5 pt (B,E,G,H) Rovral 1SC 1.5pt (D,F)	0.5 bc	1.8 abcd	2.5 bc	2.8 bc	4.5 bc	12.5 b	3.0 b	197	290
4 Quadris 2SC 0.38 pt + Bravo WS 2SC 1.5 pt (A,C) Bravo WS 2SC 1.5 pt (B,E,G,H) Topsin 75WDG 2.0lb (D,F)	1.3 ab	2.3 abc	3.0 ab	2.0 bc	5.0 bc	9.3 bc	3.3 b	232	322
5 Quadris 2SC 0.38 pt + Bravo WS 2SC 1.5 pt (A,C) Bravo WS 2SC 1.5 pt (B,E,G,H) T-80 80WDG 2.0lb (D,F)	1.3 ab	2.3 abc	3.0 ab	2.8 bc	5.8 b	11.3 bc	3.5 b	222	301
6 Quadris 2SC 0.38 pt + Bravo WS 2SC 1.5 pt (A,C) Bravo WS 2SC 1.5 pt (B,E,G,H) Omega 5SC 0.5pt (D,F)	0.8 abc	1.0 d	1.3 d	2.3 bc	5.0 bc	1.5 d	2.0 b	212	292
7 Quadris 2SC 0.38 pt + Bravo WS 2SC 1.5 pt (A,C) Bravo WS 2SC 1.5 pt (B,E,G,H)	1.0 abc	2.5 ab	3.8 a	3.5 b	6.5 b	6.5 bcd	4.0 b	208	309
8 Headline 2SC 0.38 pt + Bravo WS 6SC 1.5 pt (A,C) Bravo WS 62SC1.5pt (B,E,G,H) Sonata 1SC 4.0pt (D,F)	0.8 abc	1.5 bcd	2.0 bcd	0.3 c	1.5 d	7.8 bc	2.0 b	221	303
9 Headline 2SC 0.38 pt + Bravo WS 6SC 1.5 pt (A,C) Bravo WS 62SC1.5pt (B,E,G,H) Sonata 1SC 8.0 pt (D,F)	0.8 abc	1.0 d	1.5 cd	0.3 c	1.0 d	7.3 bcd	1.5 b	234	316
10 Headline 2SC 0.38 pt + Bravo WS 6SC 1.5 pt (A,C) Bravo WS 62SC1.5pt (B,E,G,H) BAS 51004F 70WDG 0.14lb (D,F)	0.0 c	1.0 d	1.0 d	0.3 c	1.0 d	7.8 bc	1.3 b	217	311
11 Untreated	1.8 a	2.8 a	3.8 a	12.5 a	23.8 a	30.0 a	17.0 a	193	278
sem P = 0.05[h]								9.9	11.7

[a] White mold *(Sclerotinia sclerotiorum)* index was calculated by counting the number of stems from each sample of 50 stems, falling into class 0 = no visible symptoms; 1 = 1 - 5% of stem with visible sporulation; 2 = 6 - 10% of stem with lesions and sporulation; 3 = 11 - 50% of stems with lesions; 4 = 51 - 100% of stem with lesions and internal sclerotia.

[b] *Alternaria solani and A. alternata*, natural inoculum, percent leaf area diseased, separation of two diseases not attempted.

[c] Late blight leaf area diseased, inoculum spread from inoculated plots within 10 m of trial plot, [*Phytophthora infestans* (US8, A2 mating type, mefenoxam-insensitive)].

[d] *Botrytis cinerea*, natural inoculum, percent leaf area diseased.

[e] Days after planting (5 Jun).

[f] Application dates: A= 25 Jun; B= 2 Jul; C= 9 Jul; D= 16 Jul; E= 23 Jul; F= 30 Jul; G= 6 Aug; H= 13 Aug.

[g] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

[h] Standard error of the least squares mean included if no significant differences between treatment means at P = 0.05.

Pansy (*Viola x wittrockiana* 'Delta Tapestry'
Black root rot: *Thielaviopsis basicola*

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EFFICACY OF MYCOSTOP, PRESTOP, BIOPHOS AND VITAL FOR CONTROL OF BLACK ROOT ROT IN PANSY 2003. Black root rot is an insidious disease problem in greenhouses where pansies are produced. Sources of inoculum have not been identified but dispersal with infected plugs or infested medium may be important. Two biofungicides including Mycostop (based on *Streptomyces griseoviridis* K61) and Prestop (based on *Gliocladium catenulatum* J1446) were compared for efficacy in control of damping-off along with the biorational fungicides, Biophos (phosphonate/di-potassium phosphate) and Vital (potassium phosphite) and the fungicide Cleary's 3336 (thiophanate-methyl). Pansy plugs 'Delta Tapestry' in 256 plug trays were obtained from a commercial grower and transplanted to Fafard 4P in 6-cell market packs on 03 Jan 2003. Plants were maintained on a capillary mat on the greenhouse bench with hand watering as needed. Pansies were fertilized with 20-20-20 Peter's at 200 ppm-N weekly. Mycostop (0.07 oz/cu yd) and Prestop (10 oz/cu yd) were incorporated while the other products were drenched at 100 ml on 03 Jan, 5 days prior to inoculating. Controls included an untreated, inoculated control and an untreated, non-inoculated control. Inoculum of *T. basicola* was grown on sterilized rice grains for 3 wk. On 08 Jan, a glass rod was used to punch a hole about 2-cm deep in the mix near the transplant and one rice grain colonized by *T. basicola* was inserted and covered. There were four replications of each treatment arranged in a randomized complete block. All biopesticides were re-applied as drenches on 11 Feb and 05 Mar for a total of three applications (30-day schedule). At the end of the experiment, 19 Mar (75) days after inoculation, the root system of each plant was rated for extent of black root rot and top weights were measured.

Disease pressure was severe in both controls. After 75 days, the non-inoculated control had become heavily infected by splash dispersal of inoculum from overhead watering. Plants drenched with Biophos and Vital at the highest rates had significantly less black root rot and greater top weight than the controls. Top weight of pansies followed a dose response relationship with rate of Biophos and Vital. Prestop and Mycostop did not control black root rot on pansy when incorporated initially, then drenched at 30 days.

Treatment	Rate/100gals	Root rating* Day 75	Top wt (g) Day 75
Prestop 37WP	27 oz	3.6 a	4.5 e
Mycostop 11G	0.18 oz	3.6 a**	4.7 e
Biophos 43L	25.6 fl oz	2.7 bc	8.8 bc
Biophos 43L	64 fl oz	2.5 c	9.4 b
Biophos 43L	128 fl oz	2.5 c	10.4 ab
Vital 4L	32 fl oz	2.2 c	8.4 bc
Vital 4L	64 fl oz	2.1 c	9.6 ab
Cleary 3336 50W	8 oz	2.3 c	11.9 a
Inoculated control	-	3.1 ab	7.0 cd
Non-inoculated control	-	3.1 ab	4.8 de

*Root rot rating scale was 1= healthy, no black root rot, 2= lesions of black root rot on some roots, 3= root rot severe, 50% of root system diseased, 4= root rot very severe, 75% or more of root system diseased, and 5 = plant dead, few roots and all diseased.

**Means within a column followed by the same letter are not different according to the Waller-Duncan k ratio, k=100, p=0.05.

Evaluation of Biophos for controlling Pythium and Phytophthora crown rot of Calibrachoa

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Introduction

Calibrachoa has been a very popular floricultural crop for the last several years, and new cultivars continue to increase interest in this solanaceous plant. The Achilles heel of *Calibrachoa* is its susceptibility to *Phytophthora* and *Pythium*. In particular, the *Calibrachoa* industry has been plagued by *Phytophthora drechsleri* crown rot as well as root rot caused by several *Pythium* species. Most of the *Pythium* and several of the *P. Drechsleri* isolates that we have recovered from *Calibrachoa* at the UMass Plant Disease Diagnostic Laboratory, have been resistant to the fungicide metalaxyl (mefenoxam). Other conventional fungicides exist but the purpose of this study was to test the "biorational" fungicide Biophos™ (dipotassium phosphonate + dipotassium phosphate). This is a new low-risk fungicide that has shown promise against oomycete plant pathogens.

Methods

Calibrachoa plugs were transplanted into Metro Mix 360 in 4-in. pots and maintained in the greenhouse. There were nine replications per treatment distributed in a randomized complete block design with three blocks. To prepare inoculum, *Pythium aphanidermatum* and *Phytophthora drechsleri* were grown on V8 juice agar in standard petri dishes in the laboratory until the colonies filled the plate. For inoculum, for each pathogen, one petri dish culture and 200 ml of sterile water were blended briefly in a household blender by several short bursts on high power. Inoculum was dispensed with a wide-bore pipette by introducing 5 ml of suspension into the container mix at a depth of about one in. on two sides of the plant crown. Immediately after inoculation, pots were placed in aluminum pie pans with about 1 in. of water for 24 h. Pie pans then were removed and plants were watered as needed. Fungicides were applied on 7 Aug, 48 h before inoculation. Biophos and Banol were applied every two weeks for the duration of the experiment. Plants received Peter's 15-16-17 soluble fertilizer twice weekly at 200 ppm N. Plants were scored as either dead or alive on 9 Sep, the conclusion of the experiment. This experiment was repeated (referred to in the results as Trial II) starting on 8 Sep and concluding 30 Sep. Due to personnel issues, the second trial was not satisfactorily completed.

The following treatments were applied:

<u>*Phytophthora* trial</u>

1. Untreated with Biophos, uninoculated control
2. Untreated with Biophos, inoculated with *Phytophthora*
3. 2% Biophos foliar-applied , uninoculated
4. 1% Biophos soil drench, uninoculated
5. 1% Biophos foliar-applied, inoculated with *Phytophthora*
6. 2% Biophos foliar-applied, inoculated with *Phytophthora*
7. 0.5% Biophos soil drench, inoculated with *Phytophthora*
8. 1% Biophos soil drench, inoculated with *Phytophthora*
9. 20 oz Banol soil drench, inoculated with *Phytophthora*
10. 20 oz Banol soil drench, uninoculated

Pythium trial

1. Untreated with Biophos, uninoculated control
2. Untreated with Biophos, inoculated with *Phytophthora*
3. 2% Biophos foliar-applied , uninoculated
4. 1% Biophos soil drench, uninoculated
5. 1% Biophos foliar-applied, inoculated with *Phytophthora*
6. 2% Biophos foliar-applied, inoculated with *Phytophthora*
7. 0.5% Biophos soil drench, inoculated with *Phytophthora*
8. 1% Biophos soil drench, inoculated with *Phytophthora*
9. 20 oz Banol soil drench, inoculated with *Phytophthora*
10. 20 oz Banol soil drench, uninoculated

Results

Trial I

Treatments with *Phytophthora*	# dead, n=9
2. Untreated with Biophos, inoculated with *Phytophthora*	7 a
5. 1% Biophos foliar-applied, inoculated with *Phytophthora*	7 a
9. 20 oz Banol soil drench, inoculated with *Phytophthora*	6 ab
6. 2% Biophos foliar-applied, inoculated with *Phytophthora*	4 ab
7. 0.5% Biophos soil drench, inoculated with *Phytophthora*	4 ab
8. 1% Biophos soil drench, inoculated with *Phytophthora*	3 bc
1. Untreated with Biophos, uninoculated control	0 c
4. 1% Biophos soil drench, uninoculated	0 c
3. 2% Biophos foliar-applied , uninoculated	0 c
10. 20 oz Banol soil drench, uninoculated	0 c

Treatments with *Pythium*	# dead, n=9
2. Untreated with Biophos, inoculated with *Pythium*	1 a
5. 1% Biophos foliar-applied, inoculated with *Pythium*	1 a
7. 0.5% Biophos soil drench, inoculated with *Pythium*	1 a
8. 1% Biophos soil drench, inoculated with *Pythium*	1 a
1. Untreated with Biophos, uninoculated control	0 a
6. 2% Biophos foliar-applied, inoculated with *Pythium*	0 a
3. 2% Biophos foliar-applied , uninoculated	0 a
4. 1% Biophos soil drench, uninoculated	0 a
9. 20 oz Banol soil drench, inoculated with *Pythium*	0 a
10. 20 oz Banol soil drench, uninoculated	0 a

Trial II

Treatments with *Phytophthora*	# dead, n=9
2. Untreated with Biophos, inoculated with *Phytophthora*	9
9. 20 oz Banol soil drench, inoculated with *Phytophthora*	7
6. 2% Biophos foliar-applied, inoculated with *Phytophthora*	6
5. 1% Biophos foliar-applied, inoculated with *Phytophthora*	2
7. 0.5% Biophos soil drench, inoculated with *Phytophthora*	2
4. 1% Biophos soil drench, uninoculated	2
8. 1% Biophos soil drench, inoculated with *Phytophthora*	1
1. Untreated with Biophos, uninoculated control	1
10. 20 oz Banol soil drench, uninoculated	1
3. 2% Biophos foliar-applied , uninoculated	0

Treatments with *Pythium*	# dead, n=9
2. Untreated with Biophos, inoculated with *Pythium*	4
4. 1% Biophos soil drench, uninoculated	2
10. 20 oz Banol soil drench, uninoculated	2
5. 1% Biophos foliar-applied, inoculated with *Pythium*	1
7. 0.5% Biophos soil drench, inoculated with *Pythium*	1
1. Untreated with Biophos, uninoculated control	1
8. 1% Biophos soil drench, inoculated with *Pythium*	0
6. 2% Biophos foliar-applied, inoculated with *Pythium*	0
3. 2% Biophos foliar-applied , uninoculated	0
9. 20 oz Banol soil drench, inoculated with *Pythium*	0

Conclusions

Trial I: The best protection against Phytophthora crown rot was with 1% Biophos soil drench. Banol, 1% Biophos applied to the foliage, and 0.5% Biophos drench were not significantly different from the inoculated, untreated control. It is possible that the isolate of *P. drechsleri* is insensitive to Banol. *Pythium*-insensitivity to Banol has been reported. There was not enough mortality in the *Pythium*-inoculated plants to demonstrate differences between treatments.

Trial II: This trial could not be statistically analyzed because the data were not recorded by block. Also, it is clear that cross contamination in both the *Phytophthora* and *Pythium* trials occurred; several uninoculated treatments had mortality. Nevertheless, as in the first trial, the 1% soil drench gave very good protection against *P. drechsleri*. The 0.5% Biophos soil drench and the 1% foliar application also resulted in relatively low mortality (2 plants of 9 in both cases). However, the 2% foliar application of Biophos had high mortality 6 plants of 9). As in trial I, the 20 oz Banol treatment did not provide adequate protection against *Phytophthora* crown rot. Overall low mortality and lack of statistical analysis precluded interpretation of the *Pythium*-inoculated plants in trial II

This project was made possible by a USDA, IR-4 grant. Thanks are due Stephanie Slinski for her assistance.

GERBERA DAISY (*Gerbera jamesonii*)
Powdery mildew; *Erysiphe cichoraceaum*

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Evaluation of fungicides and Biophos for management of powdery mildew on Gerbera daisy, 2003

The evaluation was conducted in a polyhouse on the University of Georgia Griffin Campus located in Griffin, GA. Plants were maintained in 1 gal. pots containing Sunshine GBX potting mix (Sun Gro Horticulture Inc.). Plants were irrigated through drip irrigation as needed and fertilized with Peters 15-15-15 Geranium Special (The Scotts Co.) weekly. Insect and arthropod pests were managed using standard practices. Treatments started on 11 Apr 03 and were applied at 14-day intervals for three applications. Foliar applications were applied with a hand sprayer until run-off and 0.1 gal. of Biophos were added per pot for the drench application. Eight replications composed of two plants each were arranged in a randomized complete block design. The progression of powdery mildew of each plant was estimated weekly using the Horsfall-Barrett scale and the ratings were converted to percent midpoint values. Data were analyzed using the PROC GLM procedure of SAS and means were separated using Fisher's protected least significant difference (LSD) at P=0.05.

All treatments lowered disease severity compared to the non-treated check. At the onset of the experiment the average powdery mildew severity was approximately 10%. By the final rating, the percent powdery mildew was 73% in the non-treated check. Biophos applied as a foliar spray had less disease compared to the drench application, however, some residue remained on the leaves from the foliar applications. No evidence of phytotoxicity was observed from any treatment.

Treatment and Rate (per 100 gal.)	Application Method	Percent powdery mildew					
		18-Apr	25-Apr	2-May	9-May	16-May	23-May
Non-treated check	---	12.3	18.5	29.4	40.3	55.2	72.6
Biophos (1% v/v)	Drench	11.5	19.7	29.5	28.8	25.2	31.1
Biophos (2% v/v)	Foliar	10.0	14.1	13.5	14.7	8.9	7.2
Biophos (1% v/v)	Foliar	6.9	10.3	11.0	8.8	5.8	7.4
Heritage 50 WG (2.0 oz.)	Foliar	6.8	6.4	6.0	3.8	1.5	1.7
Heritage MAXX (10.08 fl. oz)	Foliar	7.1	4.7	4.7	4.8	2.3	1.8
Heritage + Chlorothalonil (2.66 fl. oz)	Foliar	6.5	4.9	4.2	3.5	1.7	3.3
Pipron (8.0 fl. oz)	Foliar	5.2	5.3	2.4	3.0	1.3	1.2
LSD (0.05)	---	4.0	3.9	6.1	5.1	4.2	3.6

VINCA (*Catharanthus roseus* 'Little Bright Eye')
Phytophthora root rot; *P. nicotianae* var. *parasitica*

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Evaluation of Biophos for management of Phtophthora root rot on Vinca, 2003

The evaluation was conducted in a polyhouse on the University of Georgia Griffin Campus located in Griffin, GA. Vinca seed were sown in 72-pack containers containing Fafard 3d potting mix. Seedlings were irrigated as needed and fertilized with Peters 15-15-15 Geranium Special (The Scotts Co.) weekly. A single treatment was applied on 16 Apr 03 to 8 week-old plants. The foliar application was applied with a hand sprayer until run-off and enough product was added to thoroughly wet the root zone for the drench applications. Three days post-treatment, plants were dipped into water to remove potting mix and then transferred to *P. nicotianae*-amended potting mix. Three isolates of *P. nicotianae* var *parasitica* were cultured on V8-vermiculite for three weeks, mixed, and added to the potting mix at a final concentration of 4% (v/v). Control treatments included pathogen-free potting mix and a non-treated but pathogen amended check. Two weeks post-inoculation all plants were dipped in water to remove potting mix, dried at 122° F for three days and weighed. Three replications composed of six plants each were arranged in a randomized complete block design. Data were analyzed using the PROC GLM procedure of SAS and means were separated using Fisher's protected least significant difference (LSD) at P=0.05.

The Subdue MAXX treatment resulted in significantly greater dry root weight compared to the Biophos treatments. No difference was observed between the Biophos treatments and the no-treated check.

Treatment and rate (per 100 gal.)	Application Method	Dry root weight (g)
Non-treated check	---	0.038 c
Biophos (0.5% v/v)	Drench	0.039 c
Biophos (1.0% v/v)	Drench	0.041 c
Biophos (1% v/v)	Foliar	0.049 c
Subdue MAXX (1.0 fl. oz.)	Drench	0.094 b
Non-inoculated check	---	0.188 a
LSD (P=0.05)		0.037

Screening of Biopesticides and Conventional Fungicides for the Control of Phytophthora Root and Crown Rot of Squash in Georgia

Project Final Report - 2003

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Introduction

Phytophthora root and crown rot, caused by *Phytophthora capsici*, is responsible for serious losses to growers of summer squash each year. No effective fungicides are currently labeled for control of this disease, and recommended control practices have had only limited success. Several biopesticides and synthetic active ingredients with potential to control Phytophthora crown and fruit rot have been introduced recently and should be evaluated for efficacy against *P. capsici*. The objectives of the project were to 1) identify new biopesticides and fungicides that are efficacious against *P. capsici* on yellow squash and test materials alone and in combination to determine potential for disease control, and 2) determine any phytotoxic effects that new fungicides may incite. The biopesticides evaluated were: ABM-127, strain G41 of *Gliocladium virens* (BioWorks, Geneva NY), and FNX-100 (Foliar Nutrients, Inc.). Evidence to suggest that these materials have potential to control Phytophthora crown and fruit rot on yellow squash has been published. Smith et al. (1990) reported that *G. virens*, when added to potting mix, suppressed *Phytophthora cactorum* on apple seedlings. Rosskopf et al. (2002) applied PCC-1210 (also known as FNX-100), a formulation of phosphonic acid, to greenhouse-grown pepper seedlings on a 10-day schedule and reduced the severity of *P. capsici*-induced blight by as much as 100%, depending upon the rate of inoculum used. The fungicides evaluated included pyraclostrobin, cyazofamid, fenamidone, dimethomorph plus maneb, and mefenoxam. The majority of these fungicides were reported previously as being active against *P. capsici* on yellow squash (Seebold et al., 2002).

Materials and Methods

Summer squash (cv. 'Dixie') was direct-seeded with a vacuum planter April 21, 2003 (spring trial) on bare ground at the Blackshank Research Farm in Tifton, GA. The cultivar 'Destiny III' was transplanted September 9, 2003 for the fall trial. The field where the trials were conducted is known to have a high level of *P. capsici* in the soil. Land was prepared according to guidelines recommended by the Georgia Cooperative Extension service. Plots were laid out in a split-plot design with 5 replications. The whole-plot factors were biopesticide type, and sub-plot factors were fungicide type (Table 1). The treatment total was 18, including untreated checks. Whole-plot size was 3 beds (2 rows per bed on 36-inch centers) by 15 feet for the spring trial; single rows were transplanted on each bed for the fall trial. Sub-plots consisted of single

beds within whole-plots. Materials were applied with a CO_2-powered backpack sprayer set to deliver 60 gallons per acre at 40 psi. With the exception of seed-applied ABM-127, materials were applied a 7-10 schedule day beginning 7 days after seeding (spring trial) or 14 days after transplanting (fall trial) for a total of 6 applications. FNX-100 was applied to whole plots before the application of individual fungicide treatments. ABM-127 was applied at a rate of 2 oz per cwt of seed before direct seeding (spring) or seeding of transplants (fall).

Plant populations for each plot were recorded at the time of the first biopesticide/fungicide application. The number of *P. capsici*-infected plants was counted on a weekly basis following the first appearance of symptoms, and continued until maximum mortality was observed in check plots. Weekly evaluations of mortality were used to construct disease progress curves, from which the area beneath the disease progress curve (AUDPC) was calculated. Squash were be harvested twice for the spring trial; however, severe infection of fruit by papaya ringspot virus prevented harvest in the fall trial. Data were be analyzed with the general linear model procedure (SAS Institute, Cary NC) and means were separated with Fisher's protected least significant difference test ($P \leq 0.05$).

Results and Discussion

No interaction was observed in either trial between biopesticide (whole plots) and fungicide (sub-plots). Means are therefore presented as averages across biopesticide type or fungicide type.

Spring trial. The severity of Phytophthora crown and fruit rot (PCFR) was high due to warm temperatures and high moisture. In terms of efficacy, Ridomil Gold (mefenoxam), Cabrio (pyraclostrobin), and Ranman (cyazofamid) reduced the severity of PCFR relative to the untreated control (no fungicide, no biopesticide) (Table 1). Differences in yield between these treatments and the untreated check were not observed. The onset of disease occurred after the first harvest of squash and probably played a role in the lack of differences in yield. No effects on PCFR were observed from either biopesticide product, ABM-127 or FNX-100, in terms of disease severity or yield.

Fall trial. Disease onset was delayed due to lack of natural rainfall; however, supplemental overhead irrigation was employed to create conditions favorable to infection by *P. capsici*. All fungicide treatments significantly reduced the severity of PCFR compared to the check (Table 1). Ridomil Gold 4EC was the most effective fungicide treatment. No difference in severity of disease was found between the untreated control (no fungicide, no biopesticide) and ABM-127; however, FNX-100 significantly reduced the AUDPC of PCFR. Although the onset of disease was delayed due to dry weather, the application of overhead irrigation resulted in higher severity of disease than was seen in the spring trial.

In general, Cabrio, Ranman, and Ridomil gave consistent suppression of PCFR in the two trials conducted in 2003, and the addition of FNX-100 was beneficial in the fall only. Data from a single year of testing are inconclusive and indicate that additional testing with FNX-100 is warranted. Increased rates of FNX-100 or earlier initiation of application could result in increased efficacy against PCFR when applied alone or with synthetic fungicides, and could allow for reduced rates or fewer applications of the synthetic compounds.

Table 1. Effect of foliar-applied compounds and biopesticides on the severity of Phytophthora crown and fruit rot of 'Dixie' summer squash – 2003, Tifton GA (PCAP03002).

		Spring trial			Fall Trial
			Fruit yield per plot		
Treatment	**Fungicide Rate / Acre**	**AUDPC[a]**	**No. marketable**	**Weight (lbs)**	**AUDPC[a]**
SUB-PLOT EFFECT (FUNGICIDE)					
Untreated check	--	3.52 a	83.1 abc	42.1 a	12.6 a
Cabrio 20EG	12 oz	1.98 b	81.7 abc	43.1 a	9.0 b
Ranman 400SC + Silwet L-77	2.75 fl oz 2 fl oz	1.61 b	93.0 ab	42.1 a	9.3 b
Reason 500 SC	7 fl oz	2.61 ab	78.8 bc	36.1 ab	9.5 b
Ridomil Gold 480EC	1 pt	0.06 c	95.8 a	43.9 a	6.5 c
Acrobat 50WP + Maneb 75WP	6.4 oz 2 lb	3.26 a	68.5 c	31.9 b	9.0 b
WHOLE PLOT EFFECT (BIOPESTICIDE)					
ABM-127	2 oz/cwt	2.49 a	84.7 a	41.1 a	10.5 a
No Biopesticide	--	2.29 a	84.8 a	41.1 a	10.3 a
FNX-100	2% v/v	1.70 a	81.0 a	37.4 a	7.2 b

Means followed by the same letter do not differ significantly as determined by Fisher's protected least significant difference test ($P \leq 0.05$).

[a]AUDPC=area under the disease progress curve, constructed from evaluations taken on 5/23/03, 5/30/03, 6/04/03, and 6/13/03 (spring test); or 10/10/03, 10/17/03, 10/24/03, 10/31/06, and 11/06/03 (fall test).

[b]Yield data are the total of two harvests - 5/27/03, and 6/02/03.

An Integrated Approach for Control of Powdery Mildew of Cucurbits
IR-4 Project, 2003
Final Report

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2003

Summary page

Common name of biopesticides: Serenade® and Milsana®
Genus and species or chemical name: *Bacillus subtilis* and *Reynoutria sachalinensis*
Commodities or site protected: Pumpkins
Target pests: *Sphaerotheca fuliginea* and *Erysiphe cichoracearum*, causal organisms of powdery mildew of cucurbits

Summary

The powdery mildew coverage was minimal to moderate in this particular field of pumpkins, though it was relatively easy to find. The abundant rainfall prompted a more than anticipated growth and early flowering in the plants causing an alteration in spray scheduling and more difficulty in application. By far, the most prominent disease was bacterial blight later identified as a *Xanthomonas*. This particular disease was very prevalent in plots and adjacent pumpkin fields.

The treatment data were statistically non-significant. The lack of widespread powdery mildew coverage disallowed any statistical separation. Based on raw data and overall observations, the Cabrio treatments (perhaps alternated with Serenade) were the most effective in terms of mildew control. A more susceptible cultivar with more effective plot set-up in terms of ease of application and coverage is warranted for repeat of this field test.

Materials and Methods

Pumpkin (cv. Abbott and Cobb Harvest Time) plants were seeded into commercial fields at Ladd farms (Figures 1-2) in Tupelo, Arkansas on June 22, 2003. The plants had reached cotyledon stage by July 1 and were growing rapidly due to high rainfall amounts. Flowering began by the third week in July. The initial application (see timeline) was made on August 10 using a backpack sprayer down the row at approximately 50 GPA. Volume was adjusted up to 75 GPA to achieve coverage on larger pumpkins later in the test. The Milsana (alone) treatments were not applied on September 8.

Pumpkins were evaluated on October 7 for mildew and bacterial blight. Ten leaves per plot (40 per treatment) were randomly selected, bagged and transported to the ARI facilities for evaluation. Each leaf was evaluated on a 0-4 rating scale where 0=no disease; 1=1-25% of leaf surface covered; 2=26-50% of leaf surface covered; 3=51-75% of leaf surface covered and 4=76-100% of leaf surface covered with clear symptoms and/or fruiting structures. Powdery mildew, bacterial blight and viral infection(s) were all evaluated in this manner. The numbers of rotted fruit down the middle of each plot were also evaluated. Data were analyzed using the StatsDirect statistical analyses package with means separated at the 0.05 level.

Plot Design (Randomized within two border blocks)

South

Border Row	Border Row	Border Row	Border Row	Border Row
Border Row	Border Row	Border Row	Border Row	Border Row
Trt 1	**Trt 2**	**Trt 3**	**Trt 4**	**Trt 5**
Untreated	**Trt 9**	**Trt 8**	**Trt 7**	**Trt 6**
Trt 4	**Trt 3**	**Trt 5**	**Trt 9**	**Untreated**
Trt 6	**Trt 8**	**Trt 7**	**Trt 1**	**Trt 2**
Road	Road	Road	Road	Road
Border Row	Border Row	Border Row	Border Row	Border Row
Border Row	Border Row	Border Row	Border Row	Border Row
Untreated	**Trt 6**	**Trt 2**	**Trt 4**	**Trt 1**
Trt 5	**Trt 7**	**Trt 8**	**Trt 9**	**Trt 3**
Trt 8	**Trt 1**	**Trt 7**	**Untreated**	**Trt 6**
Trt 2	**Trt 3**	**Trt 9**	**Trt 4**	**Trt 5**
Road	Road	Road	Road	Road

North

Treatments applied*

1) Quadris® (azoxistrobin) at 12.8 fl oz/A, eight times on a bi-weekly schedule
2) Quadris at 12.8 fl oz/A, alternating each time with a spray of Serenade at 6 lb/A
3) Quadris at 12.8 fl oz/A, alternating each time with a spray of Milsana at 0.5% v/v in 50 – 100 gal H_20/A
4) Cabrio® EG (Kresoxim-methil) at 16 oz/A, eight times on a bi-weekly schedule
5) Cabrio EG at 16 oz/A, alternating each time with a spray of Serenade at 6 lb/A
6) Cabrio EG at 16 oz/A, alternating each time with a spray of Milsana at 0.5% v/v in 50 – 100 gal H_20/A
7) Serenade at 6 lb/A, eight times on a bi-weekly schedule
8) Milsana at 0.5% v/v in 50 – 100 gal H_20/A eight times on a bi-weekly schedule
9) Milsana at 1% v/v in 50 – 100 gal H_20/A eight times on a bi-weekly schedule
10) Untreated control

*Quadris and Cabrio rates are slighter higher than originally proposed per recommendations from the U of A extension service for use of these particular fungicides on pumpkins in this area.

Timeline of Testing*

June 22, 2003

Pumpkins planted.

July 1, 2003

Pumpkins at cotyledon stage.

July 23, 2003

Pumpkins beginning to flower. The abundant rain has accelerated the growth and flowering of the pumpkins beyond what is normally seen.

August 10, 2003

Initial application(s) made. No powdery mildew observed (to date).

August 26, 2003

Pumpkins sprayed. Weather is hot and dry at this point. Mildew observed on the leading edge of one plot.

September 8, 2003

Pumpkins sprayed. The Milsana treatments (Treatments 8 and 9) were not applied on this date.

September 16, 2003

Pumpkins sprayed. Powdery mildew easily found but spread minimum.

September 22, 2003

Pumpkins sprayed. Powdery mildew not progressing a great deal.

*There were fewer applications than originally proposed due to the late onset of disease. Initial applications were also delayed because of the nighttime temperatures that were thought to be too high in late July and very early August, prompting a later starting date.

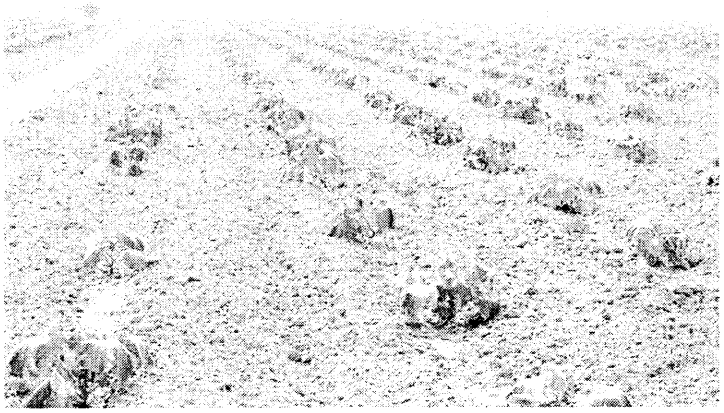

Figure 1. Pumpkin plots on the Ladd Farm(s) in Tupelo, AR.

Figure 2. Pumpkin plants on the Ladd Farm(s) in Tupelo, AR.

Table 1. Disease on pumpkins at the Ladd farm (IR-4 Plots) during the season, 2003.*

Treatment	% Powdery Mildew Mean (Range)	% *Xanthomonas* Mean (Range)	% Viral Infection Mean (Range)	Number of non-rotted fruit
Quadris @ 11 fl oz/A	9 (0-100)	43 (0-100)	7 (0-25)	4.5
Quadris/Serenade	5 (0-25)	44 (0-100)	4 (0-25)	5
Quadris/Milsana	5 (0-50)	40 (0-100)	5 (0-25)	6
Cabrio EG @ 12 fl oz/A	2.5 (0-25)	36 (0-100)	8 (0-25)	3.75
Cabrio EG/Serenade	7 (0-50)	35 (0-100)	6 (0-25)	5.25
Cabrio EG/Milsana	7.5(0-50)	41(0-100)	6(0-25)	3.25
Serenade @ 6 lb/A	13 (0-75)	54 (0-100)	6 (0-25)	4.5
Milsana (0.05%)	7.5(0-75)	54(0-100)	4(0-25)	5.0
Milsana (1%)	12.5(0-100)	41(0-100)	4(0-25)	3.5
Untreated Control	11 (0-100)	40 (0-100)	6 (0-25)	3.75

A total of 10 randomly selected pumpkin leaves were selected from each replicate of each treatments (total of 40 leaves per treatment). Leaves were evaluated visually for the presence of powdery mildew, bacterial blight (*Xanthomonas*) or viral infection based on a 0-4 scale were 0=no disease; 1=1-25% of leaf covered; 2=26-50% of leaf covered; 3=51-75% of leaf covered and 4=76-100% of leaf covered. Ratings were converted to maximum percentages for analysis and presentation in the table. The numbers of fruit were counted down the middle of each replicate row.

No significant differences were found between any treatments per disease data.

Results and Discussion

Bacterial blight was the most problematic disease in this test. Blight was widespread and severe on a good number of leaves and/or plants (Table 1). To a lesser degree, viral symptoms were found in most plots but not quite as widespread. Gummy stem blight (data not shown) was also present but not significant, at least from our observations. Mildew was first seen in the plots in Late August along the edge of the road running between the two major treatment blocks. Though spreading occurred throughout the month of September, severity did not increase to the point where plants were significantly affected. Mildew was present, however, in most plots in each major treatment block. Based on observations and simple means, the Cabrio treatments seemed to work slightly better than others (Table 1). Also, some of the combination treatments had slightly less mildew. Examples are the Quadris mixes and the Cabrio/Serenade combination (Table 1). Because of the rapid growth of the plants, coverage was difficult, especially late in the season when mildew did begin to spread a little. It appears that some of these treatments can be effective but different cultivar(s) of pumpkins should be used and a different plot design utilized to spread plants and make application and coverage more effective.

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Rotation of biocides with powdery mildew fungicides to suppress powdery mildew of squash in Georgia.

Squash seeds were planted on 1 May in black plastic mulch covered beds at the RDC Expo Area Farm, a unit of the Coastal Plain Experiment Station in Tifton, GA. Mulched beds had a 32-in. top and were planted on 6-ft centers. Seeds were planted in one row and were spaced 2 ft apart within the row, resulting in 8 plants per plot. Plots were 15 ft long, were separated on each end by 3 ft of bare plastic, and were arranged in a randomized complete block design with 4 replications. Fertility, insect and weed control were managed according to standard University of Georgia Extension Service recommendations. Fungicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 40 gal/A at 75-80 psi through TX-18 hollowcone nozzles. Plots were oversprayed with Reason at 8.0 fl oz/acre on 28 May to control downy mildew. Weather during the experiment was near the 77 year average for temperature and rainfall.

Powdery mildew was first observed on 5 Jun and increased to high levels by 30 Jun. All treatments significantly reduced disease on 10 Jun compared to the non-treated check. Disease suppression was significantly greatest when Nova was applied alone or when alternated with Serenade or Milsana when compared to Cabrio. Significant disease suppression was only observed on 26 Jun in plots treated with Milsana alone, Kaligreen alone, Nova alone, Nova alternated with Milsana, and Cabrio and Nova alternated with Kaligreen. There was some stunting associated with Kaligreen applied alone.

Treatments, rates, and (spray times)[z]	Powdery Mildew[y] 10 Jun	Powdery Mildew 26 Jun
Milsana, 0.5% v/v + Tween 20, 0.02% v/v (1-4)	4.0 b[x]	6.8 bc
Kaligreen, 3.0 lb/acre (1-4)	3.4 bc	4.8 e
Cabrio, 12.0 oz/acre (1-4)	3.0 b-d	8.0 ab
Nova, 4.0 oz/acre (1-4)	1.5 e	5.0 de
Serenade, 4.0 lb/100 gallons (1-4)	3.6 b	8.8 a
Cabrio, 12.0 oz/acre (1, 3) Milsana, 0.5% v/v + Tween 20, 0.02% v/v (2, 4)	3.4 bc	9.0 a
Nova, 4.0 oz/acre (1, 3) Milsana, 0.5% v/v + Tween 20, 0.02% v/v (2, 4)	2.5 c-e	6.5 b-d
Cabrio, 12.0 oz/acre (1, 3) Kaligreen, 3.0 lb/acre (2, 4)	2.4 c-e	6.8 bc
Nova, 4.0 oz/acre (1, 3) Kaligreen, 3.0 lb/acre (2, 4)	2.3 de	5.8 c-e
Cabrio, 12.0 oz/acre (1, 3) Serenade, 4.0 lb/100 gallons (2, 4)	3.9 b	7.8 ab
Nova, 4.0 oz/acre (1, 3) Serenade, 4.0 lb/100 gallons (2, 4)	2.1 de	8.0 ab
Non-treated	5.8 a	9.3 a

[z]Spray dates were: 1=28 May; 2=5 Jun; 3=13 Jun; 4=20 Jun.
[y]Powdery mildew was rated on a 1-10 scale where 1=1-10% leaf area affected by powdery mildew and 10=100% leaf area affected by powdery mildew on both leaf surfaces.
[x]Means followed by the same letter(s) are not significantly different according to Fisher's Protected LSD test at $P \leq 0.05$.

Examine the Efficacy of Milsana for the Control *Botrytis* on Greenhouse Tomatoes

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Weslaco, TX

The objective of this trial was to examine the efficacy and investigate the potential for use of biopesticides, such as Milsana, Serenade, and Pre-Stop, in the integrated pest management system for controlling *Botrytis* on greenhouse grown tomatoes.

Six week old Better Boy seedlings were transplanted in late September into 2-gal pots filled with Sunshine Mix #1 and Osmocote 18-6-12 (1% v/v). Pots were arranged having 5 pots in a single row per treatment plot replicated three times in a random block design. Greenhouse temperatures ranged from 65 °F to mid-day highs up to 95 °F. Greenhouse was equipped with a fog cooling system which aided in maintaining a high humidity.

In mid-October we received tomato stalks heavily infected with *Botrytis cinerea* from Village Farm Greenhouses in Pennsylvania. Dr. Marvin Miller, plant pathologist, confirmed that conidia was present on the stalks. To test our inoculation procedure, we brought three tomato plants into the lab and caused two injuries to each plant by trimming off a lower leaf and scraping the stem with a rough pad. Each site of injury was rubbed with the infected stalk and then a clear plastic bag was placed over each plant. After five days, fungus growth was observed on the area where the leaf was trimmed off whereas the scraped area exhibited very little to no fungicidal growth.

Applications of test substances began on Oct. 20 and were applied every 7 to 10 days. Application dates were Oct. 20, Oct. 27, Nov. 3, Nov. 13, Nov. 21 and Dec. 2. All fungicides were mixed using reverse osmosis water. Applications were made using a CO2 backpack spray unit calibrated to a rate equivalent to 60 gallons per acre.

Two days after the second application, plants were inoculated by trimming of the lower three leaves and developing lateral shoot and then rubbing the cut area with infected stalks newly received from Pennsylvania. On Nov. 7, plants were re-inoculated. From remaining stalks, cultures of *Botrytis cinerea* were established indicating that the fungus was viable.

Disease rating was made on Dec. 9th, one week after the final application. Ratings were based on the severity of disease development at the injury sites. Each of the three sites that were innoculated on the center 3 plants of each treatment plot were given a rating. Severity of the disease was low. This could have been due to high mid-day temperatures and increased lateral air flow used to cool the greenhouse. Using the fog cooling system aided in maintaining a high humidity.

This same trial was conducted in Spring '03, yet a source for inoculum was not located before the temperatures became too warm in the greenhouse for disease development. During both trials, no signs of phytoxicity due to spray applications were observed.

Acknowledgments: Special thanks to Mike Bledsoe and Cheryl Young of Village Farms for supplying disease material. Thanks to Dr. Marvin Miller for his aid in identifying and culturing of the disease.

Results.

Trt #	Test Substance	Rate	Application Schedule	12-9-03 Rating[1]
1	Switch 62.5 WG	0.875 lb/A	1 3 5	0.44 ab [2]
2	BAS 516 38WG	1.2 lb/A	1 3 5	0.94 bc
3	CaptEvate	3.5 lb/A	1 2 3 4 5 6	0.11 a
4	Serenade	4.0 lb/A	1 2 3 4 5 6	1.74 c
5	Milsana + Silwet	0.5 % + 0.02 %	1 2 3 4 5 6	1.19 bc
6	SBTX-016	2 oz/ 10 gal	1 2 3 4 5 6	0.15 a
7	Pre-Stop	10 g/liter	1 2 3 4 5 6	0.44 ab
8	Milsana + Silwet CaptEvate	0.5 % + 0.02 % 3.5 lb/A	1 2 4 6 3 5	0.22 ab
9	SBTX-016 CaptEvate	2 oz/ 10 gal 3.5 lb/A	1 2 4 6 3 5	0.11 a
10	CaptEvate	3.5 lb/A	1 3 5	0.11 a
11	Milsana + Silwet SBTX-016	0.5 % + 0.02 % 2 oz/ 10 gal	1 3 5 2 4 6	0.37 ab
12	SBTX-016 Pre-Stop	2 oz/ 10 gal 10 g/liter	1 3 5 2 4 6	0.22 ab
13	CaptEvate Switch	3.5 lb/A 0.875 lb/A	1 3 5 2 4 6	0.07 a
14	Untreated	-	-	2.80 d

[1] 0 = no disease; 1 = very slight disease growth; 3 = disease growth spreading to surrounding tissue; 5 = disease growth spreading to over 1 square inch; 10 = stem death.

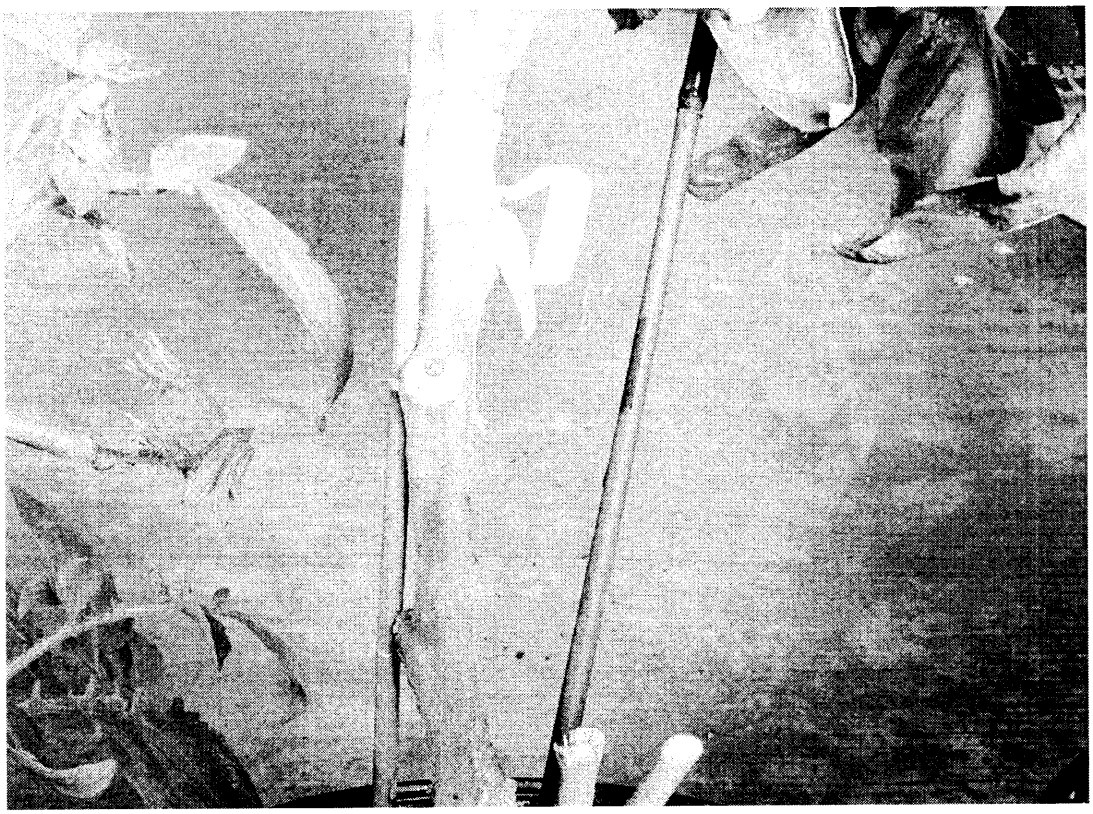
[2] Means within a column followed by the same letter are not significantly different, (p=0.05, Duncans's Multiple Range Test).

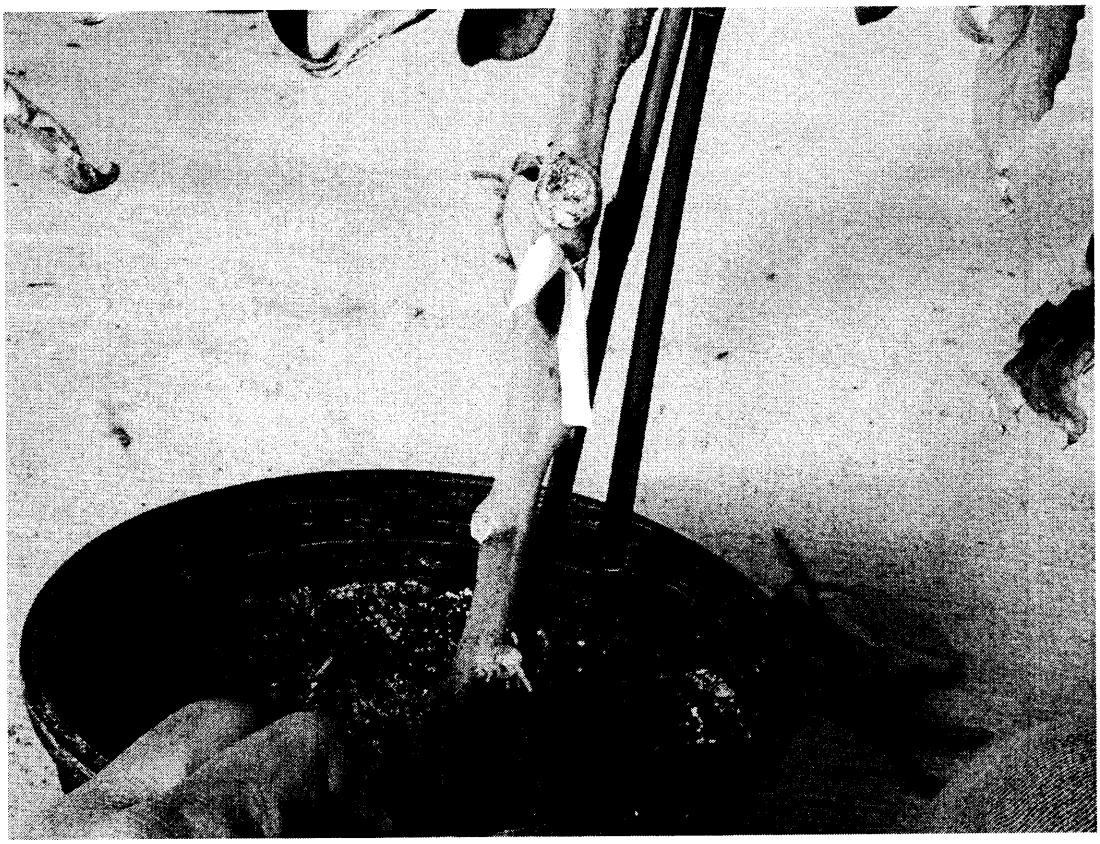
Another trial is currently in progress. It is hoped that during the winter months we will be able to maintain a more favorable environment for disease development by maintaining cooler temperatures with less lateral air flow similar to conditions that exists in commercial greenhouses where the disease is problematic.

Trt #	Test Substance	Rate	Application Schedule
1	Switch 62.5 WG	0.875 lb/A	1 3 5
2	CaptEvate	3.5 lb/A	1 2 3 4 5 6
3	Serenade	4.0 lb/A	1 2 3 4 5 6
4	Milsana + Silwet	0.5 % + 0.02 %	1 2 3 4 5 6
5	SBTX-016	2 oz/ 10 gal	1 2 3 4 5 6
6	Pre-Stop	10 g/liter	1 2 3 4 5 6
7	Milsana + Silwet CaptEvate	0.5 % + 0.02 % 3.5 lb/A	1 2 4 6 3 5
8	SBTX-016 CaptEvate	2 oz/ 10 gal 3.5 lb/A	1 2 4 6 3 5
9	Milsana + Silwet SBTX-016	0.5 % + 0.02 % 2 oz/ 10 gal	1 3 5 2 4 6
10	SBTX-016 Pre-Stop	2 oz/ 10 gal 10 g/liter	1 3 5 2 4 6
11	CaptEvate Switch	3.5 lb/A 0.875 lb/A	1 3 5 2 4 6
12	Untreated	-	-

Rating Examples.

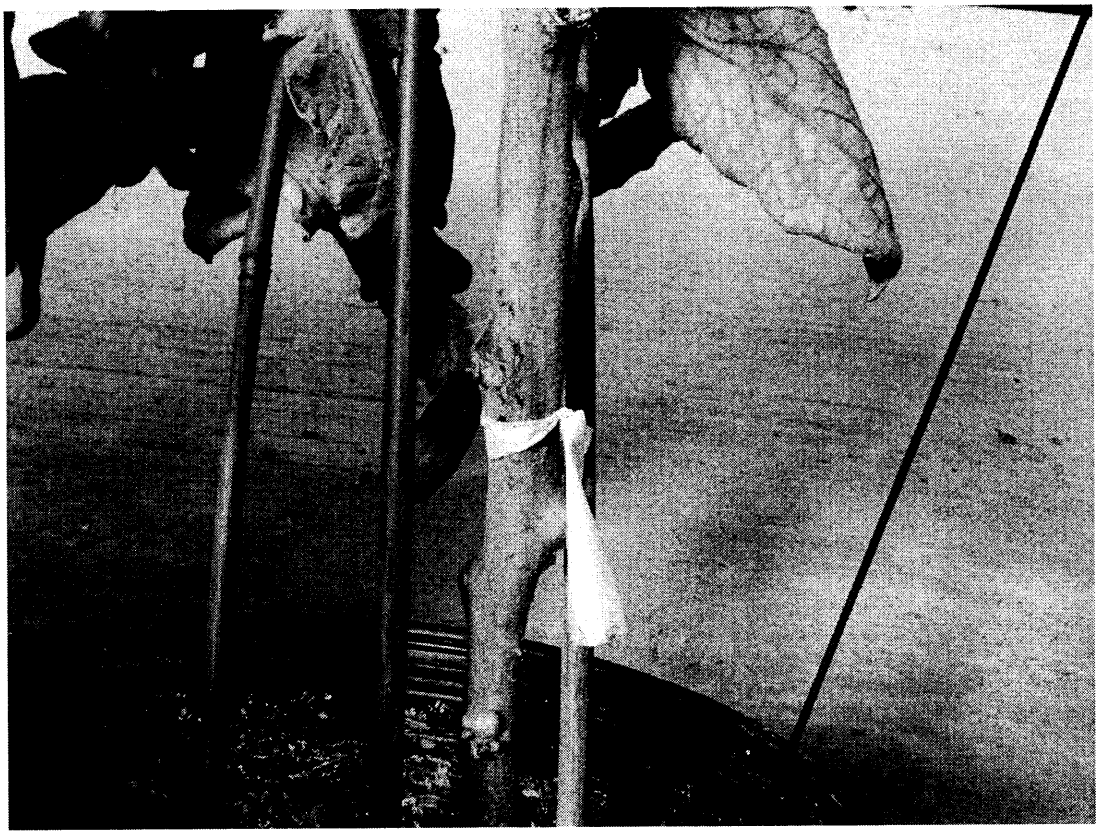
Picture 1: Rating = 0, no disease development.

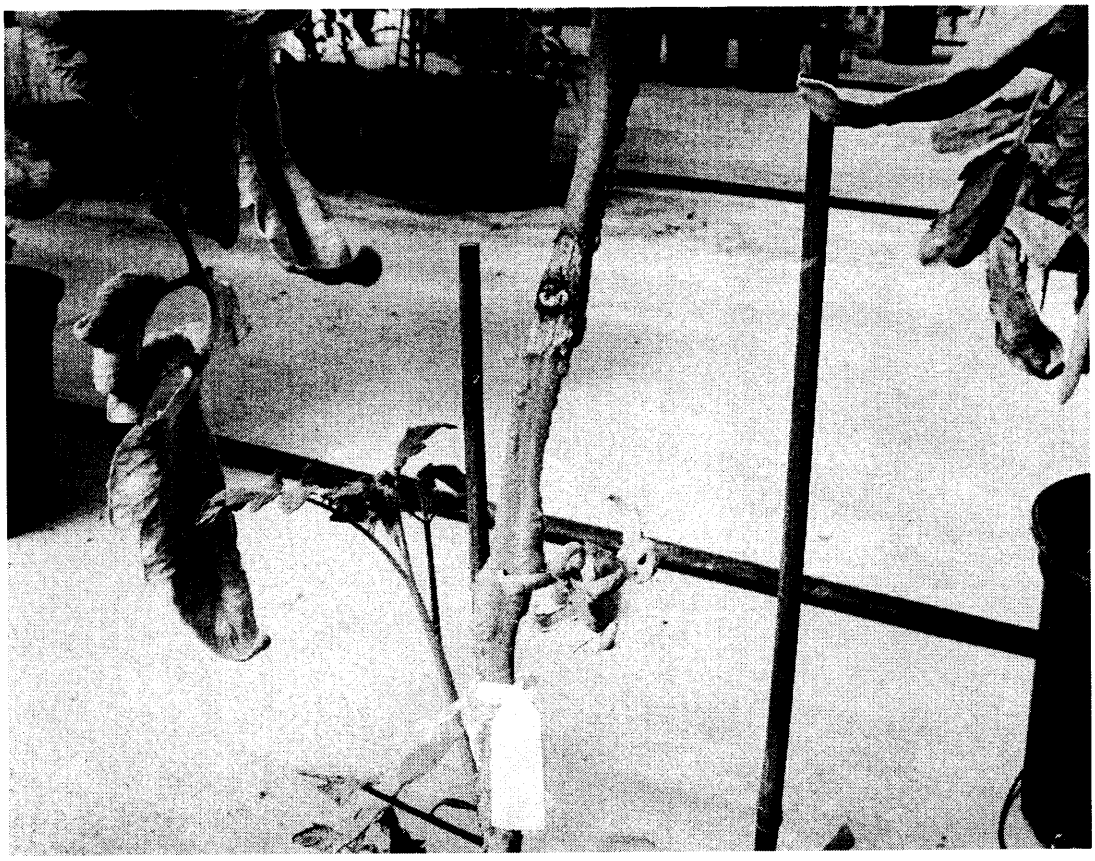




Picture 2: Rating = 1, very slight disease growth

Picture 3: Rating = 3, disease beginning to spread to surrounding tissue





Picture 4: Rating = 5, disease spread to over 1 square inch area.

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Evaluation of fungicides for control of foliar diseases of strawberries, 2003.

The experiment was conducted in a mature, commercial, matted-row strawberry planting in Suttons Bay, MI. Rows were spaced 42 in. apart. Treatments were applied to 10-ft sections of row and were replicated four times in a randomized complete block design with no buffer rows. Sprays were applied with an R & D Research CO_2 cart-styled sprayer equipped with six bottles (0.8 gal each), a twin gauge Norgren pressure regulator set at 55 psi, and a single XR TeeJet 8002VS nozzle on a 5-ft spray boom. Spray volume was 100 gpa. Spray dates and corresponding phenological stages were as follows: 3 Jun (early bloom), 12 Jun (mid-late bloom), 19 Jun (green fruit), 30 Jun (pink fruit), and 7 Jul (pre-harvest). Rainfall between sprays was 1.02, 0.0, 0.25 and 0.0 in. respectively. On 15 Jul, powdery mildew and Phomopsis leaf blight were visually estimated as % total leaf area affected on twenty leaves taken from the center 3 ft of each plot.

Powdery mildew and Phomopsis leaf blight pressure were light, presumably due to the cool growing season. Therefore incidence as well as overall severity are reported. All treatments significantly reduced powdery mildew overall severity. Pristine (1.45 lb/A) provided numerically the best control of both powdery mildew incidence and overall severity. All other treatments including the programs containing Milsana were statistically equivalent to Pristine. Phomopsis leaf blight incidence was reduced most by Milsana and overall severity was reduced most by the Captec/Topsin/Elevate/Cabrio program. Pristine (1.18 lb/A) tended to provide the poorest control of Phomopsis leaf blight. This trial shows that Milsana has activity against powdery mildew as well as against Phomopsis leaf blight. Alternation of Milsana with other fungicides resulted in similar control as the straight Milsana program. Substitution of Captec + Topsin by Milsana in the standard program showed no significant differences and even a small improvement over the standard program

		% Leaf area affected			
		Powdery mildew		Phomopsis leaf blight	
Treatment, rate/A	Application Timing[z]	Incidence (%)	Overall severity (%)	Incidence (%)	Overall severity (%)
Untreated		47.5 a[y]	1.05 a[x w]	100.0 a[x]	3.7 a[x v]
Captec 4L 2.5 qt + Topsin M 70WP 1.5 lb Elevate 50WDG 1.5 lb Cabrio EG 14 oz	1, 3, 2, 5 4,	25.0 ab	0.13 b	88.8 abc	0.50 b
Milsana 1% v/v Elevate 50WDG 1.5 lb Cabrio EG 14 oz	1, 3, 2, 5 4,	23.8 b	0.09 b	82.5 bcd	0.61 b
Milsana 1% v/v Elevate 50WDG 1.5 lb	1, 3, 4, 2, 5	22.5 b	0.15 b	73.8 d	0.51 b
Pristine 1.18 lb	1, 2, 3, 4, 5	20.0 b	0.04 b	92.5 ab	1.31 b
Milsana 1% v/v	1, 2, 3, 4, 5	15.0 b	0.11 b	77.5 cd	0.87 b
Pristine 1.45 lb	1, 2, 3, 4, 5	10.0 b	0.03 b	78.8 cd	0.88 b

[z] Spray dates: 1 = 3 Jun (early bloom), 2 = 12 Jun (mid-late bloom), 3 = 19 Jun (green fruit), 4 = 30 Jun (pink fruit), 5 = 7 Jul (pre-harvest).

[y] Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.065$).

[x] Column means followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P \leq 0.05$).

[w] Values shown are actual means; statistical analysis was performed on Arcsin-transformed data.

[v] Data did not pass Bartlett's test for homogeneity of variance; assumptions of ANOVA may have been violated.

Final Report

Effect of Messenger on Ramularia Leaf Spot and Yields of Artichokes

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Abstract

Ramularia leaf spot (RLS) caused by *Ramularia cinerae* is a serious disease of artichokes that interferes with the photosynthesis of the host plant and consequently reduces crop yield. During the production phase, the disease spreads to the developing buds and affects their quality by producing dark spots before harvest or during their transportation to the market. Currently effective control measures against this disease are not available. The suppression of many members of herbivore community by induced plant resistance is well documented. In this ecological phenomenon, host-plants treated with certain naturally occurring proteins are induced to produce their own defensive proteins that impart resistance against various herbivores. Harpin is one such naturally occurring bacterial protein present in a number of plant pathogenic bacteria. When applied to a host plant it is shown to elicit hypersensitive response that leads to resistance to broad array of viral, fungal, and bacterial diseases. Utilizing this harpin protein, EDEN Bioscience Corporation has developed its first commercial product, Messenger® that provides natural defense mechanism to host against various herbivores. We investigated the potential of Messenger in the artichokes grown under annual cropping system for the suppression of ramularia leaf spot, which often becomes a limiting factor in the normal production. Field studies carried out at two locations indicated the standard fungicide Rally out performed Messenger in suppressing the disease. However, due to low to moderate disease pressure, artichoke yield was not affected by any of the treatments including untreated control.

KEY WORDS Ramularia leaf spot, Messenger, Rally, Quadrus,

Introduction

Ramularia leaf spot (RLS) caused by *Ramularia cinerae* is a serious disease of artichokes, which affects the crop in two ways. 1. When present on the foliage, the necrotic spots resulting from infection gradually enlarge and coalesce with each other covering the entire leaf surface. At this stage, the infected leaves turn brown and dry up. If not controlled, the fungus spreads to the entire plant canopy seriously affecting plant's ability to carry on photosynthesis ultimately causing significant yield reduction. This disease syndrome is very much prevalent in the annual artichoke production system particularly in fields that are planted in rainy season, sprinkle irrigated, and/or planted at close plant spacing on 40-inch beds. In the perennial system the diseases is prevalent in the rainy season when the splashing raindrops scatter the fungal spores to healthy foliage. 2. When the disease spreads to the artichoke buds dark brown to black spots develop on buds' surface before their harvest or during the course of their transportation to the market thus affecting the quality of the produce. Ten to 15% of the artichoke buds harvested are affected this way.

Currently, effective control measures are not available against this disease. Rally (Myclobutanil) is the only fungicide that is registered on artichokes under Section 18 Emergency Exemption with a restricted use against powdery mildew, another serious disease of this crop. This fungicide while highly effective against powdery mildew is also moderately effective in controlling RLS. However, sole reliance on one material for the management of two different diseases could lead to the development of resistance in either organism. Further, the plant-back restriction prohibits its use in crop rotation with non-labeled crops. Increased environmental risk due to multiple applications of this fungicide is also a concern. Even though there is enough interest among the artichoke growers to incorporate environmentally sound disease management methods; few options are currently available.

The suppression of many members of herbivore community by induced plant resistance is well documented. In this ecological phenomenon, host-plants treated with certain naturally occurring proteins are induced to produce their own defensive proteins that impart resistance against various herbivores (Jennifer S. Thaler et al., 2001). Plant signals responsible for inducing resistance are highly conserved among plant species and appear to be effective in many crop and pest situations (Constable and Rayan 1988, Morris et al. 1998). Several elicitors have been tested against pathogens and marketed for crop use. For example, Syngenta is currently marketing BTH in Europe to induce resistance against powdery mildew in wheat (Karban 1999). Harpin is one such naturally occurring bacterial protein present in a number of plant pathogenic bacteria. The first harpin protein was isolated from the bacterium *Erwinia amylovora*. When applied to a host plant it is shown to elicit hypersensitive response that leads to resistance to broad array of viral, fungal, and bacterial diseases (Wei, et al., 1992). Utilizing this harpin protein, EDEN Bioscience Corporation developed its first commercial product, Messenger® that reportedly provided natural defense mechanism to host plants against various herbivores (Eden Bioscience Corporation 2001). Initial studies conducted indicated that Messenger when applied to artichokes for the suppression of RLS resulted not only in acceptable disease control but it also increased the winter/spring production by 11 percent (Bari, 2002-unpublished). We investigated the potential of Messenger in the artichokes grown under annual cropping system for the

suppression of ramularia leaf spot, which often becomes a limiting factor in the normal crop production.

Materials and Methods

The Study was conducted at two locations in the major artichoke production area on the central coast of California, viz., Castroville (Monterey county, Gularte Ranch, Seamist Farms) and Lompoc (Santa Barbara county, Baroda Ranch) in cooperation with local growers.

At Gularte Ranch artichoke seedlings (cultivar: DG 2002) were transplanted on June 17, 2003 on 80-inch beds with 24-inch plant spacing. The crop was sprinkle irrigated immediately after transplanting and continued at approximately 2-wk interval thereafter throughout the growing season. At Baroda Ranch the crop (cultivar: S-19) was directly seeded on April 13, 2003 in 40-inch beds and irrigated with sprinklers initially. After thinning the plants to 24-inch spacing at 4-6 leaf stage, drip tape was installed and the crop was irrigated according to the evapotranspiration (Eto) reading. Other cultural practices such as intercultivation, fertilization, and insect control were carried out according to local standards.

Treatments at Gularte Ranch included: 1. Rally 40 W (4.0 oz), 2. Messenger 4.5 oz, 3. Rally 40 W (4.0 oz) + Messenger 4.5 oz, and 4. Untreated Control. The test materials in treatments 1-3 were applied to 2 rows of 20 plants each replicated 6 times in a randomized complete block design. Sprays were applied 4 times from June 18, 2003 through September 2, 2003 at approximately 3-wk intervals. A backpack sprayer equipped with CO_2 charged system was used to deliver the sprays. In the first two applications the spray boom was equipped with a single TeeJet D-7 w/46 core nozzle delivering 50 gallons per acre at 40 psi. For the last two sprays two Teejet DG 8005 VS nozzles were used to deliver 75 gallons per acre at 60 psi for thorough coverage of bigger plants.

Treatments at Baroda Ranch included: 1. Rally 40 W (4.0 oz), 2. Messenger (4.5 oz), 3. Rally 40 W (4.0 oz) + Messenger (4.5 oz), 4. Quadrus (12.3 oz), and 5. Untreated Control. The test materials in treatments 1-4 were applied to 2 rows of 20 plants each replicated 6 times in a randomized complete block design. Sprays began on June 25, 2003 when the plants reached 4-6-leaf stage and the subsequent sprays continued through September 3, 2003 at approximately 3-wk intervals. The other parameters (sprayer, nozzle type, and volume) were similar to those used at Gularte Ranch. Treatment dates at the two locations are listed in Table 1.

Table 1. Treatments evaluated at the two geographic locations, application rates, and spray dates.

Treatment and Rate of application (ounces of product/a)		Dates of spray application: Gularte Ranch Castroville	Dates of spray application: Baroda Farms Lompoc
1. Rally 40 W	4.0	6/18, 7/9, 8/8, and 9/2	6/25, 7/15, 8/13, and 9/3
2. Messenger	4.5	6/18, 7/9, 8/8, and 9/2	6/25, 7/15, 8/13, and 9/3

3. Rally +	4.0		
Messenger	4.5	6/18, 7/9, 8/8, and 9/2	6/25, 7/15, 8/13, and 9/3
4. Quadrus	12.3		6/25, 7/15, 8/13, and 9/3
Untreated Control			

Disease incidence (DI: % of artichoke leaflets infected) and Disease Severity (DS: % leaf area covered with disease lesions rated on a scale 0-4) were visually estimated by examining 20 leaflets randomly collected from the lower half of the plant canopy between crop's vegetative phase and harvest. As the crop reached the production phase, mature buds were harvested at weekly interval and the crop yield (number and weight of harvested buds) was recorded. Data on DI, were subjected to analysis of variance after transforming the data to arcsine $\sqrt{}$(percentages) followed by LSD mean separation when the F test for specific data was significant. Data on DS, and cumulative crop yield (number and weight of harvested buds) were analyzed after $\sqrt{}(x+0.5)$ transformation.

Results and Discussion

The data collected on the disease incidence (DI) at both locations indicate that the disease potential was present at all times as high percentages of leaflets examined in the control plots at different times during the course of study were infected (Table 2). However, the disease severity (DS) hardly exceeded 2.2 on the scale of 0-4 (approximately 50% of leaf surface covered with the disease lesions). Nonetheless, among the various treatments, the standard fungicide program (Rally applied at 4 oz/a) suppressed both DI and DS significantly as compared to untreated control. Messenger applied alone did not have any effect on the disease, as the two indices were not significantly different from untreated control at both locations. Further, mixing Messenger with Rally did not show any improvement in the performance of Rally either indicating Rally being solely responsible for the control in this treatment. At the Lompoc location we tested Quadrus (Azoxystrobin), a reduced risk product with a pending registration on artichokes for RLS control. It reduced the DI and DS significantly as compared to Messenger and untreated control.

Table 2. Mean Disease incidence (DI)[a] and mean disease severity (DS)[b] recorded on three specified dates during the crop cycle at each geographic location[c].

Castroville, Gularte Ranch

		September 20		October 01		October 10	
Treatment		DI	DS	DI	DS	DI	DS
Rally 40 W	4.0 oz	4.0±2.3a	0.1±0.02a	25.0±1.8a	0.29±0.40a	73.8±6.8a	0.83±0.20a
Messenger	4.5 oz	98.8±1.3b	1.5±0.29b	97.5±2.0b	2.10±0.25b	83.8±5.9a	0.95±0.19a
Rally 40 W +	4.0 oz						
Messenger	4.5 oz	29.5±6.6a	0.2±0.07a	20.0±5.0a	0.21±0.05a	75.0±4.5a	0.93±0.15a

Untreated Control		100.0±0.0b	1.8±0.11b	96.3±1.5b	2.23±0.15b	80.0±7.0a	0.88±0.30a

Lompoc, Baroda Ranch

		September 10		September 17		September 24	
Treatment		DI	DS	DI	DS	DI	DS
Rally 40 W	4.0 oz	0.0±0.0a	0.00±0.00a	15.8±2.7a	0.16±0.03a	42.5±12.4a	0.44±0.13a
Messenger	4.5 oz	54.2±13.6c	0.54±0.14b	98.3±1.7c	1.74±0.17c	100.0±0.0c	2.53±0.25c
Rally 40 W + Messenger	4.0 oz 4.5 oz	5.0±3.1a	0.05±0.03a	27.5±9.1a	0.28±0.09ab	43.3±8.8a	0.43±0.09a
Quadrus	12.3 oz	19.2±6.1b	0.19±0.04a	53.3±8.0b	0.53±0.09b	86.7±4.0b	0.88±0.05b
Untreated Control		70.8±7.6c	0.71±0.03b	100.0±0.0c	2.04±0.18c	100.0±0.0c	2.14±0.18c

[a]Percent leaflets showing the disease. [b]Disease severity rated on the scale of 0-4 (0=no lesions, 1=1-25%, 2=26-50%, 3=51-75%, and 4=>75% of the leaflet area covered with the lesions. [c]Means within columns with the same letter are not statistically different (*P = 0.05;* LSD)

Data presented in Table 3 on the effect of various treatments on crop yield indicate no significant differences among various treatments including control at both locations. This could be due to the lesser severity of RLS resulting from abnormally warm and dry weather in fall.

Table 3. Crop yield recorded as cumulative number of marketable buds harvested and their total weight at each geographic location[a].

Treatment		Castroville, Gularte Ranch[b] Mean No. of buds	Castroville, Gularte Ranch[b] Mean Weight (lb)	Lompoc, Baroda Ranch[c] Mean No. of buds	Lompoc, Baroda Ranch[c] Mean Weight (lb)
Rally 40 W	(4.0 oz)	50.5±4.5 a	24.6±3.2 a	51.5±3.5 a	26.3±2.8 a
Messenger	(4.5 oz)	39.5±5.6 a	23.8±2.8 a	51.2±6.0 a	23.7±4.5 a
Rally 40 W + Messenger	(4.0 oz) (4.5 oz)	56.8±6.8 a	28.7±3.9 a	47.2±5.5 a	22.3±3.2a
Quadrus	(12.3 oz)	-	-	57.8±6.0 a	28.9±4.0 a
Untreated Control		59.5±2.5 a	28.4±3.9 a	56.5± 3.8 a	28.3±3.8 a

[a] Means within columns with the same letter are not statistically different ($P = 0.05$; LSD)
[c] Pooled data for buds harvested between October 15 and November 12, 2003.
[d] Pooled data for buds harvested between September 24 and October 22, 2003.

Conclusion

While the disease pressure was low in the beginning of the trial at Baroda Ranch, Lompoc, it was moderate at Gularte Ranch, Castroville. As the season progressed the disease pressure increased to moderate level in the control plots in Lompoc, but it never reached a high level to inflict yield loss. At Castroville, the disease pressure decreased in the final stages of the crop cycle. This low pressure at both locations could be attributed to abnormally high atmospheric temperature and low relative humidity recorded during the fall of 2003 throughout the coastal region of California.

At both locations the conventional fungicide Rally applied alone and in combination (tank-mixed) with Messenger significantly reduced RLS as compared to untreated control. Messenger failed to provide any control of this disease. At Lompoc, Quadrus (Azoxystrobin), a reduced-risk fungicide suppressed the disease significantly as compared to Messenger and Untreated control. However it was out-performed by Rally in reducing the disease severity throughout the crop cycle.

From these data it appears that Messenger applied four times during the vegetative phase of the crop was not enough to give needed control. Optimizing timing of its application may enhance its performance since it has little or no eradication activity. However, that would increase the crop protection cost significantly as compared to Rally. Quadrus on the other hand seems to have significant potential against RLS. Its higher rate of application combined with optimized timing would further increase its efficacy. Further, this fungicide might be of significant importance in situations where Rally could not be used because of plant-back restriction in crop rotation program since Quadrus would be registered soon on a broader range of vegetables. For artichokes grown for organic production, the gap remains to be wide open, as alternatives for disease control in this production system simply do not exist.

Acknowledgement

We thank the Interregional Research Project #4 for financial support under the 2003 Biopesticide Grant Program, and Artichokes Research Association for providing matching funds. We also thank Dale Huss, Production Manager, Seamist Farms, Castroville and Steve Jordan, General Manager and Charles Kolding, Ranch Manager, Baroda Farms, Lompoc for kindly providing commercial fields and technical support for this research. Our thanks are also due to Eden Bioscience Corporation for the technical support.

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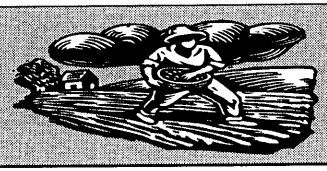
Review of Results from 2003 IR4 Study "Effect of Messenger on Avocado root rot Caused by *Phytophthora cinnamoni* rands

David Holden

Holden Research and Consulting

Aerial View of Mature Tree Site Prior to Commencement of Trial

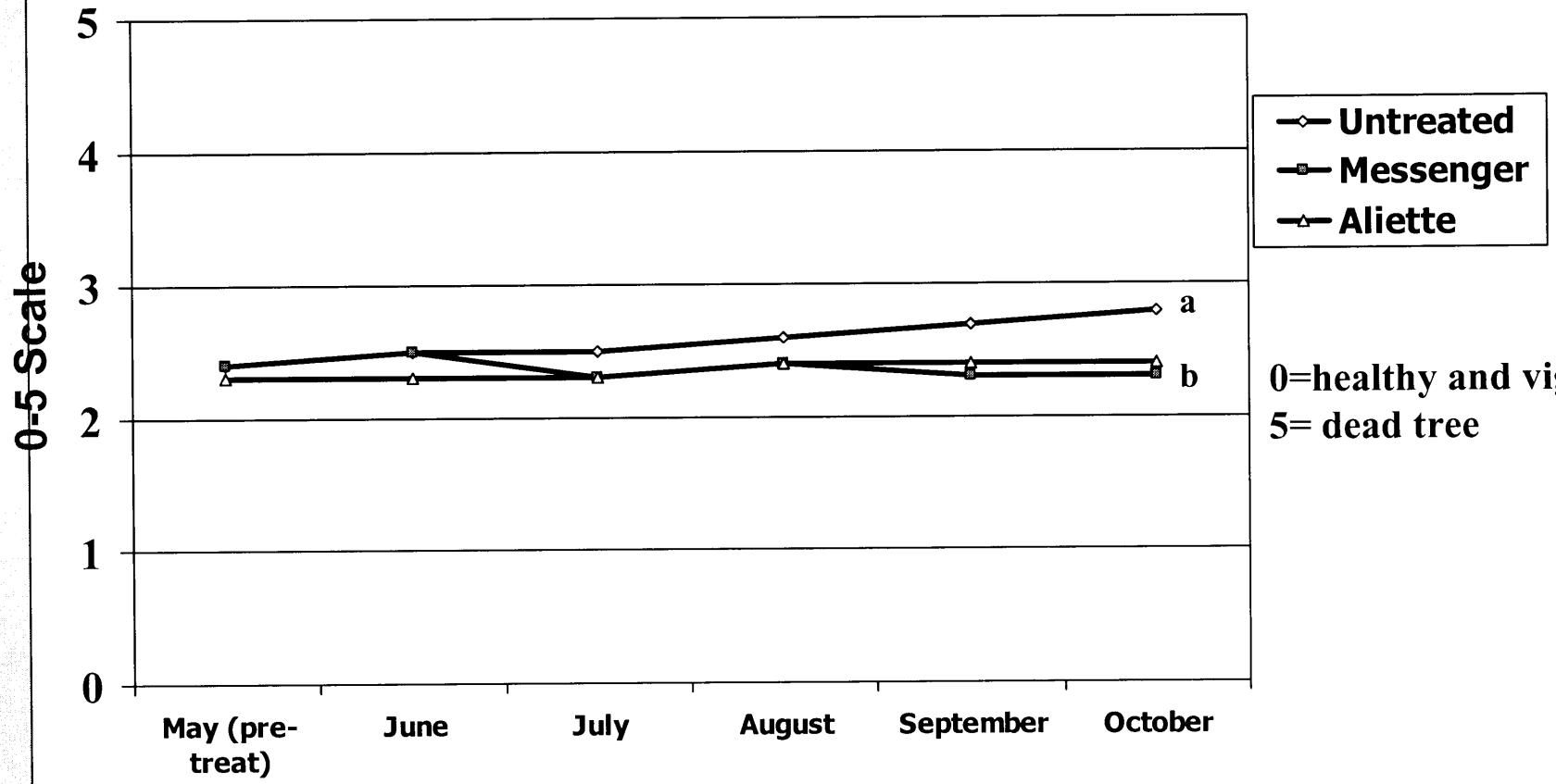


Treatment Schedule for Two Locations

TMT Number	Treatment	Rate	Timing	# apps
1	Non-Inoculated			
2	Messenger	9.0 oz/A	Applied foliar every 30 days beginning at spring flush	6
3	Aliette WDG	5 lb/A	Applied foliar every 60 days beginning at spring flush	3

- **Hass Avocado**
- **Trial on mature trees**
  - **Trees rated every 30 days on a 0-5 scale. 0=perfect, 5=dead**
  - **Yield measured as a pre-count and actual yield**
- **Trial on replants**
  - **Height, diameter, volume was rated monthly**
  - **Trees rated on a 0-5 scale. 0=perfect, 5=dead**

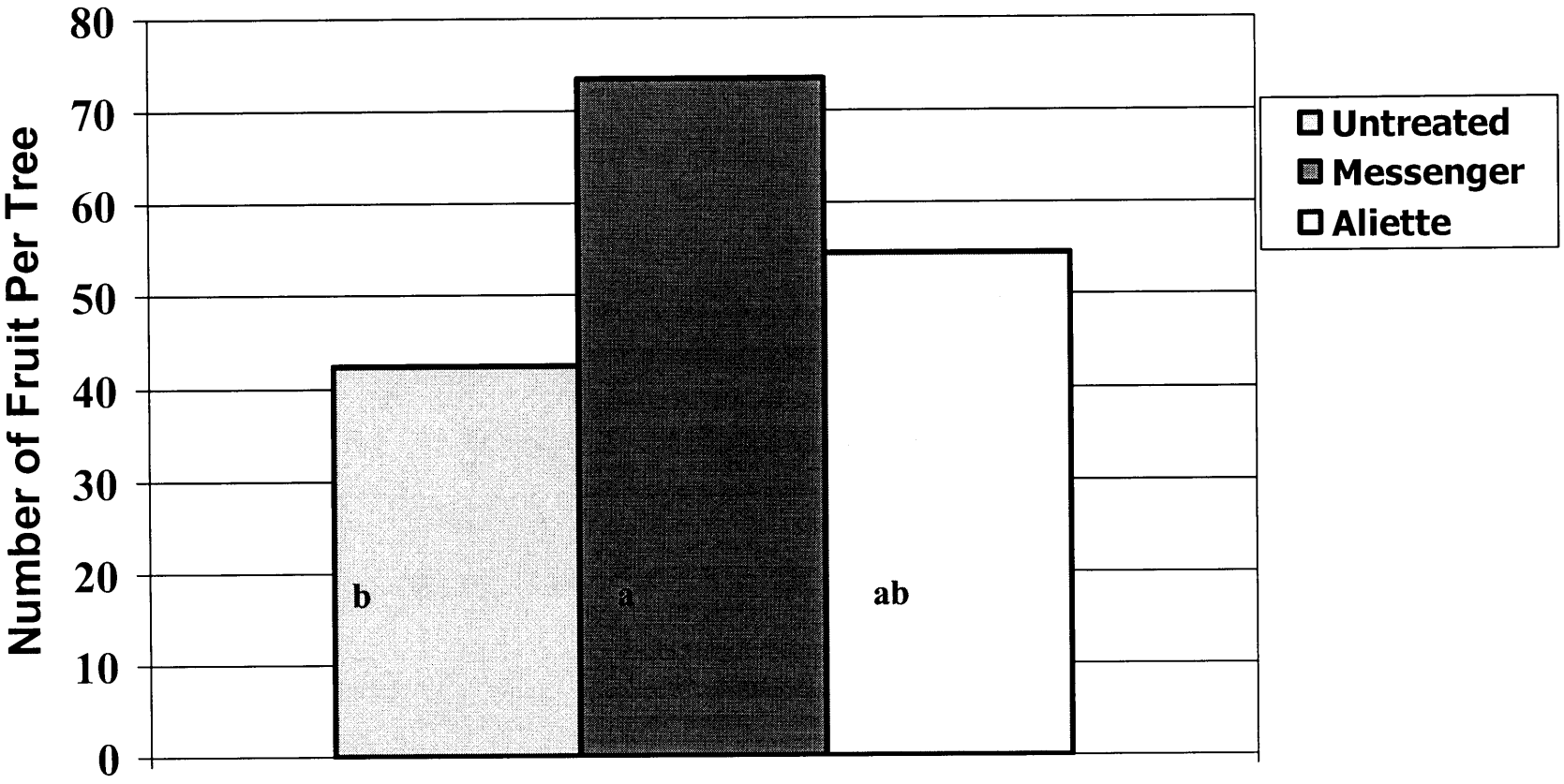
Disease Rating on Mature Trees



0=healthy and vigorous
5= dead tree

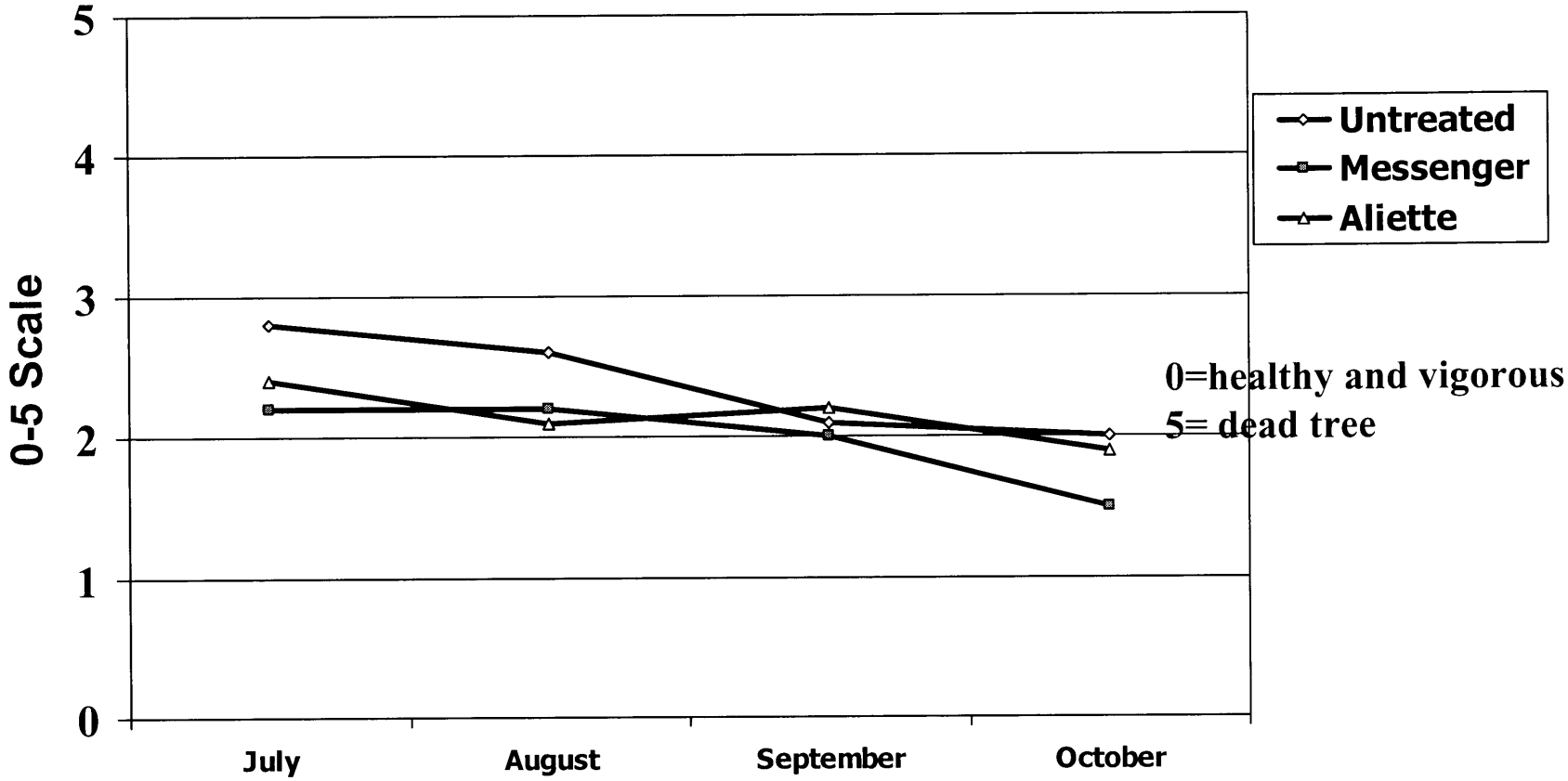
Means followed by the same letter do not differ according to LSD, P=.05

Pre-Harvest Fruit Count on Mature Trees



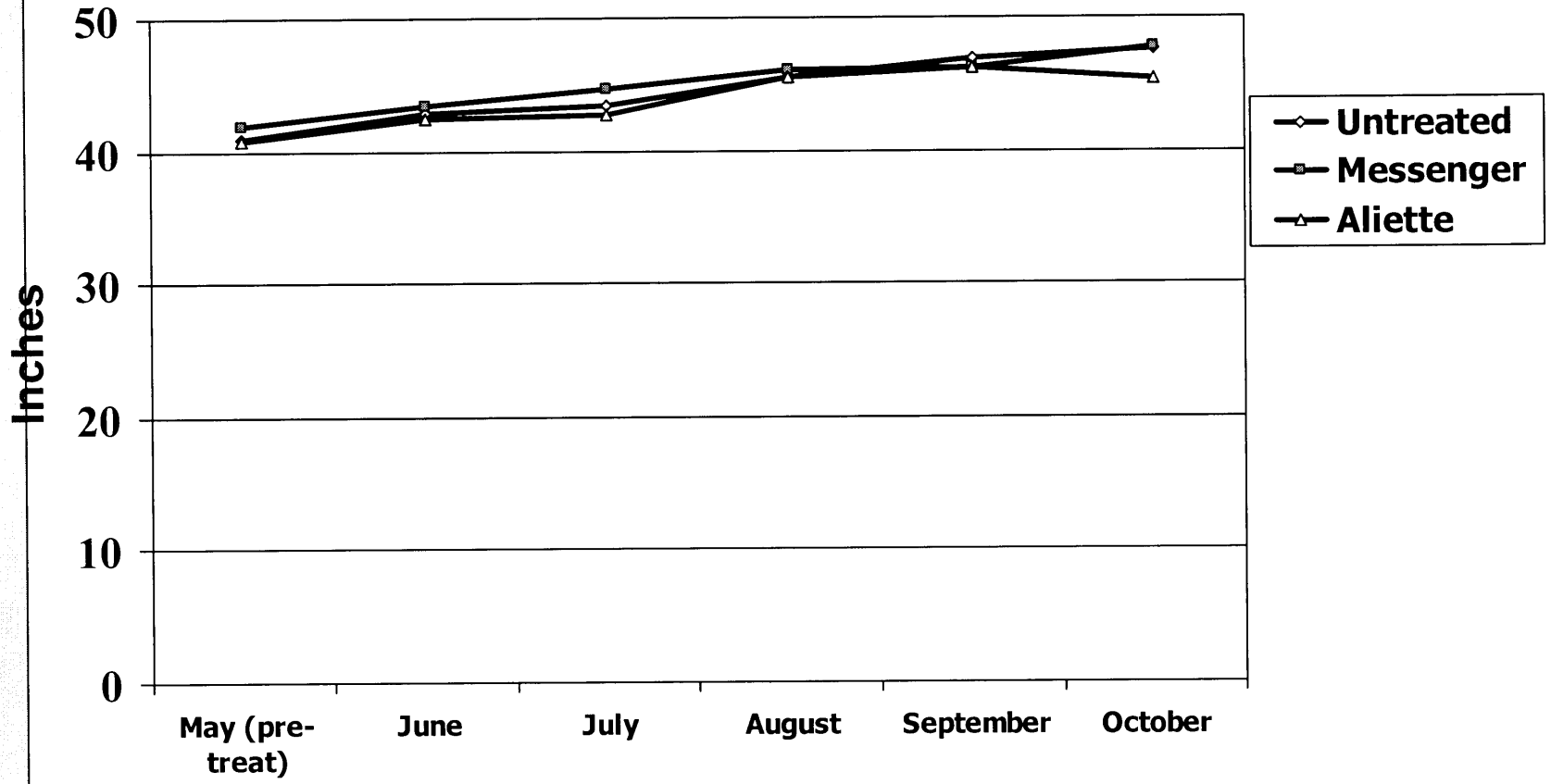
Means followed by the same letter do not differ according to LSD, P=.10

Disease Rating on Replant Trees

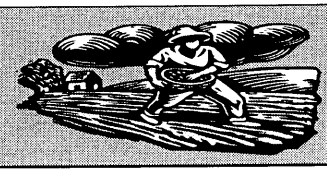


Means followed by the same letter do not differ according to LSD, P=10

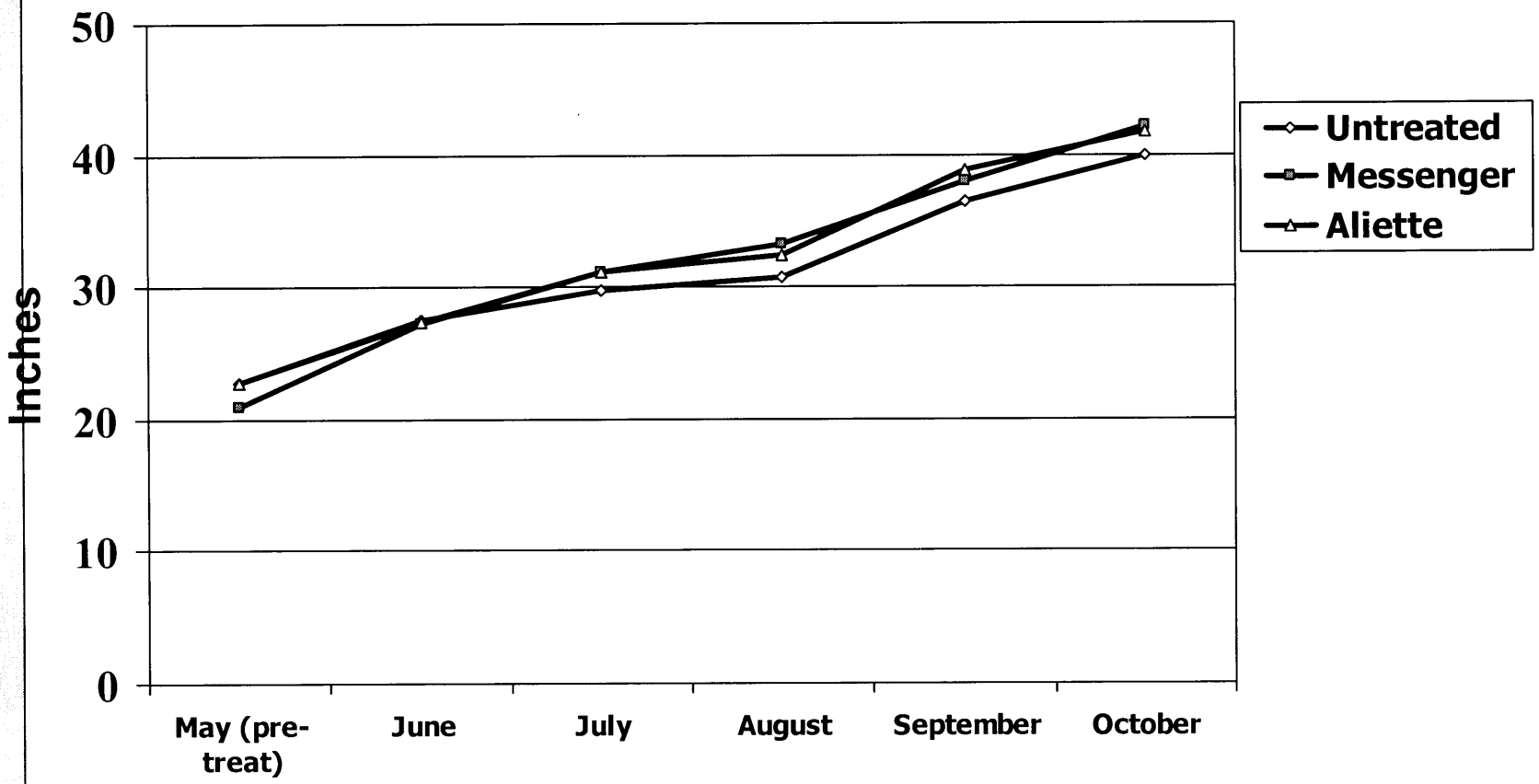
Tree Height of Avocado Replants



Means followed by the same letter do not differ according to LSD, P=10

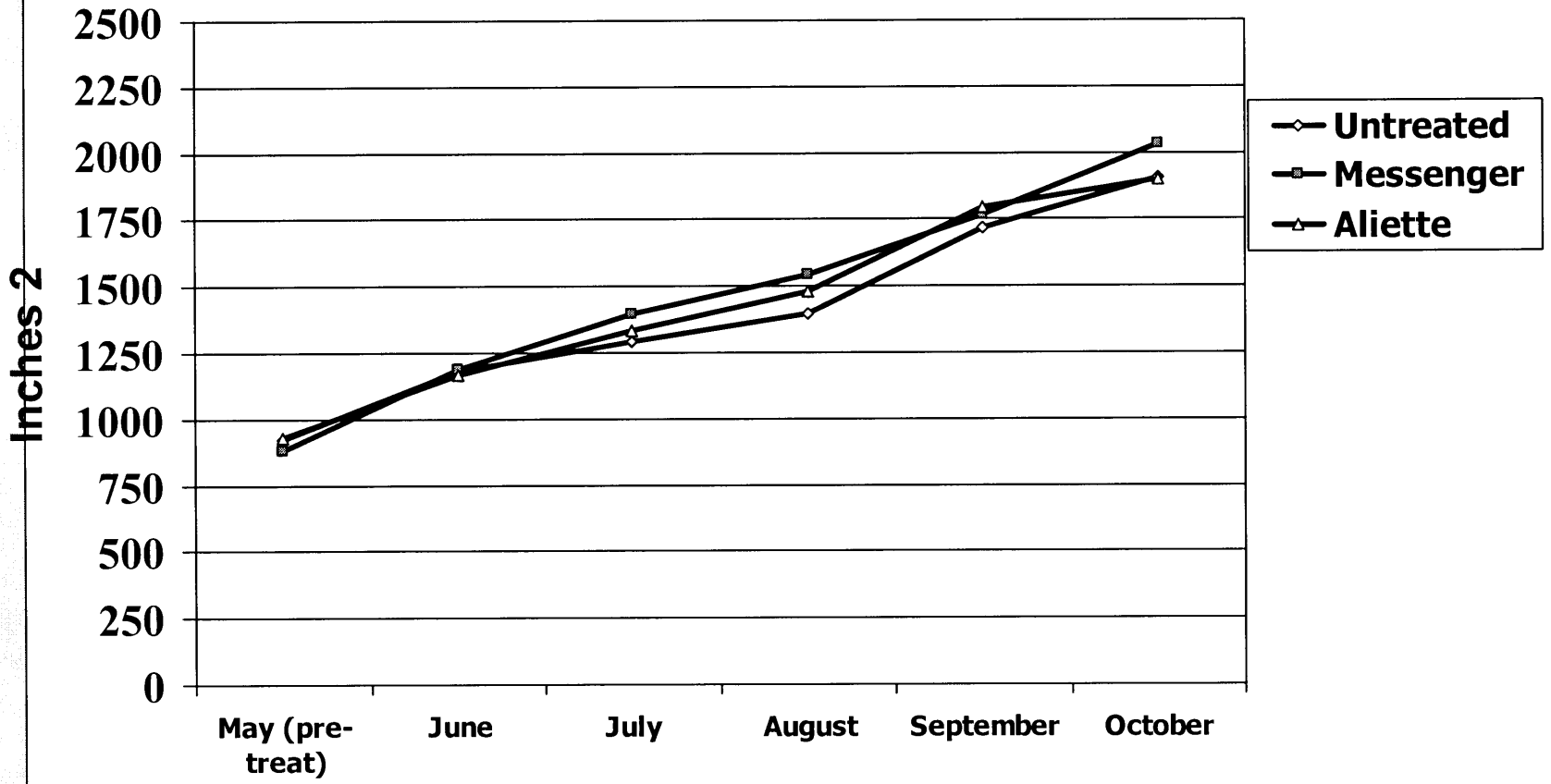


Canopy Diameter of Avocado Replants



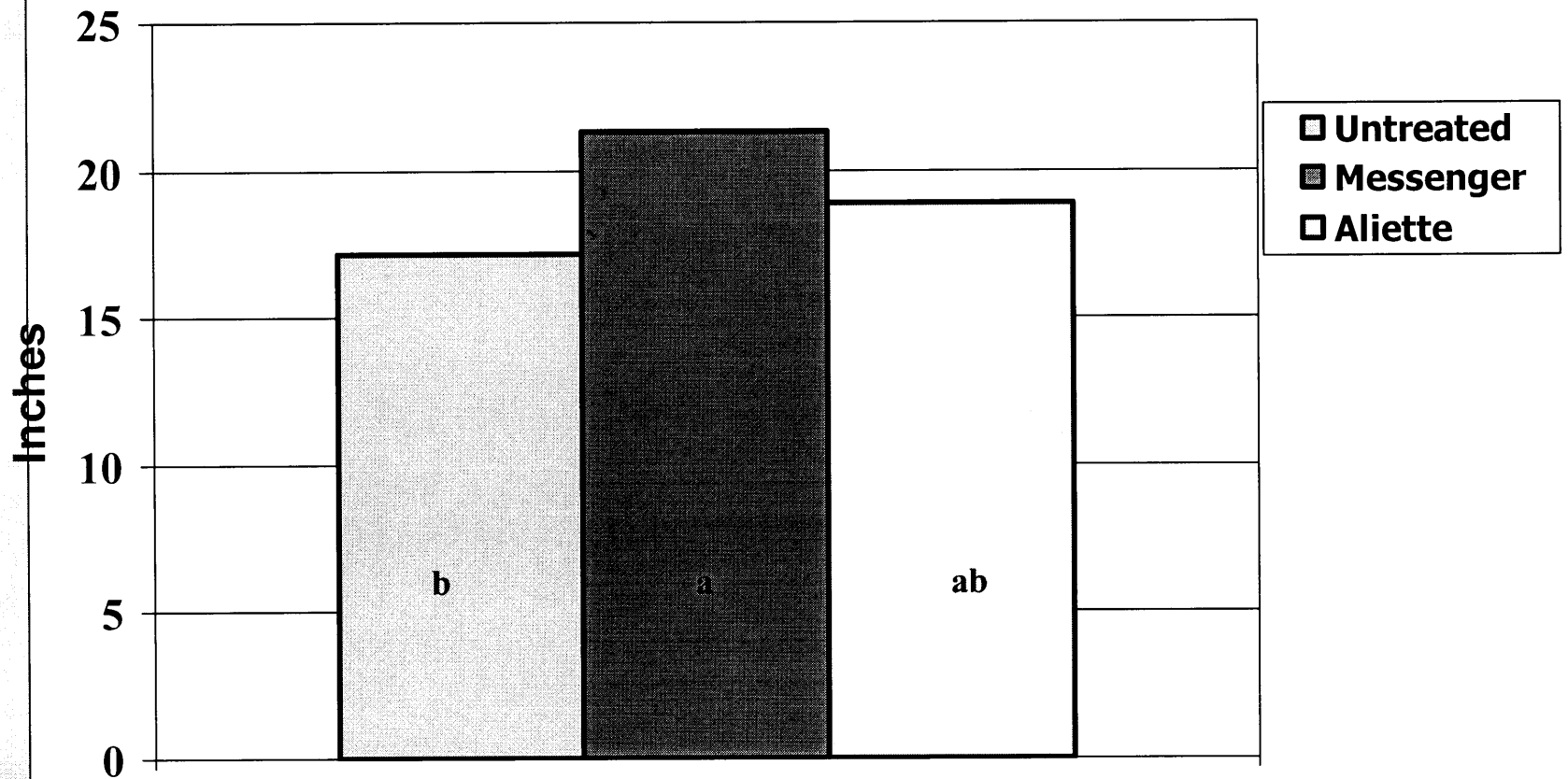
Means followed by the same letter do not differ according to LSD, P=10

Canopy Volume of Avocado Replants (ht x diam)



Means followed by the same letter do not differ according to LSD, P=10

Inches Grown on Avocado Replants From May-October (canopy diameter)



Means followed by the same letter do not differ according to LSD, P=10

Avocado Replants Untreated October 2003

Avocado Replants Alliette Treatment, October 2003

Avocado Replants Messenger Treated October 2003

Conclusions

- Messenger improves growth of avocado trees infected with *Phytophthora*
- Messenger would appear to improve yields of avocados. To be confirmed in Spring of 2004.

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Evaluation of fungicides for anthracnose fruit rot and gray mold management, 2003.

The test was located at the Horticultural Crops Research Station in Castle Hayne, NC. Plug plants grown in a greenhouse located on site were field-set 23 Oct 2002. Fungicide sprays were initiated on 25 Mar at 10% bloom. Plots were single, 6-in. tall, 27-in. wide, raised plastic mulched-beds on 60-in. centers with a 2-ft spacing between adjacent plots. Plots were 12 ft long and contained 24 plants on 12-in. spacing, staggered in two rows 12 in. apart. Treatments were randomized in four complete blocks. Commercially recommended fertilization and insect management practices were followed. Fruit were harvested weekly from 24 Apr through 22 May. Total yield and percent of marketable and cull fruit (undersized, misshapen) were calculated based on weight. Eight treatment sprays were applied weekly from 25 Mar through 15 May using a CO_2 back-pack sprayer equipped with a 2-nozzle, hand-held boom centered over the row, with fan nozzle tips and operating at 90 psi (100 gal/A). The sanitation treatment consisted of removal of all dead and dying strawberry leaves just prior to bloom. No inoculum was applied to the trial.

Weather conditions were unseasonably wet during the growing season with frequent rainfall. Gray mold pressure was moderate and anthracnose fruit rot incidence was high throughout the harvest season in all treatments. All fungicide programs, except Oxidate, reduced anthracnose fruit rot incidence. Use of Cabrio or a rotation program that included BAS 516 offered superior control compared to other products. An integrated program that included Elevate and Switch reduced gray mold incidence, and all fungicide programs, except Oxidate, increased the percentage of marketable fruit. The cultural practice of sanitation offered no benefit in this trial.

Treatment and rate/A	Timing	Gray mold (%)	Anthracnose (%)	Total yield (lb/plot)	Marketable fruit (%)
No spray		6.3 bc*	70.3 e	10.9 ab	19.5 a
TM45002 5.25 lb	1 - 8	3.3 ab	55.1 bc	15.0 cd	39.0 cd
Captan 50 WP 4.0 lb + Cabrio 20 EG 12.0 oz	1 - 8	4.6 abc	40.4 a	19.7 ef	49.8 e
Captan 50 WP 4.0 lb + Cabrio 20 EG 14.0 oz	1 - 8	7.0 c	40.2 a	19.4 f	50.6 e
Cabrio 20 EG 14.0 oz	1 - 8	7.9 c	42.4 a	16.9 de	47.4 de
Captan 50 WP 4.0 lb + Topsin M 70 W 1.1 lb	1, 3	1.7 a	66.0 de	13.1 bc	30.6 bc
Elevate 50 WDG 1.5 lb + Quadris 2.08 F 12 fl oz	2, 6				
Switch 62.5 WG 11.0 oz + Quadris 2.08 F 12 fl oz	4, 8				
Captan 50 WP 4.0 lb	5, 7				
Captan 50 WP 4.0 lb + Quadris 2.08 F 12 fl oz	1, 2, 4, 6	5.3 bc	56.7 cd	15.0 cd	35.4 c
Captan 50 WP 4.0 lb + Topsin M 70 W 1.1 lb	3				
Captan 50 WP 4.0 lb	5, 7, 8				
Captan 50 WP 4.0 lb + Topsin M 70 W 1.1 lb	1, 3	4.9 abc	45.1 ab	20.4 f	45.2 de
BAS 516 1.45 lb	2, 4, 6, 8				
Captan 50 WP 4.0 lb	5, 7				
Oxidate 128 fl oz/100 gal	1, 2, 3**	5.6 bc	69.1 e	9.7 a	23.0 ab
Oxidate 128 fl oz/300 gal	4, 5, 6, 7, 8				
Sanitation		6.1 bc	69.1 e	9.6 a	22.4 ab
LSD (*P*=0.05)		3.3	10.1	2.4	9.0

* Values followed by the same letter within a column are not significantly different based on Fisher's protected LSD.

** Applications 1-3 were done on 3-day intervals and 4-8 on 5-day intervals.

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Effect of postharvest dip treatments on Fusarium root rot of sweetpotato, 2004.

The experiment was conducted at the Central Crops Research Station in Clayton, NC. Sweetpotato roots were harvested on 23 Oct 02 and stored at 55°F in a commercial sweetpotato storage facility until experiments were conducted in Jan 04 (nearly 15 mo). Roots were gently washed by hand with tap water and allowed to dry at room temperature. A scrape injury (with a fine cheese grater) was made lengthwise on opposite sides of each root (two injuries per root). Inoculum was prepared on carnation leaf agar to increase the proportion of macroconidia. Inoculum was introduced by brushing a spore suspension (3.5×10^4 macroconidia/ml) of *F. solani* over the wounded area with a foam paintbrush. Treatments were applied by completely submerging roots in treatment solutions for 30 sec and gently agitating. Treated roots were allowed to air dry, then placed in plastic storage crates (20 roots per crate; four crates/replicates per treatment) and evaluated after 50 days of storage at 55 to 60°F. The experiment was repeated five days later using freshly mixed treatment solutions.

Decay was not evident until three to four weeks after inoculation after which it progressed steadily. The amount of decayed tissue varied among individual roots and was separated into two categories: "decay" and "restricted decay." "Decay" was a soft, pliable, but not watery, decay of the tissue extending far beyond the wounded area and often involving 40 to 60% of the root biomass. "Restricted decay" was defined as decay that did not extend more than approximately 10 mm beyond the wounded area and remained firm. Pristine and Scholar treatments were the only treatments that showed any effect on disease incidence or severity. High levels of decay in the "non-inoculated, wounded" control indicates that the pathogen was present on the root surface. Although we have worked successfully with Rhizopus soft rot without surface sterilization of sweetpotato roots, it may be necessary with Fusarium root rot. Due to the difficulty in quantifying disease severity, future experiments will likely include a method of wounding that is more uniform and discrete. A wound of defined size should allow fast and accurate measurement of disease severity.

	Experiment 1			Experiment 2		
Treatment, rate of product per 100 gal	**% Decay**	**% Restricted decay**	**Combined**	**% Decay**	**% Restricted decay**	**Combined**
Non-inoculated, non-wounded	9.5* e	0.0 c	9.5 d	13.3 c	0.0 d	13.3 c
Non-inoculated, wounded	38.8 d	17.0 bc	55.8 c	19.5 bc	42.5 a	62.0 b
Inoculated and wounded	65.0 c	22.5 ab	87.5 a	77.0 a	18.8 cd	95.8 a
Botran 75WP, 1 lb	70.0 bc	22.5 ab	92.5 a	67.5 a	25.0 bc	92.5 a
Bio-Save 10LP, 22 oz	85.0 ab	13.8 bc	98.8 a	82.5 a	15.0 cd	97.5 a
Bio-Save 10LP, 70 oz	83.8 ab	13.8 bc	97.5 a	83.8 a	13.3 cd	97.0 a
Storox, 15 fl oz	68.8 bc	23.3 ab	92.0 a	76.3 a	17.5 cd	93.8 a
Scholar 50 WP, 8 oz	38.3 d	36.3 a	74.5 b	35.0 b	37.0 ab	72.0 b
Pristine 38WG, 72.5 fl oz	64.5 c	28.3 ab	92.5 a	27.5 bc	38.8 ab	66.3 b
Tsunami 100, 6 fl oz	97.0 a	0.0 c	97.0 a	74.5 a	18.3 cd	92.5 a

* Values are the mean of 4 replicates of 40 wounds (2 wounds per root, 20 roots). Values followed by the same letter within a column are not significantly different (P=.05, Student-Newman Keuls test).

G. J. Holmes, and M. L. Adams
Dept. of Plant Pathology, N C State Univ., Raleigh, NC 27695

Effect of postharvest dip treatments on Rhizopus soft rot of sweetpotato, 2003.

The experiment was conducted at the Central Crops Research Station in Clayton, NC. Sweetpotato roots were harvested on 23 Oct 02 and stored at 55°F in a commercial sweetpotato storage facility until experiments were conducted in Nov 03 (nearly 13 mo). Roots were gently washed by hand with tap water and allowed to dry at room temperature. An impact bruise injury (8 mm diam × 1 mm deep) was made to opposite sides of the mid-section of each root (two injuries per root). Inoculum was introduced by brushing a spore suspension (10^6 spores/ml) of *R. stolonifer* over the wounded area with a foam paintbrush. Treatments were applied by completely submerging roots in treatment solutions for 30 sec. Treated roots were allowed to air dry, then placed in plastic storage crates (20 per crate; four crates/replicates per treatment) and evaluated after 10 days of storage at 55 to 60°F. The experiment was repeated using freshly mixed treatment solutions.

Both experiments yielded similar results. The inoculation method produced extremely high levels of disease (100% and 89%) in non-treated roots. Therefore, treatments were evaluated under conditions very favorable to disease development. Botran, the industry standard for decades, performed extremely well in both experiments. Certain markets are no longer accepting Botran-treated sweetpotatoes and packers are searching for suitable alternatives. StorOx and Tsunami 100 were ineffective against Rhizopus soft rot. Maxim and Pristine were highly effective. Bio-Save 10LP reduced disease incidence significantly and produced greater disease control at the high rate. However, its performance dropped markedly in the second experiment.

Treatment, rate of product per 100 gal	Experiment 1		Experiment 2	
	Number of decayed roots per 20	% Decay	Number of decayed roots per 20	% Decay
Non-inoculated, non-wounded	0.0 e *	0.0	0.0 f	0.0
Non-inoculated, wounded	1.5 de	7.5	6.3 d	31.2
Inoculated and wounded	20.0 a	100.0	17.8 a	88.7
Botran 75WP, 1 lb	0.5 e	2.5	0.3 f	1.2
Bio-Save 10LP, 22 oz	9.3 b	46.2	13.0 b	65.0
Bio-Save 10LP, 70 oz	5.3 c	26.2	10.5 c	52.5
Storox, 15 fl oz	19.3 a	96.2	15.0 ab	75.0
Maxim 4FS, 1.6 fl oz	3.5 cd	17.5	3.8 e	18.7
Pristine 38WG, 72.5 fl oz	3.3 cd	16.2	1.5 ef	7.5
Tsunami 100, 6 fl oz	19.3 a	96.2	15.0 ab	75.0

* Values followed by the same letter within a column are not significantly different (P=.05, Student-Newman Keuls test).

Appendix 6 – Results from current IR-4 project

Large Scale *Bacillus mycoides* (BmJ) efficacy trials – IR-4 2003

In 2003, IR-4 funded large-scale efficacy trials for use of BmJ for Cercospora leaf spot (CLS) of sugarbeet at two locations. The first experiment was a commercial-scale trial at the Eastern Ag Research Station at Sidney, MT and the second experiment was performed in the Red River Valley of North Dakota by sub-contractor Muhammad Khan. In Sidney, ~1 acre plots were planted using standard commercial production methods. Two varieties were included in the trial including a CLS susceptible variety, Beta 2185, and a moderately resistant variety, Crystal 947. Treatments included an untreated control, Bac J (4 sprays initiated before disease onset), Bm J (4 sprays initiated at disease onset), Eminent-BmJ-BmJ-BmJ, BmJ before disease onset-Eminent-BmJ-BmJ, and Headline-Eminent-SuperTin-Eminent. All treatments were applied using 20gpa application volume. The before disease onset BmJ treatments were applied on July 1 and the rest of the treatments were initiated 2 weeks later and sprays were applied at 2 week intervals. Disease evaluations were performed on August 1, August 20, September 4 and September 16 at 3 random locations in each large plot using the KWS scale and area under the disease progress curve (AUDPC) values were calculated.

Results

During 2003, the Sidney area was extremely dry and hot and while CLS prediction models predicted high disease pressure, it was not realized. BmJ alone significantly reduced CLS in the moderately susceptible Crystal 947 but not in the susceptible Beta 2185. For both varieties, BmJ applied before disease onset followed by Eminent the 2 sprays of BmJ was similar to the optimal chemical fungicide treatment (Table 1). The CLS never did reach the economic threshold and no differences were noted between any of the treatments for sucrose yield.

Treatment	Area Under the Disease Progress Curve	
	Crystal 947	Beta 2185
Untreated Control	9.1a	7.4abc
BmJ before disease onset (4 sprays)	0.9bc	9.8a
BmJ @ disease onset (4 sprays)	1.6b	7.8ab
Eminent – BmJ-BmJ-BmJ	0.6bc	3.5bcd
BmJ before disease onset Eminent-BmJ-BmJ	0.3c	2.2cd
Headline-Eminent-SuperTin-Eminent	0.25c	0.6d

Appendix 6

EFFECT OF BAC J ON SUGARBEET YIELD AND QUALITY IN 2003

Mohamed F. R. Khan[1] and Randy Nelson[2]
[1]Extension Sugarbeet Specialist
North Dakota State University / University of Minnesota
[2]Research Technician, Department of Soil Science
North Dakota State University

This experiment was performed under sub-contract for Barry Jacobsen at Montana State University, Bozeman, MT.

OBJECTIVE

To determine the effect of Bac J on sugar content and yield of sugarbeet in the Red River Valley.

MATERIALS AND METHODS

Research was conducted at Foxhome, MN, on a silty loam soil. 'HM Agate' and 'Crystal 999' sugarbeet seeds were planted with a John Deere MaxEmerge 2 planter on May 16. Seeds were placed 1.25 inches deep and 5 inches apart in rows that were 22 inches wide. Counter was applied at 11.9 lb/acre at planting to control sugarbeet root maggot. The experiment was arranged in a randomized complete block design with four replications. The first application of Bac J was applied to treatments 2 and 6 on July 16. The second, third, and fourth applications of Bac J to treatments 2 and 6 are as follows: July 30, August 13 and August 27.The first fungicide application on treatments 3, 4, 7 and 8 occurred on July 23. The second, third, and fourth applications to treatments 3, 4, 7, and 8 are as follows: August 7, August 21, and September 2. Fertilization was done according to standard recommendation for sugarbeet. Plots were kept weed free using micro-rates of herbicides recommended for sugarbeet, hand weeding, and cultivation.

The middle two rows of each 6-row plot were harvested on the 17 of September. Yield was determined, and quality analysis performed by American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, Minnesota. Data was analyzed for differences by analysis of variance and LSD using Agriculture Research Manager, version 6.0.

RESULTS

Shown in table 1.

ACKNOWLEDGEMENT

Thanks to Frontier Labs Inc for partial funding of this research. Thanks to Charles Hotvedt of American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, Minnesota, for sugarbeet quality analysis.

Table 1. Effect of Bac J on sugarbeet yield and quality at Glyndon, MN 2003.

Treatments And Rates Per Acre	Sucrose Content (%)	SLM (%)	Root Yield (T/Acre)	Rec. Sucrose (lb/T)	Rec. Sucrose (lb/Acre)	CLS*
1. HM Agate Untreated Check	13.36 d	2.47 a	12.77 e	218 d	2725 c	8.50 a
2. HM Agate Bac J alone, 4 sprays	14.32 d	2.17 ab	14.19 de	243 d	3376 c	7.38 b
3. HM Agate Eminent, Bac J, Bac J, Bac J	17.68 bc	2.13 b	18.12 abc	311 bc	5573 b	5.00 d
4. HM Agate Eminent, Gem, Tin, Eminent	17.04 c	2.20 ab	19.55 a	297 c	5818 ab	2.13 f
5. Crystal 999 Untreated Check	19.00 ab	2.08 bc	16.72 bcd	338 ab	5585 b	7.00 bc
6. Crystal 999 Bac J alone, 4 sprays	19.05 ab	1.70 d	16.12 cd	347 ab	5531 b	6.75 c
7. Crystal 999 Eminent, Bac J, Bac J, Bac J	19.50a	1.77 cd	16.68 bcd	355 a	5849 ab	3.50 e
8. Crystal 999 Eminent, Gem, Tin, Eminent	19.72 a	1.65 d	19.21 ab	361 a	6868 a	2.50 f
LSD (P=0.05)	1.67	0.32	2.77	37.89	1196	0.57
CV (%)	6.44	10.72	11.20	8.26	15.59	7.23

* Cercospora leaf spot measured on KWS scale 1-9 (no leaf spot – dead outer leaves, inner leaves severely damaged, regrowth of new leaves)

Progress Report submitted by Dr. M. S. Reddy

Title: Evaluation of BioYield™ for plant growth promotion and disease control in various ornamental crops

Objectives

The specific objectives for this project were:

Objective 1. Develop a reliable disease bioassay for evaluation of BioYield on various ornamental crops under greenhouse conditions –Year 1

Objective 2. Identify the effective dose of BioYield and its delivery for effective control of damping-off diseases of ornamental crops under greenhouse conditions – Year 1.

Objective 3. Evaluate the efficacy of BioYield based on the results from objective 2 on various ornamental crops in commercial nurseries –Year 2.

Objective 1. Development of a reliable disease bioassay for evaluation of BioYield on various ornamental crops under greenhouse conditions -Year 1.

Six ornamental crops Poinsettia, Geranium, Petunia, Snapdragon, Lilies, and Impatiens supplied by Goldsmith Seeds, Inc., (Gilroy, CA, USA) were used to develop reliable disease bioassays for *Rhizoctonia solani* and *Pythium ultimum* under greenhouse conditions. Individual pathogens were produced on moist autoclaved rye kernels (100 ml rye kernels + 150 ml water, soaked overnight, and autoclaved for 1 h on 2 consecutive days) for 2 weeks at 25 C, air died in the dark for 24 h, ground, and sieved for particles of 0.6-1.5 mm diameter. Viability of the inoculum was tested by first weighing and then plating 200 particles on water agar (WA) or potato dextrose agar (PDA). The viability of propagules on WA or PDA were used to calculate the amount of inoculum required to adjust the inoculum density of each pathogen in the soilless growth media. Soilless growth media from Speedling (Speedling Inc., FL) was used to produce ornamental transplants throughout the project. In a given crop and patho-system, a disease curve was developed to obtain a 50% disease kill of the seedlings prior to screening BioYield.

The effect of fungal inoculum density on disease severity for each pathogen on various ornamental seedlings was optimized prior to screening flaked BioYield and liquid BioYield for biological control efficacy. The inoculum densities used in this study were based on results from preliminary tests to determine populations that consistently caused moderate amounts of disease.

Inoculum of *P. ultimum* was mixed thoroughly by hand into separate batches of soilless growth media to achieve an inoculum density of 0, 50, 100, and 200 propagules/g. *Rhizoctonia solani* inocula at 0, 10, 20, 40, and 50 propagules/g were used. Noninfested soil was served as the control. The pathogen-amended and nonamended soil was then placed into 10 cm diameter plastic pots (150 g/pot). Four seeds of appropriate ornamental seeds were planted in each pot at a depth of approximately 2.5 cm. The following three treatments were used for each crop and each pathogen: (i) ornamental seeds planted in pathogen-free soilless growth media, (ii) ornamental seeds planted in pathogen-infested soilless media at appropriate inocula, and (iii) ornamental seeds planted in pathogen-infested soilless media that had been amended with the fungicide

metalaxyl (Ciba-Geigy) to a final concentration of 10 ug of active ingredient (a.i)/g of soil for *P. ultimum* and, pentachloronitrobenzene (PCNB) at a rate of 20 ug a.i/g soil for *R. solani*. The moisture content of the soil was maintained at 60%. Plants were fertilized once a week with 15-15-15 fertilizer suspension (NPK, 3g/L). Experiments consisted of six replicated pots in each treatment, four seedlings per pot for each crop. The pots were arranged in a completely randomized block design on a plant growth bench in a growth chamber maintained at 18-25C, with 14 h cool-white fluorescent light (10,000 lx) per day.

After 6 weeks, all the surviving plants were gently pulled and the number of completely healthy plants devoid of any disease symptoms was determined for each pathogen and host system. To confirm pathogen identity for seedlings with disease symptoms, infected or dead tissues were plated onto selective medium for each pathogen.

Objective 2. Identify the effective dose of BioYield and its delivery for effective control of damping-off diseases of ornamental crops under greenhouse conditions -Year 1.

Only one fungal inoculum concentration of each fungus was tested on the basis of the results of the disease optimization assays. Inocula of at 200 propagules and *R. solani* at 50 were tested.

Commercially prepared dry chitosan flakes and liquid formulation of BioYield were used for efficacy screening assays. Flaked BioYield was mixed with the soilless growth media at 1:20, 1: 40, 1: 80, and 1:100 (v/v) concentrations prior to seeding. Liquid BioYield was applied as spray after seeding at the following concentrations: 1X, 2X, 3X, and 4 X.

Twelve sets of experiments were conducted, one set each for the challenge pathogen and crop. Each experiment consisted of a randomized complete block design with the following treatments: 1) BioYield at 1:20 (v/v) + pathogen; 2) BioYield at 1:40 (v/v) + pathogen; 3) BioYield at 1:80 (v/v) + pathogen; 4) BioYield at 1:100 (v/v) + pathogen; 5) healthy control; 6) pathogen control; and 7) chemical control. Similarly there were 7 treatments for liquid BioYield. They were as follows: 1) BioYield liquid at 1X; 2) BioYield liquid at 2X; 3) BioYield liquid at 3X; 4) BioYield liquid at 4X; 5) healthy control; 6) pathogen control; and 7) chemical control. Each treatment was replicated 6 times, with four plants per replication. The treatments were completely randomized.

Experiments were conducted in environmentally controlled growth chambers appropriate to each pathogen and crop. Normal cultural practices were followed and each experiment was run for 4-6 weeks. After 6 weeks, all the surviving plants were gently pulled and the number of completely healthy plants devoid of any disease symptoms was determined for each pathogen and host system. To confirm pathogen identity for seedlings with disease symptoms, infected or dead tissues were plated onto selective medium for each pathogen.

Data was analyzed by ANOVA with mean separation using LSD at $P = 0.05$.

Results – Year 1

Effect of fungal inoculum density on disease severity

Increasing levels of fungal inoculum density increased damping-off caused by *Pythium* (Figs. 1a-1f) and *Rhizoctonia* (Figs. 1a-1f) on six ornamental seedlings. Two hundred propagules per gram of soilless media of *Pythium* and 50 propagules/g soil of *Rhizoctonia* provided a degree of disease severity on all ornamental seedlings selected here as optimal for testing the disease suppressiveness of BioYield flakes and liquid.

Influence of BioYield on suppression of damping-off of ornamental seedlings

The BioYield flaked introduced as soil amendments or liquid as spray exhibited differential suppression effects on the damping-off caused by *Pythium* and Rhizoctonia on ornamental seedlings (Tables 1 – 4).

Two concentrations of BioYield flaked (1:20 and 1:40 v/v) significantly suppressed damping-off disease caused by *Pythium* on most of the ornamentals tested except on Geranium and on Lilies by 1:40. Other BioYield flaked concentrations varied. Similarly BioYield liquid at 1 X and 2 X significantly suppressed damping-off caused by *Rhizoctonia*.

Fig. 1a. Effect of Pythium inoculum density on final healthy stand of Poinsettia seedlings grown in soilless mix 6 weeks of seeding.

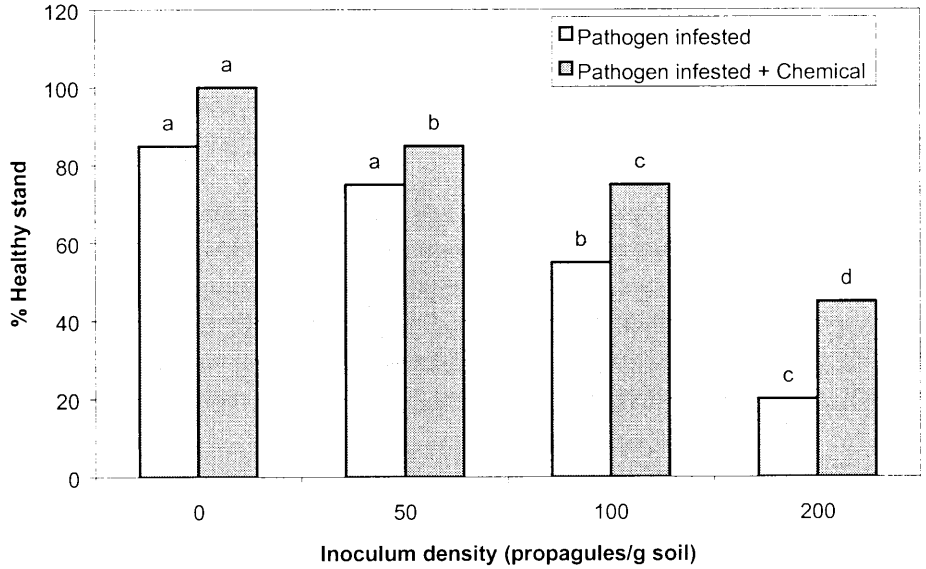


Fig. 1b. Effect of Pythium inoculum density on the final healthy stand of Geranium seedlings grown in soilless mix 6 weeks of seeding.

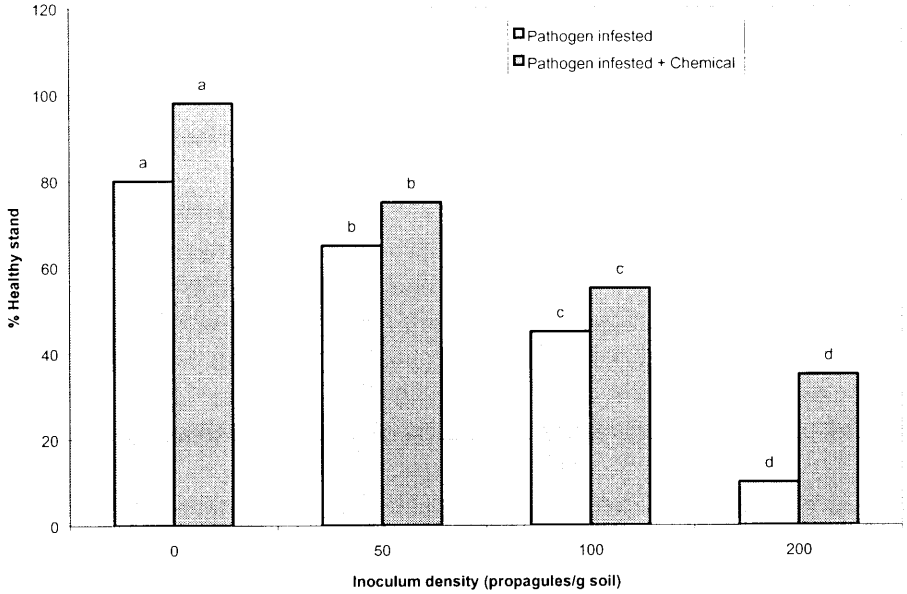


Fig. 1c. Effect of Pythium inoculum density on the final healthy stand of Petunia seedlings grown in soilless mix 6 weeks of seeding.

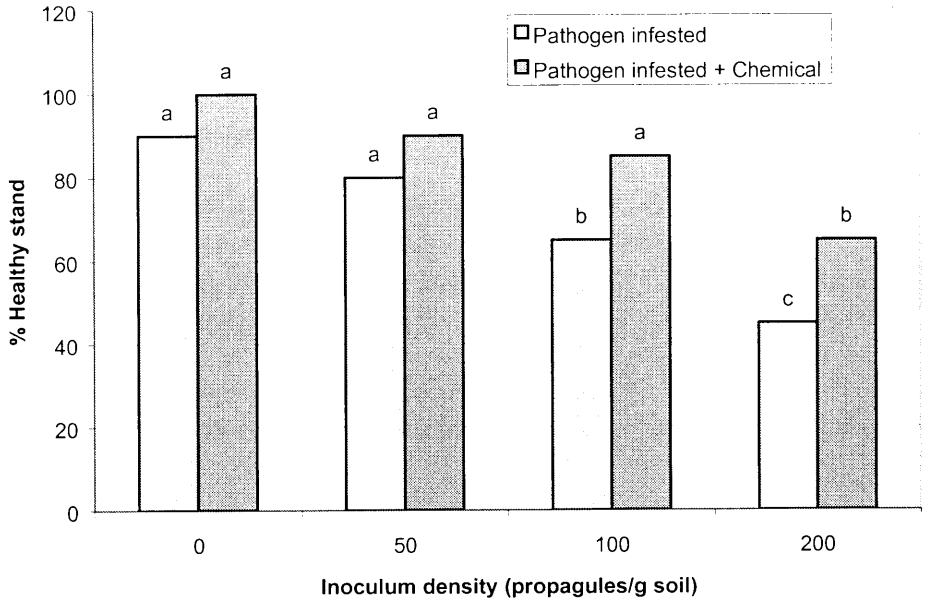


Fig. 1d. Effect of Pythium inoculum density on the final healthy stand of Snapdragon seedlings grown in soilless mix 6 weeks of seeding.

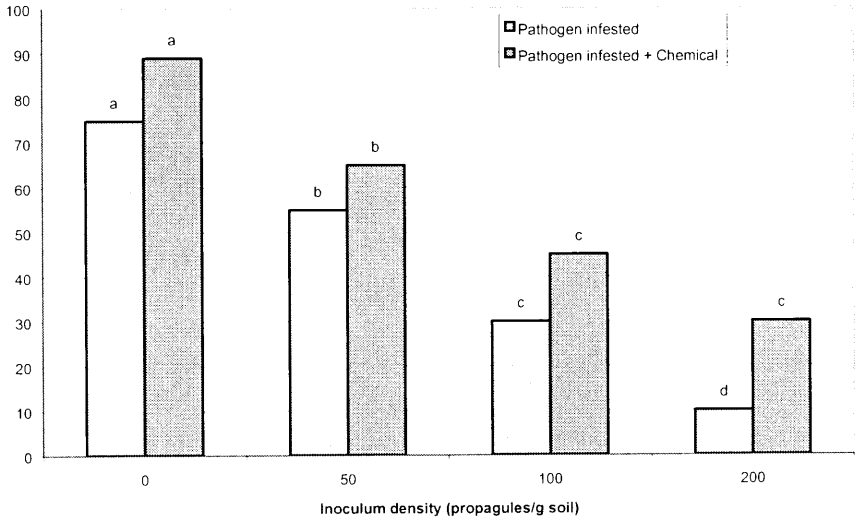


Fig. 1e. Effect of Pythium inoculum density on final healthy stand of Lilies seedlings grown in soilless mix 6 weeks of seeding.

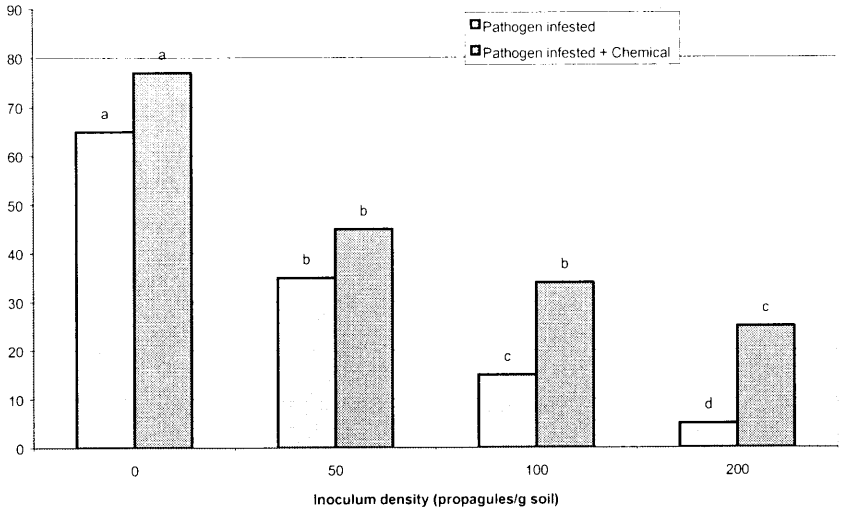


Fig. 1f. Effect of Pythium inoculum density on final healthy stand of Impatiens seedlings grown in soilless mix 6 weeks of seeding.

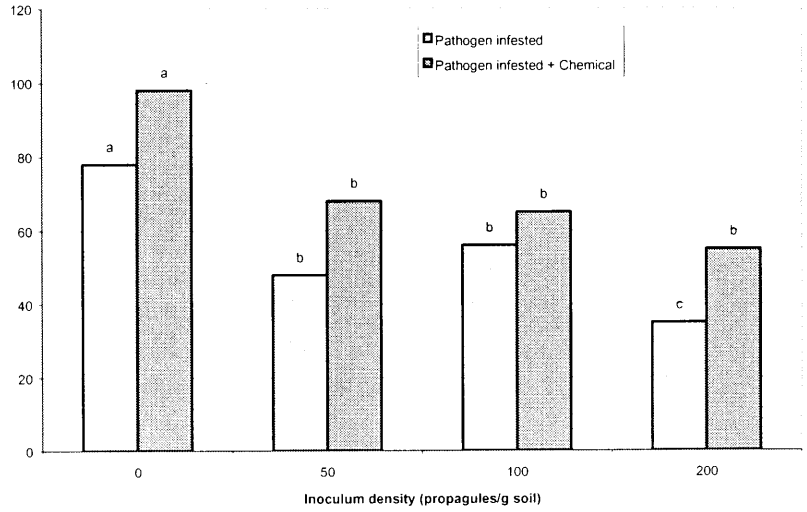


Fig. 2a. Effect of Rhizoctonia inoculum density on final healthy stand of Poinsettia seedlings grown in soilless mix 6 weeks of seeding.

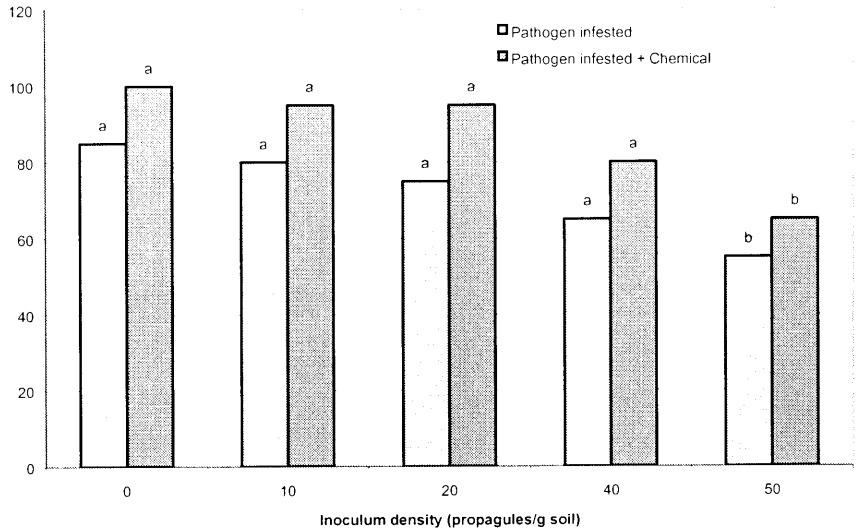


Fig. 2b. Effect of Rhizoctonia inoculum density on final healthy stand of Geranium seedlings grown in soilless mix 6 weeks of seeding.

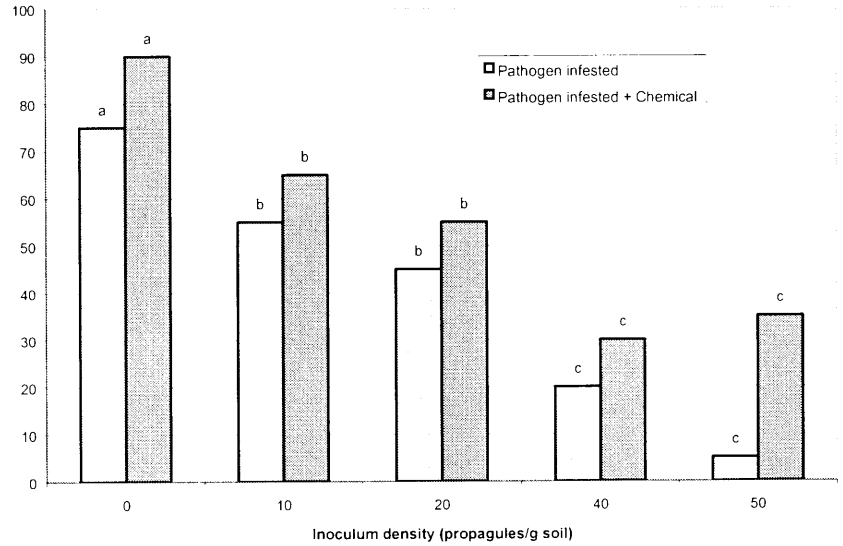


Fig. 2c. Effect of Rhizoctonia inoculum density on final healthy stand of Petunia seedlings grown in soilless mix 6 weeks of seeding.

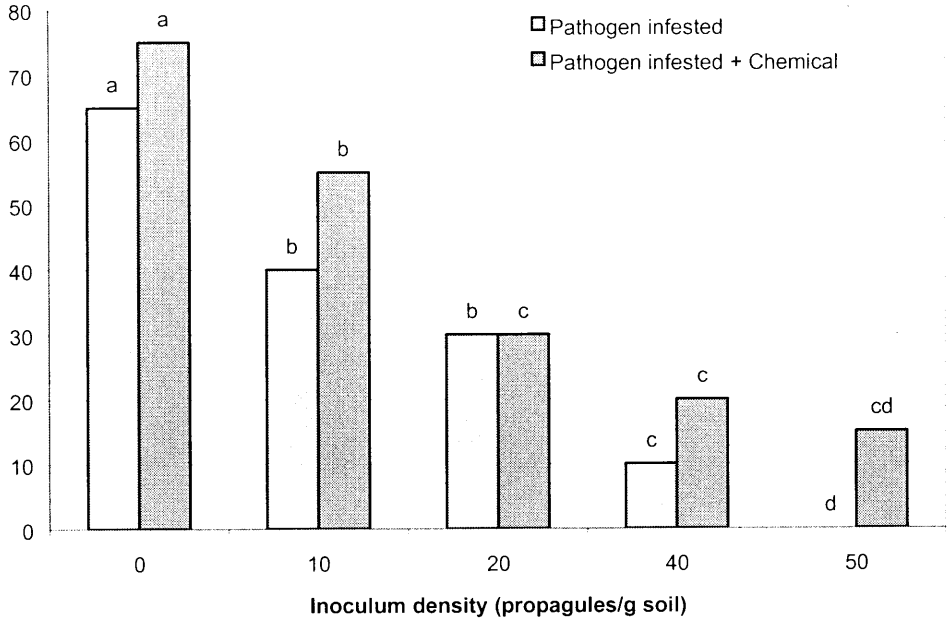


Fig. 2d. Effect of Rhizoctonia inoculum density on final healthy stand of Snapdragon seedlings grown in soilless mix 6 weeks of seeding.

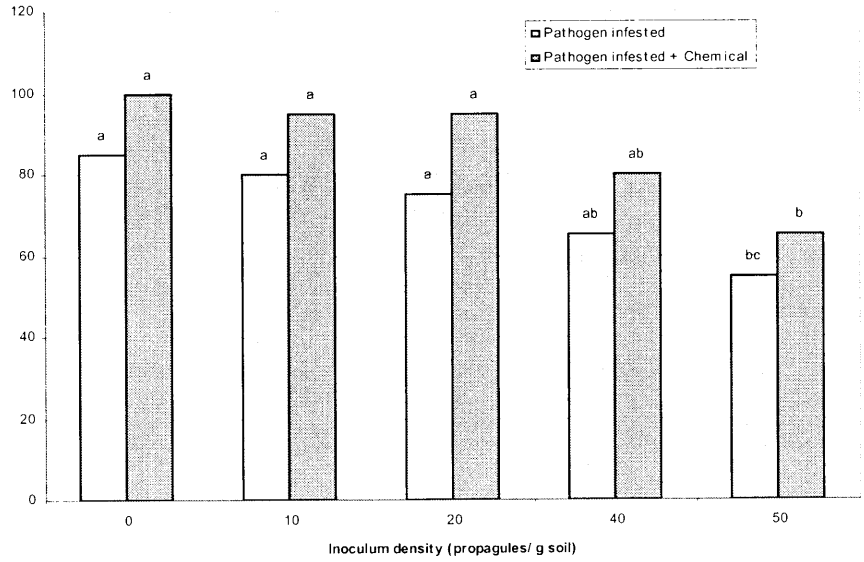


Fig. 2d. Effect of Rhizoctonia inoculum density on final healthy stand of Snapdragon seedlings grown in soilless mix 6 weeks of seeding.

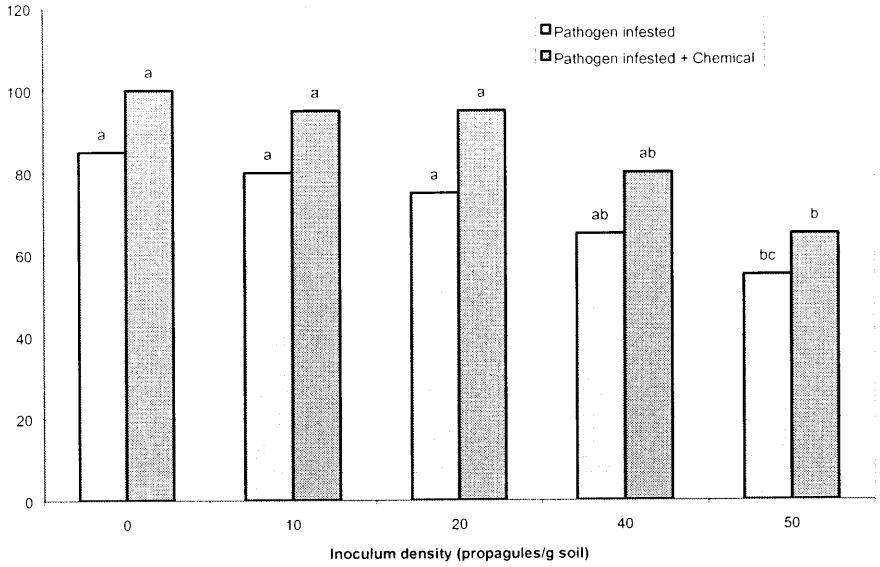


Fig. 2f. Effect of Rhizoctonia inoculum density on final healthy stand of Impatiens seedlings grown in soilless mix 6 weeks of seeding.

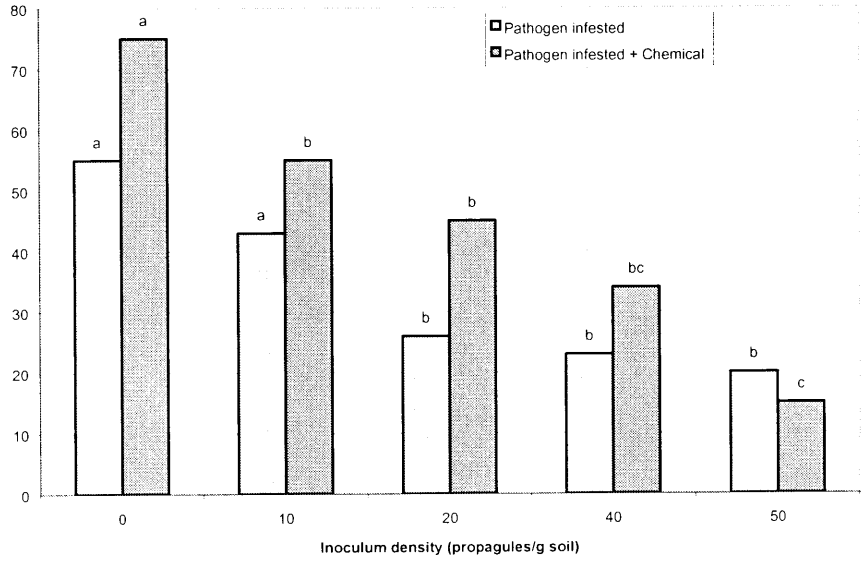


Table 1. Efficacy of various concentrations of BioYield on improvement of healthy stand of various ornamentals grown in Pythium infested soil-less mix under greenhouse conditions 6 weeks after seeding.

Treatment	**% Healthy stand[1]**					
	Poinsettia	**Geranium**	**Petunia**	**Snapdragon**	**Lilies**	**Impatiens**
Control	85*	95*	80*	75*	78*	81*
Pathogen control	32	46	35	32	28	31
Chemical control	67*	72*	74*	65*	68*	73*
BY 1:20	55*	59*	61*	69*	73*	34
BY 1:40	45*	54	65*	54*	33	54*
BY 1:80	32	48	53*	34	32	38*
BY 1:100	25	43	32	29	37	42*
LSD ($P = 0.05$)	**11**	**15**	**12**	**14**	**13**	**7**

[1]Mean of six replications, 4 seedlings per replication.
*Significantly different from pathogen control.

Table 2. Efficacy of various concentrations of BioYield on improvement of healthy stand of various ornamentals grown in Rhizoctonia infested soil-less mix under greenhouse conditions 6 weeks after seeding.

Treatment	**% Healthy stand[1]**					
	Poinsettia	**Geranium**	**Petunia**	**Snapdragon**	**Lilies**	**Impatiens**
Control	90*	85*	77*	85*	82*	71*
Pathogen control	22	46	25	22	18	21
Chemical control	47*	52*	44*	45*	43*	33
BY 1:20	37*	49	38*	49*	38*	38*
BY 1:40	39*	34	45*	54*	23	34*
BY 1:80	19	28	23	14	12	48*
BY 1:100	16	23	12	9	6	42*
LSD ($P = 0.05$)	**9**	**7**	**12**	**8**	**15**	**13**

[1]Mean of six replications, 4 seedlings per replication.
*Significantly different from pathogen control.

Table 3. Efficacy of various concentrations of BioYield liquid on improvement of healthy stand of various ornamentals grown in Pythium infested soil-less mix under greenhouse conditions 6 weeks after seeding.

Treatment	% Healthy stand[1]					
	Poinsettia	**Geranium**	**Petunia**	**Snapdragon**	**Lilies**	**Impatiens**
Control	85*	85*	86*	85*	76*	91*
Pathogen control	28	36	45	42	17	21
Chemical control	57*	62*	64*	55*	48*	43*
BY 1X	45*	49*	51*	79*	43*	24
BY 2 X	45*	64	55*	64*	53	44*
BY 3 X	22	58	58*	54	42	58*
BY 4 X	25	23	59	49	27	62*
LSD ($P = 0.05$)	**9**	**11**	**8**	**13**	**10**	**11**

[1]Mean of six replications, 4 seedlings per replication.
*Significantly different from pathogen control.

Table 4. Efficacy of various concentrations of BioYield liquid on improvement of healthy stand of various ornamentals grown in Rhizoctonia infested soil-less mix under greenhouse conditions 6 weeks after seeding.

Treatment	% Healthy stand[1]					
	Poinsettia	**Geranium**	**Petunia**	**Snapdragon**	**Lilies**	**Impatiens**
Control	75*	95*	76*	95*	66*	65*
Pathogen control	18	46	35	22	27	11
Chemical control	37*	52*	44*	35*	28*	13*
BY 1X	35*	6*	56*	39*	23*	12
BY 2 X	25*	44	45*	24*	33	9*
BY 3 X	32	38	48*	14	12	8*
BY 4 X	35	13	19	9	17	0*
LSD ($P = 0.05$)	**7**	**15**	**13**	**17**	**18**	**19**

[1]Mean of six replications, 4 seedlings per replication.
*Significantly different from pathogen control.

Progressive Report – Year 2

Objective 3:

Commercial nursery trials

Commercial nursery trials were conducted in year two at the following two commercial greenhouses: 1) Plant Development Services, Inc., and 2) Young's Plant Farm, Inc. Both locations were located in Alabama.

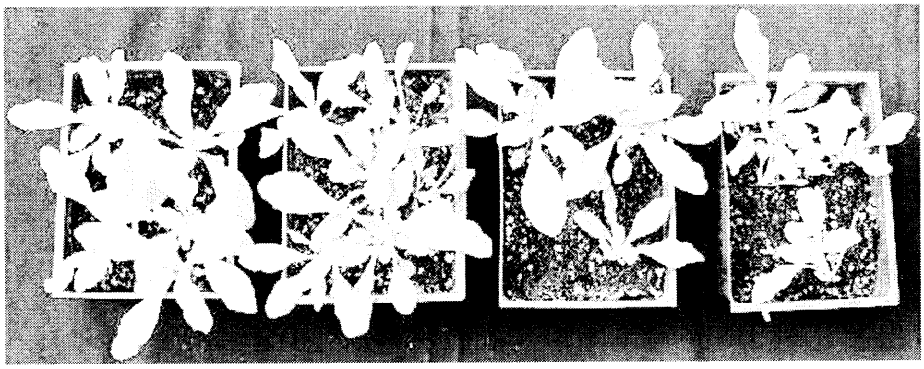
At each location the following treatments were tested on six ornamentals (Poinsettia, Geranium, Petunia, Snapdragon, Lilies, and Impatiens):

1. Control
2. BioYield flakes at 1:40
3. BioYield liquid at 2 x
4. Chemical control

There were six experiments, one for each crop at each location. At each location, the trial was a randomized complete block with six replications (100 plants each). BioYield flakes and liquid were applied to the soilless mix, as described above. Plants were monitored for healthy stand and vigor of growth at 6 weeks after seeding. In addition, plants were continually monitored for presence of naturally occurring pathogens. Data was analyzed by ANOVA with mean separation using LSD at $P = 0.05$.

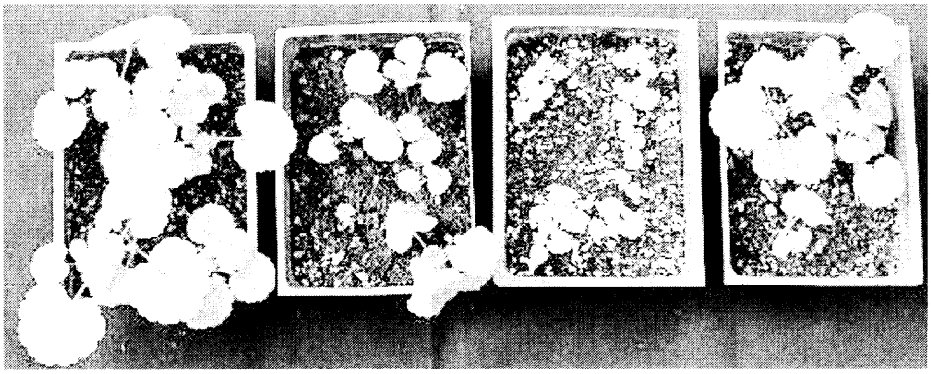
Examples of visual shots

Healthy stand of Petunia grown in Pythium infested soil-less media 6 weeks after seeding



BioYield flakes **BioYield liquid** **Control** **Pathogen control**

Healthy stand of Geranium grown in Pythium infested soil-less growth media 6 weeks after seeding



BioYield flakes BioYield liquid Pathogen Control Control

Table 4. Efficacy of BioYield on improvement of healthy stand of various ornamentals grown under commercial nursery conditions 6 weeks after seeding – Year 2 at Plant Development Services Inc.

Treatment	**% Healthy stand[1]**					
	Poinsettia	**Geranium**	**Petunia**	**Snapdragon**	**Lilies**	**Impatiens**
Control	70	60	55	64	58	66
Chemical control	85*	85*	65	78*	64	79*
BY Flakes1:40	95*	90*	68	79*	69*	82*
BY Liquid 2X	90*	85*	71*	69	72*	75*
LSD ($P = 0.05$)	**14**	**12**	**15**	**13**	**10**	**12**

[1]Mean of six replications, 100 seedlings per replication.
*Significantly different from control.

Table 5. Efficacy of BioYield on improvement of healthy stand of various ornamentals grown under commercial nursery conditions 6 weeks after seeding – Year 2 at Young Farm.

Treatment	**% Healthy stand[1]**					
	Poinsettia	**Geranium**	**Petunia**	**Snapdragon**	**Lilies**	**Impatiens**
Control	77	70	66	71	63	55
Chemical control	89*	86*	69	79	78*	82*
BY Flakes1:40	94*	89*	67	84	76*	87*
BY Liquid 2X	96*	75	64	82	83*	79*
LSD ($P = 0.05$)	**11**	**9**	**12**	**14**	**12**	**16**

[1]Mean of six replications, 100 seedlings per replication.
*Significantly different from control.

Conclusions

Selection of various concentrations of BioYield flakes and liquid prior to testing under commercial nursery conditions is the major bottleneck in the development of useful biocontrol agents. The goal of the assays described in this study was to improve the chances of selecting optimum level of BioYield concentration that can suppress damping-off pathogens in the nurseries. A preliminary test to identify competent concentrations of BioYield that reduce diseases caused by *Pythium* and *Rhizoctonia* would greatly accelerate the selection process.

Both formulations of provided good control of these damping-off diseases of ornamentals. The higher rates proved beneficial on some plants. No discernible

differences between the two formulations at higher doses were noted. These tests show that the selection of doses of BioYield an excellent choice for Rhizoctonia and Pythium control. Damping-off diseases of seedlings are found worldwide and can be caused by several species of fungi under various weather conditions. The fungi that cause these diseases may attack the seed or the seedling before it emerges above the soil surface, causing a seed rot or pre-emergence damping-off. When this happens, the result is a poor stand, which may be blamed on poor seed quality rather than the presence of a disease. Control of damping-off diseases is difficult during and after the disease has been identified in the nursery. Damping-off must be anticipated and prevented by using biologicals as seed treatments or transplant treatments before the seed or plants are put in the real commercial nurseries or fields.

In the past, soil pesticides offered relatively effective, although often only short-term solutions for suppression of these damping-off diseases. The future of soil pesticides appears questionable because of environmental and economic considerations. Along the same line, the current cost of more than $100 million for developing a new fungicide is prohibitory for these diseases particularly on minor crops. Finally, increasing numbers of consumers demand pesticide-free ornamentals. The horticultural industry is therefore in need of reliable, safe and economic alternatives to traditional root disease control.

Our results clearly show that BioYield either as a concentrate or liquid could be used a commercial biological fertilizer or biofungicide in ornamental industry to protect several soil borne pathogens. It could also be used as an alternative to chemical fungicides. However, this decision has to be taken by our sponsor company Gustafson.

Acknowledgements:

The author is greatly appreciates Drs. Braverman and Meister for their help, guidance and support throughout this project. Also thanks to USDA-IR4 program for funding this project and support from Dr. Don Kenney from Gustafson.

Screening EcoGuard (710-145f) for Efficacy Against Pathogens of Ornamentals

SUMMARY

Several trials were conducted and included the following:

Verbena: *Erysiphe cichoracearum*
Poinsettia: *Phytophthora drechsleri*
Trailing Petunia: *Phytophthora drechsleri*
Geranium: *Botrytis cinerea*
Zinnia: *Rhizoctonia solani*
Bedding Impatiens: Phytotoxicity screen
New Guinea Impatiens: Phytotoxicity screen

Greenhouse trials were conducted and several products were included in each trial to compare to the EcoGuard biopesticide. Overall, EcoGuard does not appear to have activity against root rot caused by *Phytophthora dreschleri* on either trailing petunia or poinsettia. In each of the two trials, the EcoGuard treatments were similar to the untreated controls. A rate response was not noted. In contrast, when EcoGuard was tested against root rot caused by *Rhizoctonia solani*, efficacy was noted. The lowest rate of EcoGuard was significantly better than the untreated control in controlling *Rhizoctonia* root rot on zinnia and may be useful in a management program.

When EcoGuard was tested against powdery mildew caused by *Erysiphe cichoracearum*, efficacy was noted early in the trial with the high rate (90.0 fl.oz.) of the biopesticide. The biopesticide may have become overwhelmed as the disease progressed later in the trial. Based on this trial, it is my opinion that this product warrants further testing in a management program with other fungicides that are considered standards for powdery mildew control. However, when testing EcoGuard against another foliar pathogen, *Botrytis cinerea*, disease control was not observed. Among the parameters measured, the EcoGuard treatments were comparable to the untreated controls. Phytotoxicity trials were conducted with bedding impatiens and New Guinea impatiens and foliar sprays of EcoGuard were tested. Phytotoxicity was not observed in either of the impatiens crops or the other crops tested.

In summary, EcoGuard appears to hold promise for use on powdery mildew and Rhizoctonia. Further studies would help to determine the role that EcoGuard could play in disease management of these pathogens when used in a program with other fungicides.

VERBENA (*Verbena* x *hybrida* 'Sparkler Red/White')
Powdery mildew; *Erysiphe cichoracearum*

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Evaluation of a biopesticide and fungicides for controlling powdery mildew on verbena, 2003.

Verbena plugs were transplanted from 84-cell trays to 4-in plastic pots filled with soilless media (Baccto Professional Planting Mix, Michigan Peat Company, Houston, TX) on 1 Apr. Four replicates per treatment, and one plant per replicate arranged in a randomized complete block design. Plants were hand watered once daily and were fertilized twice weekly (200 ppm of Peter's 20-20-20 liquid feed, (The Scotts Company, Marysville, OH). Insects were controlled with an application of Conserve (8 oz/100 gal) on 26 Mar. Inoculation was accomplished by shaking infected mature verbena plants over the treatment blocks, and placing the plants within the blocks. Treatments were applied to runoff with a hand pump compressed air sprayer on 16, 23, 30 Apr, and 7, 14 May. Plants were rated for disease on 30 Apr, and 7, 14 and 21 May.

Disease pressure was severe with ratings of untreated plants increasing from 6.8 to 9.3 (1=no lesions to 10=100% infection) throughout the course of this study. Weekly applications of 710-145f (90.0 fl oz) were significantly more effective in limiting disease severity compared to the untreated control on 30 April, 7 and 14 May. On the last observation date, five treatments significantly limited disease (severity ratings ≤ 1.8) compared with the untreated plants, and included the industry standard of Systhane 40WSP, and all treatments including the strobilurin fungicide, Compass 50WDG (2.0 oz). When 710-145f (67.5 fl oz and 90.0 fl oz) was used in alteration with Compass, disease control was achieved. In general, there appeared to be a rate response in the 30 Apr and 7 May rates with 710-145f (45.0 and 90.0 fl oz).

VERBENA (*Verbena* x *hybrida* 'Sparkler Red/White')
Powdery mildew; *Erysiphe cichoracearum*

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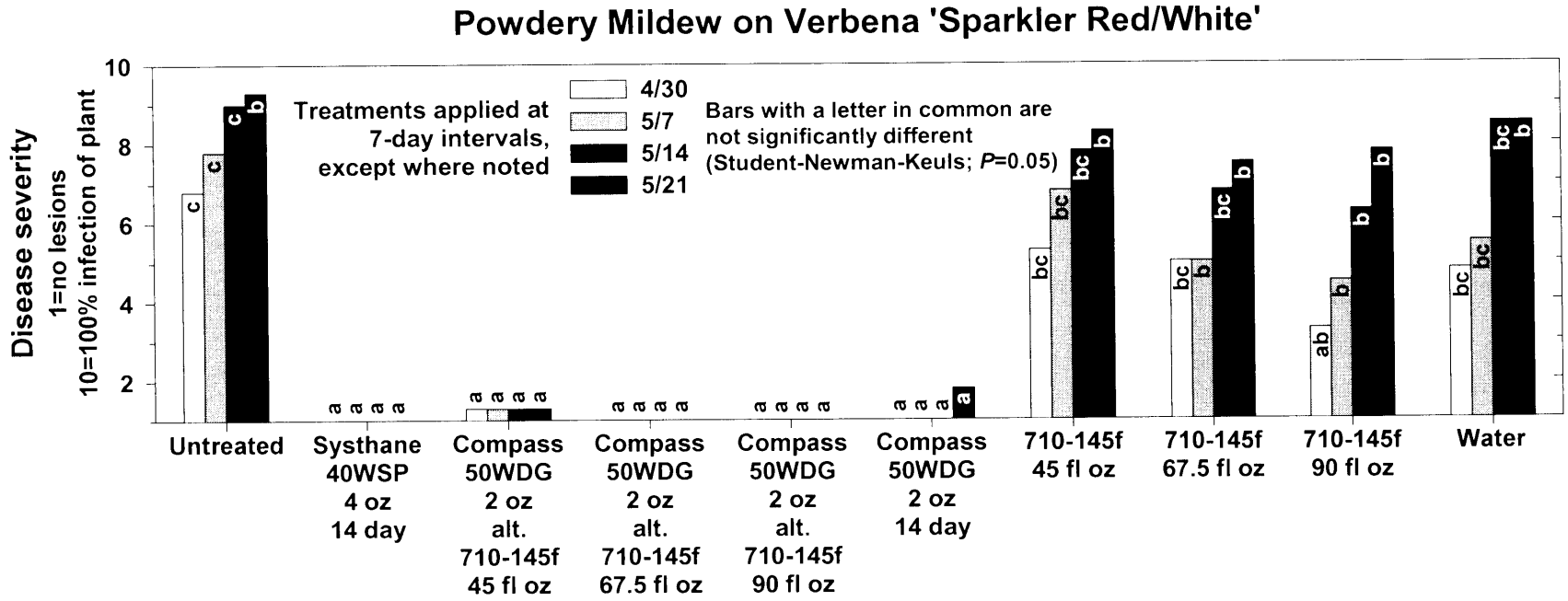
Control of powdery mildew on verbena with foliar sprays, 2003.

Treatment and rate/100 gal applied at 7-day intervals, unless otherwise noted	Disease severity[z]			
	4/30	5/7	5/14	5/21
Untreated	6.8 c[y]	7.8 c	9.0 c	9.3 b
710-145f 45.0 fl oz	5.3 bc	6.8 bc	7.8 bc	8.3 b
710-145f 67.5 fl oz	5.0 bc	5.0 b	6.8 bc	7.5 b
710-145f 90.0 fl oz	3.3 ab	4.5 b	6.3 b	7.8 b
Compass 50WDG 2.0 oz alternate 710-145f 45.0 fl oz	1.3 a	1.3 a	1.3 a	1.3 a
Compass 50WDG 2.0 oz alternate 710-145f 67.5 fl oz	1.0 a	1.0 a	1.0 a	1.0 a
Compass 50WDG 2.0 oz alternate 710-145f 90.0 fl oz	1.0 a	1.0 a	1.0 a	1.0 a
Systhane 40WSP 4.0 oz[x]	1.0 a	1.0 a	1.0 a	1.0 a
Compass 50WDG 2.0 oz[x]	1.0 a	1.0 a	1.0 a	1.8 a
Water	4.8 bc	5.5 bc	8.5 bc	8.5 b

[z]Based on a scale of 1 to 10, where 1=no lesions to 10=100% infection of plant with powdery mildew.
[y]Column means with a letter in common are not significantly different (Student-Newman-Keuls; P=0.05).
[x]Applied at 14-day intervals.


Powdery Mildew on Verbena 'Sparkler Red/White'
Disease severity
1=no lesions
10=100% infection of plant
10
8
6
4
2
Treatments applied at 7-day intervals, except where noted
4/30
5/7
5/14
5/21
Bars with a letter in common are not significantly different (Student-Newman-Keuls; P=0.05)
Untreated
Systhane 40WSP 4 oz 14 day
Compass 50WDG 2 oz alt. 710-145f 45 fl oz
Compass 50WDG 2 oz alt. 710-145f 67.5 fl oz
Compass 50WDG 2 oz alt. 710-145f 90 fl oz
Compass 50WDG 2 oz 14 day
710-145f 45 fl oz
710-145f 67.5 fl oz
710-145f 90 fl oz
Water

POINSETTIA (*Euphorbia pulcherrima* 'Freedom Red')
Root Rot; *Phytophthora drechsleri*

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Evaluation of a biopesticide and fungicides in managing Phytophthora root rot of poinsettia, 2003:

Cuttings of poinsettia 'Freedom Red' rooted in oasis cubes were transplanted into 4-inch pots containing a soilless media (Baccto Professional Planting Mix, Michigan Peat Company, Houston, TX) on 24 Apr. Inoculum was prepared by growing a mefenoxam resistant isolate of *Phytophthora drechsleri* on ¼-strength V8 agar for one week. Two 12-mm plugs of *P. drechsleri* were placed on each side of the oasis cube of each rooted cutting during transplanting. Six replicates per treatment and one plant per replicate were arranged in a completely randomized design. Plants were fertilized twice weekly with 200 ppm Peter's 20-20-20 liquid fertilizer (The Scotts Company, Marysville, OH), and were grown at 23°C day temperature, 18°C night temperature. Treatments were applied as a drench on 24 Apr, 1, 8 and 15 May. Plant height, health, and death were taken on 1, 8, 15 and 22 May.

Disease pressure in this experiment was severe with 100% of the untreated plants dead two weeks after inoculation. Truban alone or alternated with 710-145f (67.5, 90.0 fl oz) and Stature DM effectively controlled disease in this experiment with 0% plant death and health ratings of 1.5 (1=healthy to 5=dead) or lower on the last rating date. Height differences were not noted among the untreated uninoculated control plants and the treated plants that remained healthy. The product 710-145f was not effective when used alone. Since the higher rate of 710-145f was applied in a 7-day alternation with Truban 30WP, it is likely that the protection from the Truban was adequate to compensate for the 710-145f applications. Typically, Truban is applied every 30 days to manage root rots. A rate response was not observed for 710-145f, BAS 516 38WG, Ranman 3.3SC, Camelot 58EC, or Reason 4.17SC.

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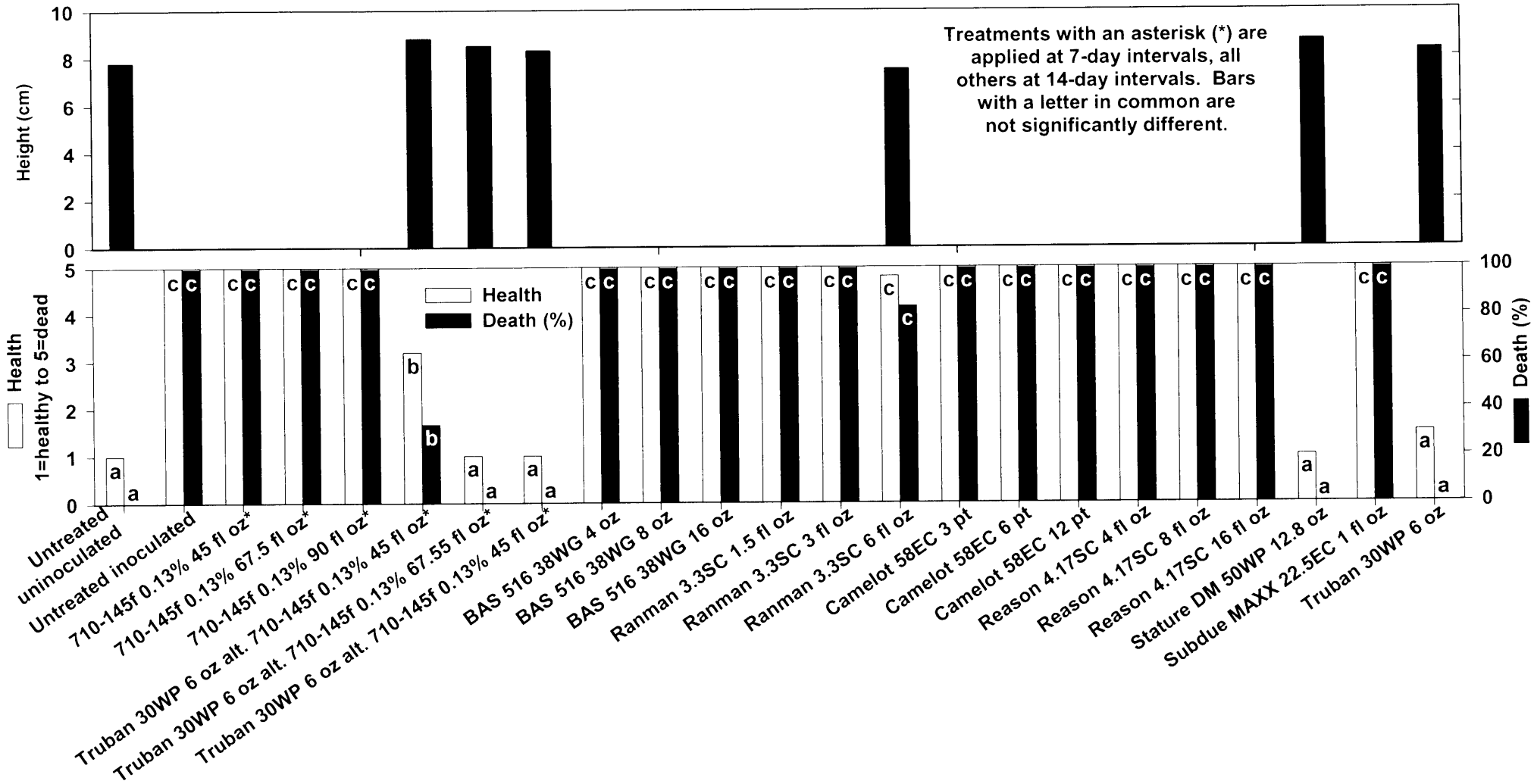
Treatment and rate/100 gal	Appl. (days)	Height (cm)				Health*				Death (%)		
		5/1	5/8	5/15	5/22	5/1	5/8	5/15	5/22	5/8	5/15	5/22
Untreated uninoculated	--	5.7**	6.4	6.8	7.8	1.0 a	1.0 a	1.0 a	1.0 a	0.0 a	0.0 a	0.0 a
Untreated inoculated	--	5.8	--	--	--	3.8 g	5.0 e	5.0 d	5.0 c	100.0 c	100.0 d	100.0 c
710-145f 0.13% 45.0 fl oz	7	5.7	--	--	--	3.2 defg	5.0 e	5.0 d	5.0 c	100.0 c	100.0 d	100.0 c
710-145f 0.13% 67.5 fl oz	7	6.0	--	--	--	3.5 efg	5.0 e	5.0 d	5.0 c	100.0 c	100.0 d	100.0 c
710-145f 0.13% 90.0 fl oz	7	5.8	--	--	--	3.7 fg	5.0 e	5.0 d	5.0 c	100.0 c	100.0 d	100.0 c
Truban 30WP 6.0 oz alternate 710-145f 0.13% 45.0 fl oz	7	6.3	6.3	6.9	8.8	1.3 abc	1.0 a	2.0 ab	3.2 b	0.0 a	16.7 ab	33.3 b
Truban 30WP 6.0 oz alternate 710-145f 0.13% 67.5 fl oz	7	6.1	6.0	6.7	8.5	1.2 ab	1.3 ab	1.2 a	1.0 a	0.0 a	0.0 a	0.0 a
Truban 30WP 6.0 oz alternate 710-145f 0.13% 90.0 fl oz	7	6.1	6.3	7.1	8.3	1.2 ab	1.3 ab	1.0 a	1.0 a	0.0 a	0.0 a	0.0 a
BAS 516 38WG 4.0 oz	14	6.2	--	--	--	2.5 abcdefg	5.0 e	5.0 d	5.0 c	100.0 c	100.0 d	100.0 c
BAS 516 38WG 8.0 oz	14	6.2	--	--	--	2.5 abcdefg	4.7 de	5.0 d	5.0 c	100.0 c	100.0 d	100.0 c
BAS 516 38WG 16.0 oz	14	5.7	5.0	--	--	3.0 cdefg	4.7 de	5.0 d	5.0 c	83.3 bc	100.0 d	100.0 c
Ranman 3.3SC 1.5 fl oz	14	6.3	5.5	--	--	2.0 abcdef	4.8 de	5.0 d	5.0 c	83.3 bc	100.0 d	100.0 c
Ranman 3.3SC 3.0 fl oz	14	6.8	8.5	--	--	2.3 abcdefg	4.8 de	5.0 d	5.0 c	83.3 bc	100.0 d	100.0 c
Ranman 3.3SC 6.0 fl oz	14	6.3	7.0	7.5	7.5	1.5 abcd	3.0 bcd	3.0 bc	4.8 c	50.0 abc	50.0 bc	83.3 c
Camelot 58EC 3.0 pt	14	5.3	--	--	--	3.3 efg	5.0 e	5.0 d	5.0 c	100.0 c	100.0 d	100.0 c
Camelot 58EC 6.0 pt	14	5.4	5.0	--	--	3.5 efg	4.8 de	5.0 d	5.0 c	83.3 bc	100.0 d	100.0 c
Camelot 58EC 12.0 pt	14	6.1	5.5	--	--	2.8 bcdefg	4.2 de	5.0 d	5.0 c	33.3 abc	100.0 d	100.0 c
Reason 4.17SC 4.0 fl oz	14	6.0	6.2	--	--	1.8 abcde	3.7 cde	5.0 d	5.0 c	50.0 abc	100.0 d	100.0 c
Reason 4.17SC 8.0 fl oz	14	5.8	6.3	--	--	1.8 abcde	4.2 de	5.0 d	5.0 c	66.7 abc	100.0 d	100.0 c
Reason 4.17SC 16.0 fl oz	14	5.7	6.0	6.5	--	2.7 abcdefg	4.5 de	4.5 cd	5.0 c	83.3 bc	83.3 cd	100.0 c
Stature DM 50WP 12.8 oz	14	6.3	6.5	7.2	8.7	1.2 ab	2.0 abc	1.0 a	1.0 a	16.7 ab	0.0 a	0.0 a
Subdue MAXX 22.5EC 1.0 fl oz	14	5.7	5.8	7.3	--	1.0 a	2.0 abc	3.7 cd	5.0 c	16.7 ab	66.7 cd	100.0 c
Truban 30WP 6.0 oz	14	6.3	6.0	7.2	8.3	1.0 a	1.2 ab	1.0 a	1.5 a	0.0 a	0.0 a	0.0 a

*Rated on a scale of 1 to 5, where 1=healthy to 5=dead.

**Column means with a letter in common or with no letter are not significantly different (Tukey's Studentized Range; P=0.05).

Phytophthora Root Rot of Poinsettia



Phytophthora rot; *Phytophthora drechsleri*

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Evaluation of a biopesticide and fungicides for managing Phytophthora rot of trailing petunia, 2003.

Calibrachoa 'Spring Fling Yellow' plugs from an 84-cell tray were transplanted 18 March into 4-inch plastic pots containing a soilless medium (Baccto Professional Planting Mix, Michigan Peat Company, Houston, TX). A *Phytophthora drechsleri,* isolate known to be resistant to mefenoxam, was grown on dilute V8 agar for two weeks. Plates were then flooded to release zoospores into solution. The zoospore solution was diluted and then injected into the soil 2 cm from the stem of each plant on 2 May (1.0 ml/plant) and on 18 May (2.0 ml/plant). Plants were fertilized twice weekly with 350 ppm Peter's 15-5-25 liquid feed (The Scotts Company, Marysville, OH). Insects were controlled with an application of Conserve (8 oz/100 gal) on 5 May. Temperatures ranged from a low of 18°C at night to a high of 30°C during the day. Six replicates per treatment with one plant per replicate were arranged in a completely randomized design. Treatments were applied as a drench on 18 and 25 Apr, 2, 9, 16 and 23 May. Plant health and death (%) were recorded on 2, 9, 16, 23 and 30 May.

Disease pressure in this experiment was moderate, with 50% of the untreated inoculated control plants dead by the last rating date. Truban, Subdue Maxx, and the biological fungicide 710-145f failed to limit disease with all three treatments resulting in greater than >50% plant death. BAS 516 (4.0 and 16.0 oz), Reason (4.0, 8.0, and 16.0 fl oz), Ranman (1.5, 3.0, and 6.0 fl oz), and Camelot (3.0, 6.0 and 12.0 pts) all effectively controlled disease and completely prevented plant death. Stature (12.8 oz) also effectively controlled disease with 16.7% of the plants dead on the last rating date. While plant health ratings did not differ significantly from the untreated control, several treatments resulted in healthy-appearing plants (rating=1) and included Ranman (all rates), Camelot (all rates), Reason (all rates), and BAS 516 38WG (4.0 oz and 16.0 oz).

Phytophthora rot; Phytophthora drechsleri

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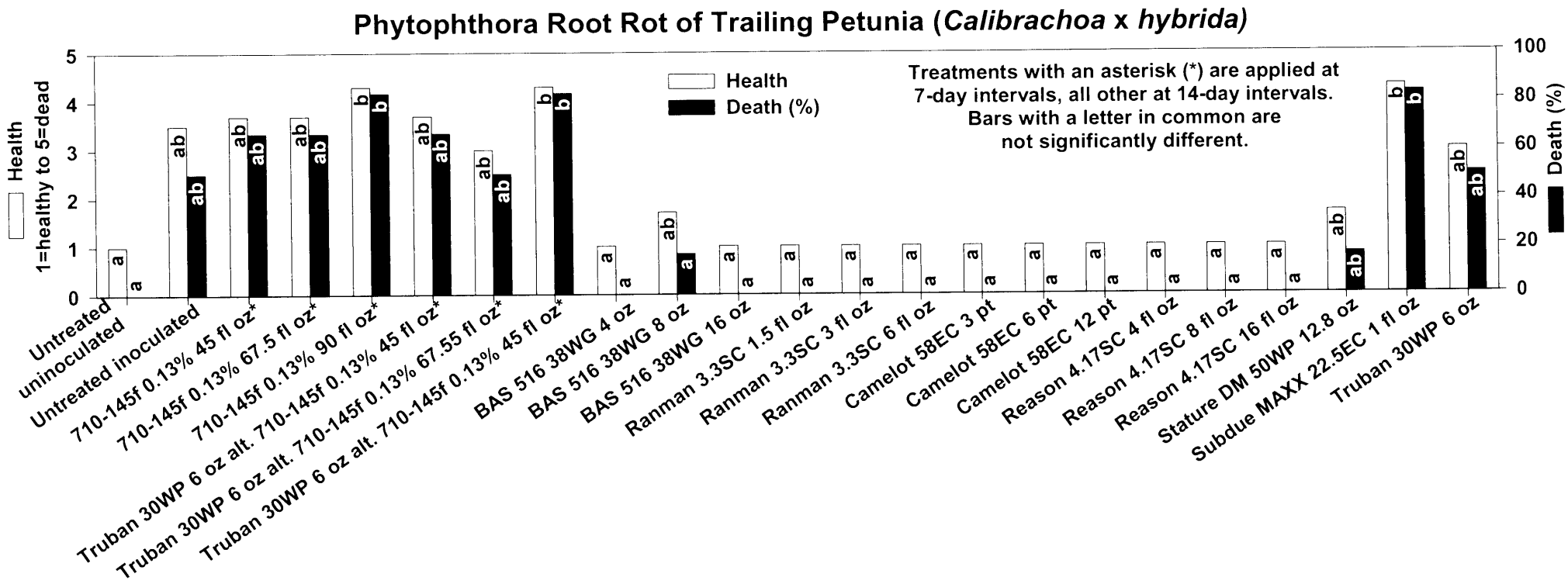
Evaluation of fungicides for managing Phytophthora rot of trailing petunia, 2003.

Treatment and rate/100 gal, applied at 14-day intervals unless otherwise noted	Health[z]					Death (%)			
	5/2	5/9	5/16	5/23	5/30	5/9	5/16	5/23	5/30
Untreated uninoculated	1.0[y]	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Untreated inoculated	1.5	2.3	1.7 ab	2.3 ab	3.5 ab	33.3	16.7	33.3 ab	50.0 ab
710-145f 0.13% 45.0 fl oz[x]	1.0	2.3	2.8 ab	3.0 ab	3.7 ab	33.3	33.3	50.0 ab	66.7 ab
710-145f 0.13% 67.5 fl oz[x]	1.3	2.7	3.8 b	4.3 b	3.7 ab	33.3	66.7	83.3 b	66.7 ab
710-145f 0.13% 90.0 fl oz[x]	1.2	2.8	3.7 b	3.7 ab	4.3 b	33.3	66.7	66.7 ab	83.3 b
Truban 30WP 6.0 oz alternate 710-145f 0.13% 45.0 fl oz[x]	1.5	2.3	2.3 ab	2.3 ab	3.7 ab	33.3	33.3	33.3 ab	66.7 ab
Truban 30WP 6.0 oz alternate 710-145f 0.13% 67.5 fl oz[x]	1.7	1.7	2.3 ab	3.0 ab	3.0 ab	16.7	33.3	50.0 ab	50.0 ab
Truban 30WP 6.0 oz alternate 710-145f 0.13% 90.0 fl oz[x]	1.0	1.5	1.7 ab	3.5 ab	4.3 b	0.0	16.7	50.0 ab	83.3 b
BAS 516 38WG 4.0 oz	1.0	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
BAS 516 38WG 8.0 oz	1.0	1.0	1.0 a	1.7 ab	1.7 ab	0.0	0.0	16.7 ab	16.7 ab
BAS 516 38WG 16.0 oz	1.0	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Ranman 3.3SC 1.5 fl oz	1.0	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Ranman 3.3SC 3.0 fl oz	1.0	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Ranman 3.3SC 6.0 fl oz	1.0	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Camelot 58EC 3.0 pt	1.0	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Camelot 58EC 6.0 pt	1.0	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Camelot 58EC 12.0 pt	1.2	1.2	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Reason 4.17SC 4.0 fl oz	1.0	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Reason 4.17SC 8.0 fl oz	1.0	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Reason 4.17SC 16.0 fl oz	1.0	1.0	1.0 a	1.0 a	1.0 a	0.0	0.0	0.0 a	0.0 a
Stature DM 50WP 12.8 oz	1.0	1.0	1.7 ab	1.7 ab	1.7 ab	0.0	16.7	16.7 ab	16.7 ab
Subdue MAXX 22.5EC 1.0 fl oz	1.5	2.7	3.0 ab	4.3 b	4.3 b	0.0	50.0	83.3 b	83.3 b
Truban 30WP 6.0 oz	1.0	2.2	2.7 ab	3.0 ab	3.0 ab	16.7	33.3	50.0 ab	50.0 ab

[z]Rated on a scale of 1 to 5, where 1=healthy to 5=dead.

[y]Column means with a letter in common are not significantly different (Tukey's Studentized Range; P=0.05).

[x]Applied at 7-day intervals.


Phytophthora Root Rot of Trailing Petunia (*Calibrachoa* x *hybrida*)
Health
1=healthy to 5=dead
Death (%)
Health
Death (%)
Treatments with an asterisk (*) are applied at 7-day intervals, all other at 14-day intervals. Bars with a letter in common are not significantly different.
Untreated uninoculated
Untreated inoculated
710-145f 0.13% 45 fl oz*
710-145f 0.13% 67.5 fl oz*
710-145f 0.13% 90 fl oz*
710-145f 0.13% 45 fl oz*
710-145f 0.13% 67.55 fl oz*
Truban 30WP 6 oz alt. 710-145f 0.13% 45 fl oz*
Truban 30WP 6 oz alt. 710-145f 0.13% 67.55 fl oz*
Truban 30WP 6 oz alt. 710-145f 0.13% 45 fl oz*
BAS 516 38WG 4 oz
BAS 516 38WG 8 oz
BAS 516 38WG 16 oz
Ranman 3.3SC 1.5 fl oz
Ranman 3.3SC 3 fl oz
Ranman 3.3SC 6 fl oz
Camelot 58EC 3 pt
Camelot 58EC 6 pt
Camelot 58EC 12 pt
Reason 4.17SC 4 fl oz
Reason 4.17SC 8 fl oz
Reason 4.17SC 16 fl oz
Stature DM 50WP 12.8 oz
Subdue MAXX 22.5EC 1 fl oz
Truban 30WP 6 oz

GERANIUM (*Pelargonium* x *hortorum* 'Orbit White')
Botrytis blight; *Botrytis cinerea*

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Evaluation of fungicides and biopesticides for control of Botrytis blight of geranium, 2003.

Geranium cuttings were taken from stock plants on 4 Mar and placed into oasis strips for rooting. Rooted cuttings were transplanted into 5-inch clay pots containing a soilless medium (Baccto Professional Planting Mix, Michigan Peat Company, Houston, TX) on 25 Mar. Plants were fertilized twice weekly with 200 ppm Peter's 20-20-20 liquid feed (The Scotts Company, Marysville, OH). Temperatures ranged from a low of 18°C at night to a high of 24°C during the day. There were six replicates per treatment with one plant per replicate. Plants were arranged in a completely randomized design. *Botrytis cinerea* cultures were grown on potato dextrose agar for four weeks. Plates were flooded with sterile distilled water, and scraped with a sterile spatula to dislodge spores. Liquid from the plates was strained through cheesecloth, and diluted to 1.0 x 10^5 spores/ml. Plants were sprayed with the *B. cinerea* inoculum to runoff on 24 Apr and 1 May. After inoculation, plants were enclosed in clear plastic bags and placed under shade cloth. Treatments were applied with a compressed air hand pump sprayer on 17 and 24 Apr, and 1, 8 and 15 May. The numbers of total leaves, infected leaves, and leaves with sporulating *Botrytis* were counted and disease severity rated on 1, 8, 15 and 22 May. Due to lack of significant differences among treatments, data is not shown for infected leaves (%) or leaves with sporulation (%) for 22 May, or for disease severity for 15 May.

Disease pressure was significant, with untreated inoculated plants having 27.1% foliar infection, and 22.9% of the foliage with sporulating *Botrytis* on 15 May. While there were no significant differences among treatments for infected leaves compared to the untreated inoculated controls on 15 May, three treatments limited foliar infection to <12%: Insignia 20WG (4.0 oz, 7-day interval), Endorse 2.5WP (1.1 lb, 7-day interval), and Daconil 6F (32 fl oz , 14-day interval). Similarly, while there were no significant differences among treatments for disease severity compared to the untreated inoculated control on 22 May, two treatments limited severity to 3.2 (1=no lesions to 10=plant death): Endorse 2.5WP 1.1 lb and Daconil 6F 32 fl oz (14-day). While statistical differences for leaves with sporulation (%) occurred on the first two observation dates, differences on the last observation date was not noted. However, the incidence of leaves with sporulation was limited to less than 10% by Insignia 20WG (4.0 oz), Endorse 2.5WP (1.1lbs) and Daconil 6F. The biopesticide 710-145f did not appear to have notable activity against *B. cinerea* on geranium.

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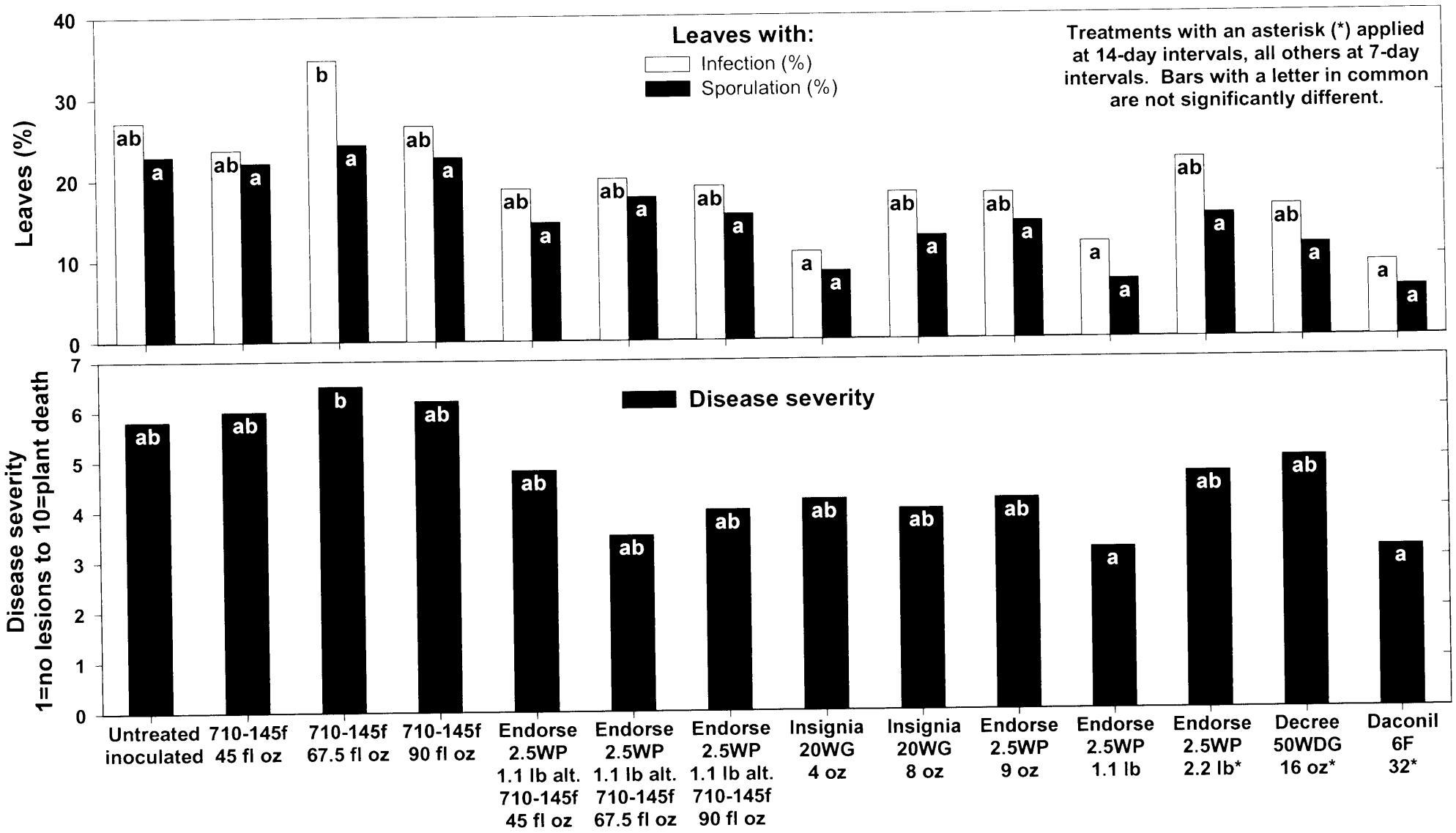
Evaluation of fungicides and biopesticides for control of Botrytis blight of geranium, 2003.

Treatment and rate/100 gal applied at 7-day intervals, unless otherwise noted	Leaves with infection (%)			Leaves with sporulation (%)			Disease severity[z]			
	5/1	5/8	5/15	5/1	5/8	5/15	5/1	5/8	5/15	5/22
Untreated inoculated	16.3 b[y]	24.2 de	27.1 ab	7.1 ab	20.9 cd	22.9 a	4.3 a	6.0 b	6.3	5.8 ab
710-145f 45.0 fl oz	16.5 b	26.6 e	23.7 ab	11.4 b	23.6 d	22.1 a	4.3 a	6.5 b	6.2	6.0 ab
710-145f 67.5 fl oz	11.5 ab	21.1 bcde	34.7 b	2.9 a	14.8 abcd	24.3 a	3.2 a	4.8 ab	6.2	6.5 b
710-145f 90.0 fl oz	15.3 b	22.1 cde	26.6 ab	6.5 ab	17.1 bcd	22.7 a	4.0 a	6.2 b	6.0	6.2 ab
Endorse 2.5WP 1.1 lb alternate 710-145f 45.0 fl oz	9.0 ab	8.6 abcd	18.8 ab	4.8 ab	6.6 ab	14.6 a	3.3 a	3.3 ab	5.0	4.8 ab
Endorse 2.5WP 1.1 lb alternate 710-145f 67.5 fl oz	10.9 ab	11.9 abcde	20.0 ab	2.6 a	9.3 abc	17.7 a	2.5 a	3.7 ab	4.3	3.5 ab
Endorse 2.5WP 1.1 lb alternate 710-145f 90.0 fl oz	7.3 ab	14.0 abcde	19.0 ab	4.9 ab	10.8 abc	15.5 a	3.2 a	3.5 ab	4.5	4.0 ab
Insignia 20WG 4.0 oz	6.1 ab	9.2 abcd	10.8 a	4.0 ab	7.7 ab	8.4 a	2.8 a	3.8 ab	3.0	4.2 ab
Insignia 20WG 8.0 oz	5.1 ab	6.0 ab	18.1 ab	0.5 a	2.8 ab	12.7 a	2.2 a	2.7 a	4.0	4.0 ab
Endorse 2.5WP 9.0 oz	11.7 ab	18.1 abcde	17.9 ab	5.9 ab	13.8 abcd	14.4 a	4.2 a	5.0 ab	4.3	4.2 ab
Endorse 2.5WP 1.1 lb	8.1 ab	8.8 abcd	11.8 a	2.3 a	4.6 ab	7.1 a	2.8 a	2.5 a	3.7	3.2 a
Endorse 2.5WP 2.2 lb[x]	11.8 ab	12.0 abcde	22.1 ab	1.6 a	5.4 ab	15.2 a	2.8 a	3.7 ab	4.0	4.7 ab
Decree 50WDG 16.0 oz[x]	8.3 ab	8.1 abc	16.2 ab	1.5 a	2.0 a	11.4 a	2.7 a	2.3 a	4.5	5.0 ab
Daconil 6F 32.0 fl oz[x]	2.5 a	3.4 a	9.2 a	1.5 a	2.2 a	6.1 a	1.7 a	2.0 a	2.5	3.2 a

[z]Rated on a scale of 1 to 10, where 1=no lesions to 10=plant death.
[y]Column means with a letter in common or with no letter are not significantly different (Student-Newman-Keuls; P=0.05).
[x]Applied at 14-day intervals.

Botrytis Blight of Geranium



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Control of Rhizoctonia root rot of zinnia with biopesticides and fungicide drenches, 2003.

Inoculum was prepared by placing 20 g of rye seed and 30 ml distilled water in an Erlenmayer flask and sterilizing it. Plugs of *R. solani* were placed in each flask and allowed to grow for one week. Zinnia 'Oklahoma Mix' plugs were transplanted into 24-cell packs containing a soilless medium (Baccto Professional Mix, Michigan Peat Company, Houston, TX). During transplanting, two infested rye seeds were placed at the bottom of each cell, and two infested seeds were placed at the base of the plant stem. Plants were fertilized twice weekly with 200 ppm Peter's 20-20-20 liquid fertilizer (The Scotts Company, Marysville, OH). Temperatures ranged from a high of 23°C during the day and a low of 18°C during the night. Eight replicates per treatment with one plant per replicate were arranged in a complete randomized design. Treatments were applied as a drench on 27 Jun and 3, 10, 18, and 25 Jul. Treatments were applied in volume so that approximately 10% drained through the pot. Plant health and death (%) was recorded on 3, 10, 17, 25 Jul and 4 Aug.

Disease pressure was severe in this trial. One half of the untreated inoculated control plants were dead by the third rating date (17 Jul). All treatments completely prevented plant death with the following exceptions: 710-145f (all rates), Endorse 2.5WP alternated with 710-145f (45.5 fl oz), and Banrot 40WP. The biopesticide 710-145f applied at the lowest rate (45.0 fl oz) was comparable to the untreated uninoculated control. The higher rate (67.5 fl oz) of 710-145f was significantly better than the untreated control but was not comparable to the untreated uninoculated control. The highest rate (90.0 fl oz) of 710-145f did not significantly limit disease. Alternating Endorse with 710-145f was not more effective than applying Endorse alone every 14 days. No differences were noted when comparing Endorse (1.1 lbs) applied every 7 days to Endorse (2.2 lbs) applied every 14 days. In the treatments where all plants survived, the plants did not differ significantly in their overall health.

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Control of Rhizoctonia root rot of zinnia with biopesticides and fungicide drenches, 2003.

Treatment and rate/100 gal	Application interval (days)	Plant Health Rating*				
		3-Jul	10-Jul	17-Jul	25-Jul	4-Aug
Untreated uninoculated.....	--	1.0 a**	1.0 a	1.0 a	1.0 a	1.0 a
Untreated inoculated.....	--	1.5 ab	3.3 b	3.4 b	3.4 b	3.4 b
710-145f 45.0 fl oz.....	7	1.3 ab	1.9 a	1.9 a	1.9 a	1.9 a
710-145f 67.5 fl oz.....	7	1.3 ab	2.9 b	2.9 b	2.9 b	3.0 b
710-145f 90.0 fl oz.....	7	1.8 b	2.9 b	3.0 a	3.1 b	3.1 b
Endorse 2.5WP 2.2 lbs alt. 710-145f 45.0 fl oz.....	7	1.0 a	1.6 a	1.6 a	1.6 a	1.6 a
Endorse 2.5WP 2.2 lbs alt. 710-145f 67.5 fl oz.....	7	1.0 a	1.1 a	1.1 a	1.1 a	1.1 a
Endorse 2.5WP 2.2 lbs alt. 710-145f 90.0 fl oz.....	7	1.0 a	1.3 a	1.3 a	1.3 a	1.3 a
Heritage 50WG 4.0 oz.....	14	1.0 a	1.0 a	1.0 a	1.0 a	1.0 a
Endorse 2.5WP 1.1 lbs.....	7	1.0 a	1.1 a	1.1 a	1.3 a	1.3 a
Endorse 2.5WP 2.2 lbs.....	14	1.0 a	1.1 a	1.1 a	1.3 a	1.3 a
Medallion 50WP 2.0 oz.....	14	1.0 a	1.0 a	1.0 a	1.0 a	1.0 a
Terraguard 50WP 4.0 oz + Terrazole 35WP 3.4 oz.....	14	1.1 a	1.1 a	1.1 a	1.1 a	1.1 a
Terraguard 50WP 1.0 oz + Terraclor 75WP 4.0 oz + Terrazole 35WP 3.4 oz....	14	1.0 a	1.0 a	1.0 a	1.0 a	1.0 a
Terraguard 50WP 2.0 oz + Terraclor 75WP 4.0 oz + Terrazole 35WP 3.4 oz....	14	1.0 a	1.0 a	1.0 a	1.0 a	1.0 a
Banrot 40WP 8.0 oz.....	14	1.5 ab	1.6 a	1.6 a	1.6 a	1.6 a
Terraguard 50WP 4.0 oz.....	14	1.1 a	1.3 a	1.3 a	1.3 a	1.3 a
Terraclor 75WP 4.0 oz.....	14	1.0 a	1.0 a	1.0 a	1.0 a	1.0 a
Cleary's 3336 50WP 4.0 oz.....	14	1.0 a	1.0 a	1.0 a	1.0 a	1.0 a

*Rated on a scale of 1-5, where 1=healthy, 5=dead.

**Columns means with a letter in common are not significantly different (LSD; P=0.05).

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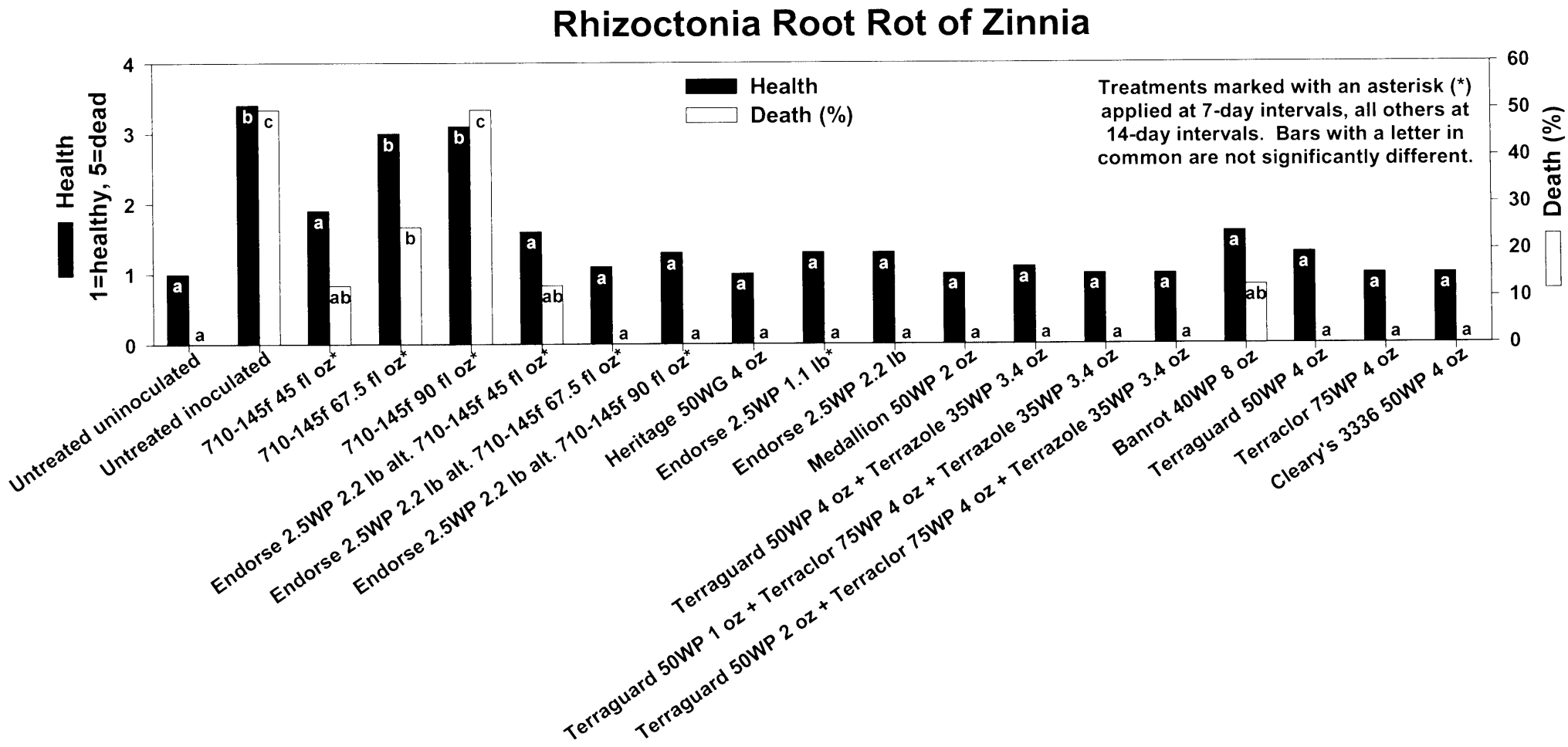
Control of Rhizoctonia root rot of zinnia with biopesticides and fungicide drenches, 2003.

Treatment and rate/100 gal	Application interval (days)	Plant Death (%)									
		3-Jul		10-Jul		17-Jul		25-Jul		4-Aug	
Untreated uninoculated.....	--	0.0	a*	0.0	a	0.0	a	0.0	a	0.0	a
Untreated inoculated.....	--	12.5	b	37.5	c	50.0	d	50.0	c	50.0	c
710-145f 45.0 fl oz.....	7	0.0	a	12.5	ab	12.5	ab	12.5	ab	12.5	ab
710-145f 67.5 fl oz.....	7	0.0	a	12.5	ab	25.0	bc	25.0	b	25.0	b
710-145f 90.0 fl oz.....	7	0.0	a	25.0	bc	37.5	cd	50.0	c	50.0	c
Endorse 2.5WP 2.2 lbs alt. 710-145f 45.0 fl oz.....	7	0.0	a	12.5	ab	12.5	ab	12.5	ab	12.5	ab
Endorse 2.5WP 2.2 lbs alt. 710-145f 67.5 fl oz.....	7	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Endorse 2.5WP 2.2 lbs alt. 710-145f 90.0 fl oz.....	7	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Heritage 50WG 4.0 oz.....	14	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Endorse 2.5WP 1.1 lbs.....	7	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Endorse 2.5WP 2.2 lbs.....	14	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Medallion 50WP 2.0 oz.....	14	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Terraguard 50WP 4.0 oz + Terrazole 35WP 3.4 oz.....	14	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Terraguard 50WP 1.0 oz + Terraclor 75WP 4.0 oz + Terrazole 35WP 3.4 oz....	14	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Terraguard 50WP 2.0 oz + Terraclor 75WP 4.0 oz + Terrazole 35WP 3.4 oz....	14	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Banrot 40WP 8.0 oz.....	14	12.5	b	12.5	ab	12.5	ab	12.5	ab	12.5	ab
Terraguard 50WP 4.0 oz.....	14	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Terraclor 75WP 4.0 oz.....	14	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
Cleary's 3336 50WP 4.0 oz.....	14	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a

*Columns means with a letter in common are not significantly different (LSD; P=0.05).


Rhizoctonia Root Rot of Zinnia
Health
1=healthy, 5=dead
Death (%)
Health
Death (%)
Treatments marked with an asterisk (*) applied at 7-day intervals, all others at 14-day intervals. Bars with a letter in common are not significantly different.
Untreated uninoculated
Untreated inoculated
710-145f 45 fl oz*
710-145f 67.5 fl oz*
710-145f 90 fl oz*
Endorse 2.5WP 2.2 lb alt. 710-145f 45 fl oz*
Endorse 2.5WP 2.2 lb alt. 710-145f 67.5 fl oz*
Endorse 2.5WP 2.2 lb alt. 710-145f 90 fl oz*
Heritage 50WG 4 oz
Endorse 2.5WP 1.1 lb*
Endorse 2.5WP 2.2 lb
Medallion 50WP 2 oz
Terraguard 50WP 4 oz + Terrazole 35WP 3.4 oz
Terraguard 50WP 1 oz + Terraclor 75WP 4 oz + Terrazole 35WP 3.4 oz
Terraguard 50WP 2 oz + Terraclor 75WP 4 oz + Terrazole 35WP 3.4 oz
Banrot 40WP 8 oz
Terraguard 50WP 4 oz
Terraclor 75WP 4 oz
Cleary's 3336 50WP 4 oz

BEDDING IMPATIENS
(*Impatiens Wallerana* 'Accent White')
NEW GUINEA IMPATIENS
(*Impatiens Hawkeri* 'SPR Sonic Lavender')

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Evaluation of fungicides on impatiens, 2003.

Bedding impatiens were transplanted into 24-cell packs and New Guinea Impatiens into 4-inch pots containing a soilless medium (Baccto Professional Planting Mix, Michigan Peat Company, Houston, TX). Plants were fertilized twice weekly with 200 ppm Peter's 20-20-20 liquid fertilizer (The Scotts Company, Marysville, OH). Treatments were applied with a compressed air hand-pump sprayer at 14-day intervals on 12, 28 May and 13 Jun. Plant health was evaluated on 28 May and 13, 27 Jun.

There were no significant differences in plant health among treatments for either crop. No phytotoxicity was observed.

Treatment and rate/100 gal applied at 14 day intervals	Plant health*		
	28-May	13-Jun	27-Jun
Untreated	0.0 a	0.0 a	0.0 a
BAS 516 4.0 oz	0.0 a	0.0 a	0.0 a
BAS 516 8.0 oz	0.0 a	0.0 a	0.0 a
BAS 516 16.0 oz	0.0 a	0.0 a	0.0 a
Endorse 2.5WP 2.2 lbs	0.0 a	0.0 a	0.0 a
Endorse 2.5WP 4.4 lbs	0.0 a	0.0 a	0.0 a
Endorse 2.5WP 8.8lbs	0.0 a	0.0 a	0.0 a
710-145f 45.0 fl oz	0.0 a	0.0 a	0.0 a
710-145f 90.0 fl oz	0.0 a	0.0 a	0.0 a
710-145f 180.0 fl oz	0.0 a	0.0 a	0.0 a

*Rated on a scale of 0 to 10, where 0=healthy and 10=dead.

Screening Endorse for Efficacy Against Pathogens of Ginseng

SUMMARY

The foliar disease trials were conducted in the greenhouse on the campus of Michigan State University and in a commercial ginseng garden in cooperation with a grower in Wausau, Michigan. In the greenhouse Botrytis trial, Endorse was a stand-out material when applied alone every 7 days. There did not appear to be a consistent rate response. However, the highest labeled rate (2.2 lbs.) of Endorse was not included in this study. Endorse appeared to be a good partner in a fungicide program with other materials. In this trial, alternating the high rate of Endorse with Quadris appeared to be a good disease management program and could offer growers an environmentally-friendly approach to control.

Results of the Alternaria trial indicated that the low rate of Endorse 2.5WP alone was not significantly better than the untreated control. When the higher rate (1.6 lbs) of Endorse was used alone or in alternation with Quadris, there was a trend of enhanced efficacy compared with using the low rate (1.1 lbs.) of Endorse in the same programs.

The Rhizoctonia trial was not successful due to the severe and unanticipated problem with Phytophthora leaf and root rot (causal agent: *Phytopthora cactorum*) which occurred naturally in the field and confounded our test.

In summary, Endorse performed favorably overall against the Botrytis and Alternaria leaf blights. Further studies could help define optimum rates and control programs.

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Evaluation of the biopesticide Endorse to control Botrytis blight on ginseng, 2003.

Ginseng roots were transplanted into two gallon plastic pots containing a soilless medium (Bacto Professional Planting Mix, Michigan Peat Company, Houston, TX) on 2 May. Plants were fertilized bi-weekly with 200 ppm Peter's 20-20-20 liquid feed (The Scotts Company, Marysville, OH). Temperatures ranged from a low of 18°C at night to a high of 26°C during the day. There were four replicates with one plant per replicate. Plants were arranged in a completely randomized design. *Botrytis cinerea* was grown on potato dextrose agar for four weeks. Plates were scraped to dislodge spores and flooded with distilled water. Liquid from the plates was strained through two layers of cheesecloth and diluted to a 1×10^5 spores/ml. Fungicides were applied until runoff with a hand pump compressed air sprayer on 17, 25 Jul and 1, 8, 15, 22 Aug. Inoculum was applied using a hand pump sprayer after each fungicide application. After the first inoculation, plants were enclosed in clear plastic bags and placed under shade cloth. The number of leaves with sporulating *Botrytis*, the total of infected leaves and a disease severity rating was taken on 1, 8, 15 and 22 Aug.

Disease pressure was significant with untreated plants having an average of 2.3 sporulating lesions per plant and a disease severity rating of 4.5 (1=no disease; 10=plant death) on 22 Aug. Dithane and Quadris, when applied alone on a 7-day spray schedule, did not limit *B. cinerea* and received severity ratings of 5.3 and 4.5, respectively. Endorse (1.1 lbs and 1.6 lbs) sprayed at a 7-day interval proved to be the most effective treatment with no sporulating *Botrytis* and severity ratings of 1.0 (1.0=healthy) on the last rating date. Although not significantly different, Endorse (1.1 lbs and 1.6 lbs) alternated with Dithane and/or Quadris was not as effective as Endorse applied alone every 7-days. Endorse 2.5WP applied every 7-days was very effective in limiting Botrytis and may be helpful in a program to manage foliar blight of ginseng. A higher rate of Endorse of Endorse 2.5WP may be helpful for use when rotating this biopesticide with other products.

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Evaluation of the biopesticide Endorse to control Botrytis blight on ginseng, 2003.

Treatment and rate/100 gal applied at 7-day intervals.	Sporulating Botrytis lesions*			Total Botrytis lesions			Disease severity**		
	8/8	8/15	8/22	8/8	8/15	8/22	8/8	8/15	8/22
Untreated.....	2.0	1.8	2.3	2.3	2.0	2.8	3.5	4.0	4.5
Dithane 75DF 2.0 lbs.....	2.0	1.5	2.3	2.3	2.5	2.8	3.0	4.0	4.5
Quadris 23EC 15.4 fl oz.....	2.8	1.5	1.5	3.0	2.3	1.8	5.0	4.8	5.3
Endorse 2.5WP 1.1 lbs.....	0.3	0.0	0.0	0.3	0.0	0.0	1.3	1.0	1.0
Endorse 2.5WP 1.6 lbs.....	0.3	0.0	0.0	0.3	0.0	0.0	1.5	1.0	1.0
Endorse 2.5WP 1.1 lbs alt. Dithane 75DF 2.0lbs....	0.8	0.8	1.5	1.0	1.3	2.3	2.8	3.0	3.3
Endorse 2.5WP 1.6 lbs alt. Dithane 75DF 2.0lbs....	1.3	2.0	3.3	1.5	2.5	3.5	3.3	3.8	4.5
Endorse 2.5WP 1.1 lbs alt. Quadris 23EC 15.4 fl oz.	1.0	2.0	1.8	1.5	2.0	1.8	2.8	4.0	4.0
Endorse 2.5WP 1.6 lbs alt. Quadris 23EC 15.4 fl oz.	0.8	0.3	0.5	0.8	0.3	0.5	2.3	1.5	2.0
Dithane 75DF 2.0 lbs alt. Endorse 2.5WP 1.6 lbs alt. Quadris 23EC 15.4 fl oz	2.0	1.3	1.5	2.0	1.3	1.8	2.3	2.8	3.0

*Numbers in column represent mean of all reps.
**Rated on a scale of 1 to 10, where 1=no disease and 10=plant death.

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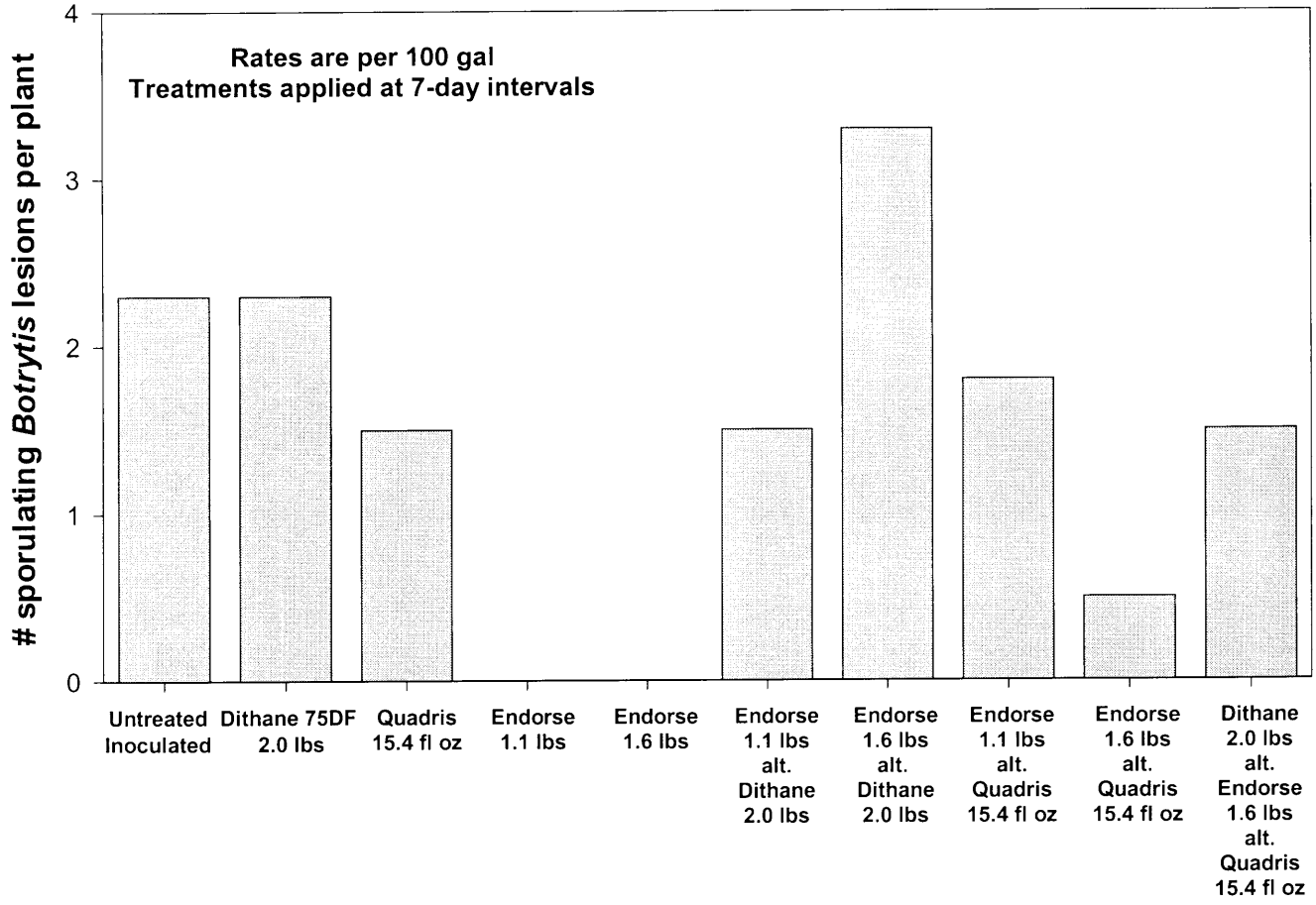
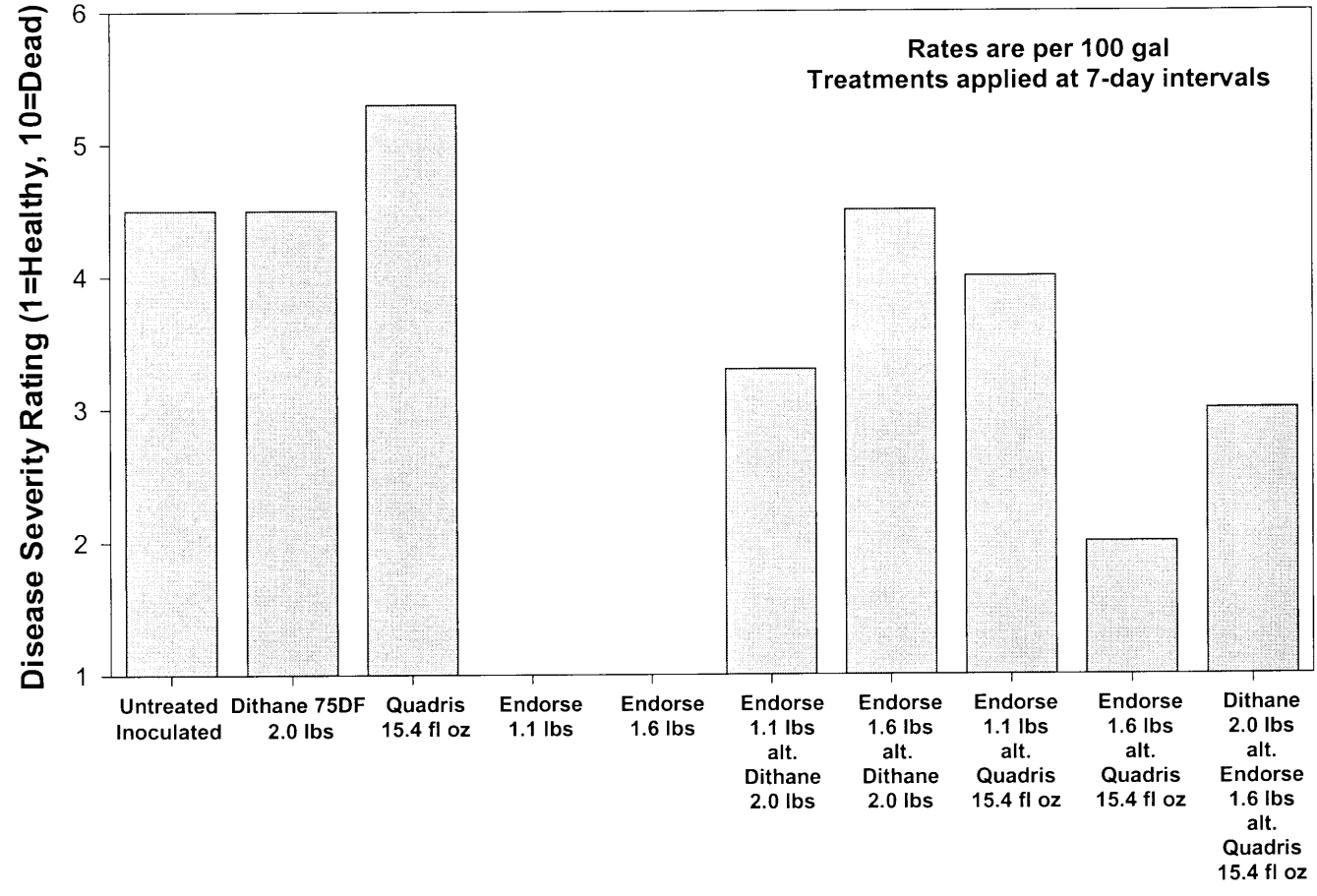
Evaluation of the biopesticide Endorse to control Botrytis blight on ginseng, 2003.

Treatment and rate/100 gal applied at 7-day intervals.	AUDPC		
	Sporulating lesions	Total lesions	Disease severity*
Untreated.....	40.3 ab**	49.9 ab	78.8 ab
Dithane 75DF 2.0 lbs.....	37.6 ab	56.0 ab	77.0 ab
Quadris 23EC 15.4 fl oz.....	47.3 b	61.3 b	102.4 b
Endorse 2.5WP 1.1 lbs.....	2.6 a	6.1 a	26.3 a
Endorse 2.5WP 1.6 lbs.....	2.6 a	3.5 a	26.3 a
Endorse 2.5WP 1.1 lbs alt. Dithane 75DF 2.0lbs....	17.5 ab	28.0 ab	59.5 ab
Endorse 2.5WP 1.6 lbs alt. Dithane 75DF 2.0lbs....	36.8 ab	44.6 ab	72.6 ab
Endorse 2.5WP 1.1 lbs alt. Quadris 23EC 15.4 fl oz.	31.5 ab	37.6 ab	71.8 ab
Endorse 2.5WP 1.6 lbs alt. Quadris 23EC 15.4 fl oz.	9.6 ab	10.5 ab	38.5 ab
Dithane 75DF 2.0 lbs alt. Endorse 2.5WP 1.6 lbs alt. Quadris 23EC 15.4 fl oz	31.5 ab	32.4 ab	52.5 ab

*Rated on a scale of 1 to 10, where 1=no disease and 10=plant death.
**Columns means with a letter in common are not significantly different (SNK; P=0.05).


sporulating *Botrytis* lesions per plant
Rates are per 100 gal
Treatments applied at 7-day intervals
0
1
2
3
4
Untreated Inoculated
Dithane 75DF 2.0 lbs
Quadris 15.4 fl oz
Endorse 1.1 lbs
Endorse 1.6 lbs
Endorse 1.1 lbs alt. Dithane 2.0 lbs
Endorse 1.6 lbs alt. Dithane 2.0 lbs
Endorse 1.1 lbs alt. Quadris 15.4 fl oz
Endorse 1.6 lbs alt. Quadris 15.4 fl oz
Dithane 2.0 lbs alt. Endorse 1.6 lbs alt. Quadris 15.4 fl oz


Disease Severity Rating (1=Healthy, 10=Dead)
Rates are per 100 gal
Treatments applied at 7-day intervals
1
2
3
4
5
6
Untreated Inoculated
Dithane 75DF 2.0 lbs
Quadris 15.4 fl oz
Endorse 1.1 lbs
Endorse 1.6 lbs
Endorse 1.1 lbs alt. Dithane 2.0 lbs
Endorse 1.6 lbs alt. Dithane 2.0 lbs
Endorse 1.1 lbs alt. Quadris 15.4 fl oz
Endorse 1.6 lbs alt. Quadris 15.4 fl oz
Dithane 2.0 lbs alt. Endorse 1.6 lbs alt. Quadris 15.4 fl oz

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Evaluation of the biopesticide Endorse to control Alternaria blight on ginseng, 2003.

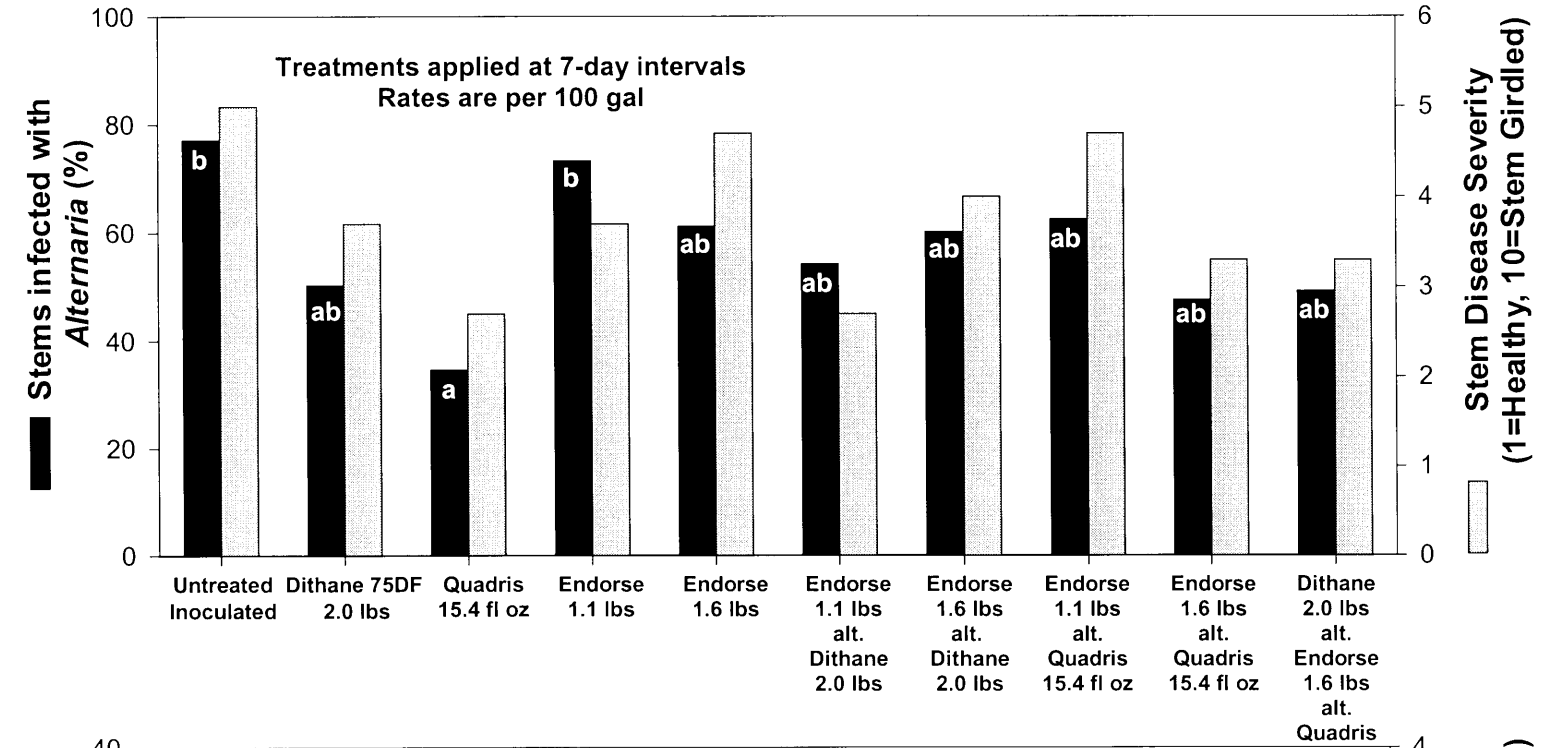
This study was conducted at a cooperator's farm in Marathon County, Wisconsin on two-year-old ginseng plants grown under shade-cloth. Beds were 4 ft wide with 1 ft between beds. Treatments consisted of a 10-ft row with a 2-ft buffer on each end. Treatments were replicated three times in a randomized complete block design. Weed control and fertilization were to commercial production standards. Aliette (5.0 lbs/100 gal) was applied weekly to control *Phytophthora* and *Pythium*. Fungicide sprays were applied with a CO_2 backpack boom sprayer equipped with four TXVS-18 nozzles spaced 18 in. apart, operating at 60 psi, and delivering 100 gal/A. Treatments were applied at 7-day intervals on 18, 24 Jul, 1, 13, 19, 28 Aug, and 4, 10, 17 Sep. Approximately 50 plants from each 10-ft section were collected on 9 Oct and evaluated for Alternaria lesions on 10 Oct. The number of stems and petioles with lesions were counted and a disease severity rating (1=no lesions, 10=stem girdled) was taken.

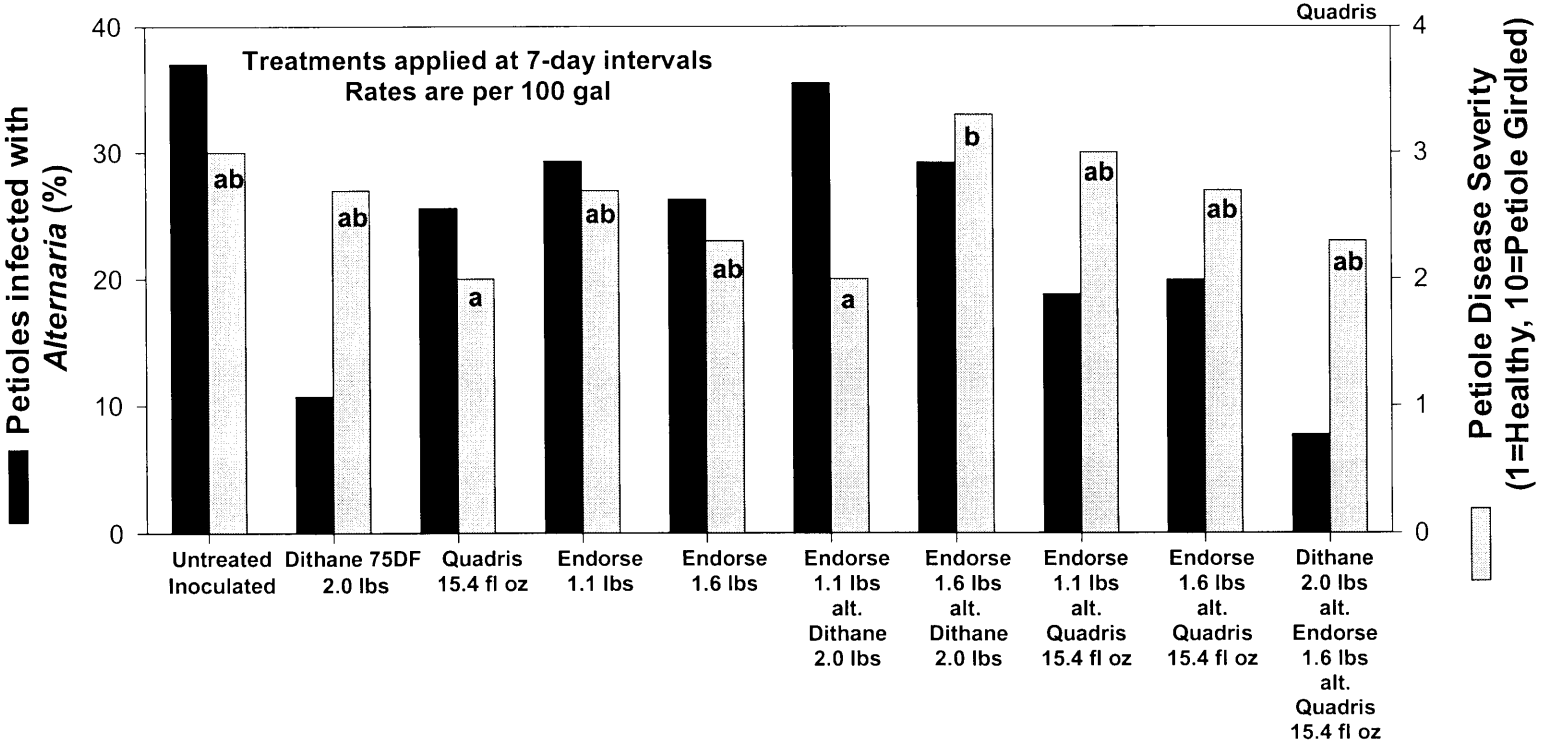
Alternaria disease pressure was significant in this trial and 77.1% of the untreated control plants had infected stems and 37.0% of the plants had infected petioles. Quadris, when applied alone, was the only treatment that significantly reduced the incidence of stem infection (34.6%). Endorse (1.6 lbs) alternated with Quadris, and Dithane alone or alternated with Endorse (1.6 lbs) and Quadris, although not significantly different than the untreated control, limited disease incidence to ≤50% of the stems. For some parameters, the high rate of Endorse (1.6 lbs) appeared to be somewhat more effective than the low rate (1.1 lbs). When Endorse (1.6 lbs), Dithane DF, and Quadris were alternated, stem infection was limited to 49.2% and the incidence of petiole infection was only 7.7%. Rotating the three fungicides not only was effective in controlling *Alternaria* but would be helpful in delaying the development of fungicide resistance. Endorse 2.5WP appears to offer potential for controlling Alternaria and could be tested at a higher rate to determine whether efficacy can be enhanced. No phytotoxicity was observed by any treatment in this trial.

Treatment and rate/100 gal applied at 7-day intervals	Stems infected with *Alternaria* (%)	Stem disease severity*	Petioles infected with *Alternaria* (%)	Petiole disease severity
Untreated	77.1 b**	5.0	37.0	3.0 ab
Dithane 75DF 2.0lbs	50.3 ab	3.7	10.7	2.7 ab
Quadris 23EC 15.4 fl oz	34.6 a	2.7	25.6	2.0 a
Endorse 2.5WP 1.1 lbs	73.3 b	3.7	29.3	2.7 ab
Endorse 2.5WP 1.6 lbs	61.2 ab	4.7	26.3	2.3 ab
Endorse 2.5WP 1.1 lbs alt. Dithane 75DF 2.0 lbs	54.2 ab	2.7	35.5	2.0 a
Endorse 2.5WP 1.6 lbs alt. Dithane 75DF 2.0 lbs	60.2 ab	4.0	29.2	3.3 b
Endorse 2.5WP 1.1 lbs alt. Quadris 23EC 15.4 fl oz	62.5 ab	4.7	18.8	3.0 ab
Endorse 2.5WP 1.6 lbs alt. Quadris 23EC 15.4 fl oz	47.6 ab	3.3	19.9	2.7 ab
Dithane 75DF 2.0 lbs alt. Endorse 2.5WP 1.1 lbs alt. Quadris 23EC 15.4 fl oz	49.2 ab	3.3	7.7	2.3 ab

*Stem and petiole rating scale is 1-10, where 1=no lesions, 10=stem/petiole girdled.
**Column means with a letter in common or no letter are not significantly different (LSD, P=0.05).

Evaluation of the biopesticide Endorse to control Alternaria blight on ginseng, 2003.





Screening EcoGuard (710-145f) for Efficacy Against Pathogens of Vegetables

SUMMARY

Several trials were conducted and included the following:

Celery: *Septoria apiicola*
Carrot: *Cercospora carotae*
Alternaria dauci
Onion: *Peronospora destructor*
Pumpkin: *Sphaerotheca fulignea*
Asparagus: *Puccinia asparagi*
Stemphylium vesicarium

Field trials were conducted at the Michigan State University Muck Soils Research Farm in Laingsburg and at the Plant Pathology Farm in East Lansing. The biopesticide EcoGuard was tested against late blight (*Septoria apiicola*) on celery but did not provide significant disease protection compared to the untreated control when used alone. When EcoGuard was alternated with known fungicide standards (i.e. Bravo Ultrex 82.5WDG or Quadris 2.08F), disease control was achieved. Similarly, when EcoGuard was tested against leaf blights on carrot caused by *Cercospora carotae* and *Alternaria dauci*, it was not effective unless it was used in a program with Bravo Ultrex 82.5WDG or Cabrio 20WG. Downy mildew on onion was especially severe in 2003 and EcoGuard did not exhibit good activity either alone or in alternation with Bravo Weather Stik 6SC or Quadris 2.08F. While powdery mildew on pumpkin was not limited by EcoGuard when used alone, a program that included EcoGuard in alternation with Nova 40WP and Flint 50WG was effective in limiting disease. In the asparagus trial, disease was relatively light in 2003 compared with other years. However, the trend indicated that EcoGuard would not likely be of significant benefit in managing diseases on asparagus.

In summary, the trials conducted in Michigan appear to indicate that EcoGuard does not have a good fit in managing the various foliar diseases on the vegetables that were included in these tests. When EcoGuard was used in a program with other products that are known for their efficacy disease was limited. However, based on the disease ratings where EcoGuard was used alone, it appears that this biopesticide is not providing adequate control and may not play a key role if it is used in a program with standard fungicides.

ONION (*Allium cepa* 'Daytona')
Downy mildew; *Peronaspora destructor*

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Evaluation of a biopesticide and fungicides for managing downy mildew of onion, 2003.

This study was conducted at the Michigan State University Muck Soils Research Farm in Laingsburg, MI on a Houghton muck field previously planted to carrots. Onion 'Daytona' seeds were planted on 14 May at a seed spacing of 1.0 in. to rows spaced 18 in. apart on three-row beds centered 64 in. apart. Treatment plots consisted of one bed 22.5 ft long with 5 ft of unsprayed buffer between plots in the same bed. One bed was left unsprayed between every two treatment beds. Fourteen treatments were replicated four times in a randomized complete block design. The field was fertilized with 500 lb/A of 8-21-29 plus micronutrients (0.5% Cu, 1% Mn, and 0.5% Zn) on 1 May, side-dressed with 100 lb/A of 46-0-0 on 27 Jun, and top-dressed with Techmag (6 lb/A) and 28% N (1.5 gal/A) on 27 Jun. Liquid fertilizer (equal parts of 28% N and 8-25-3) was applied at a rate of 20 gal/A beneath the seeds during planting. Insects were controlled with applications of Vydate C-LV (2 pt/A on 19 Jul) and Lannate LV (3 pt/A on 9 Aug). Weeds were controlled with applications of Prowl 3.3EC (2.4 qt/A on 19 May, 5 Jun, and 7 Jul), Dual Magnum (0.75 pt/A on 24 May), Frontier 6.0 (1 qt/A on 19 Jun), and Goal 2XL (3 fl oz/A on 22 Jun and 6 fl oz/A on 30 Jun); supplemental hand weeding was performed as needed. Fungicides were applied with a CO_2 backpack sprayer equipped with three XR8003 flat fan nozzles spaced 18 in. apart and calibrated to deliver 50 gal/A at a nozzle pressure of 52 psi. Eight applications were made at weekly intervals on 17, 24, and 30 Jul; 7, 14, 22, and 28 Aug; and 5 Sep. Disease was assessed using a 1-10 scale (1 = no disease; 10 = compete defoliation) and was evaluated on 14 and 21 Aug, and 11 Sep. Onions in the center row of each treatment bed were hand-harvested on 26 Sep, and the foliage was removed using a mechanical topper. Bulbs were graded and weights of small (< 2 in. diameter), medium (2-3 in. diameter), and large (> 3 in. diameter) were recorded on 9 Oct.

Disease was detected on 7 Aug and advanced slowly through mid-Aug. Disease in the untreated plots progressed rapidly during a 21-day period between 21 Aug and 11 Sep when disease levels increased from 4.0 to 8.5. There were no significant differences in disease levels among treatments on the initial evaluation date (data not presented). On the second observation date, the Bravo Weather Stik 6SC + Rovral 50WG treatment and all treatments that included Manzate 75DF provided significantly better disease control compared with the untreated. At the time of final disease evaluation, all fungicide programs that included Manzate 75DF were most effective in suppressing disease ($\leq$ 4.8) and resulted in significantly better disease control when compared with the untreated. Both the KP 481 50WG + Manzate 75DF alternated with Manzate 75DF and Ridomil Gold MZ 68WP alternated with Manzate 75DF treatments were highly effective in limiting disease to low levels (< 2.8). All treatments, including the biopesticide 710-145f 0.14% w/v, that did not include Manzate 75DF were not effective in controlling disease and were not significantly different from the untreated. When compared to the untreated, three treatments resulted in significantly higher yields and percentages of large (> 3 in.) bulbs and included KP 481 50WG + Manzate 75DF alternated with Manzate 75DF, Manzate 75DF, and Ridomil Gold MZ 68WP alternated with Manzate 75DF.

ONION (*Allium cepa* 'Daytona')
Downy mildew; *Peronaspora destructor*

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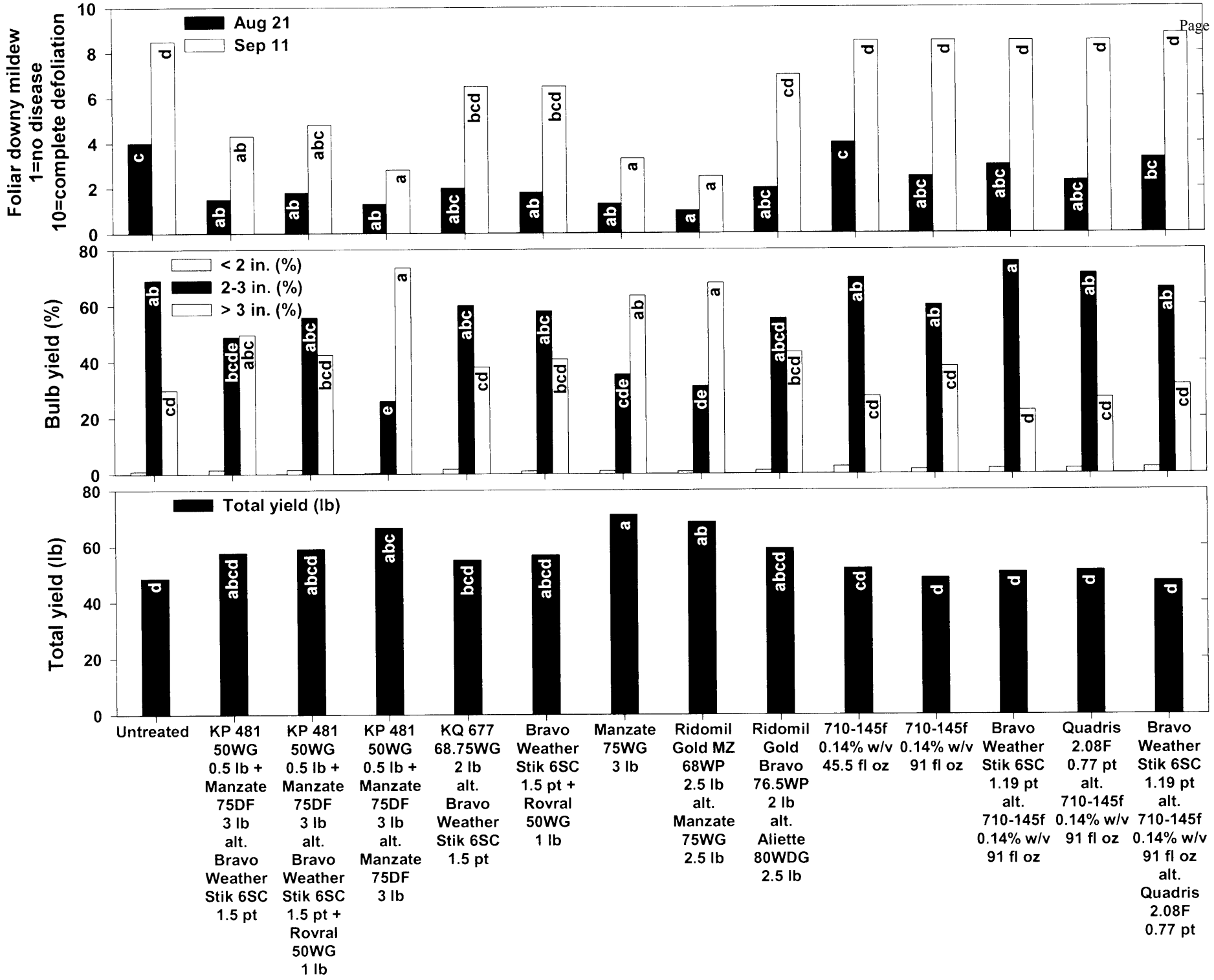
Evaluation of a biopesticide and fungicides for managing downy mildew of onion, 2003.

Treatment and rate/A (application sequence[z])	Foliar downy mildew[y] 8/21	Foliar downy mildew[y] 9/11	Bulb yield < 2 in. (%)	Bulb yield 2-3 in. (%)	Bulb yield > 3 in. (%)	Bulb yield Total (lb)[x]
Untreated	4.0 c[w]	8.5 d	1.0	69.1 ab	29.9 cd	48.5 d
KP 481 50WG 0.5 lb + Manzate 75DF 3 lb (1,3,5,7) Bravo Weather Stik 6SC 1.5 pt (2,4,6,8)	1.5 ab	4.3 ab	1.5	48.9 bcde	49.7 abc	57.6 abcd
KP 481 50WG 0.5 lb + Manzate 75DF 3 lb (1,3,5,7) Bravo Weather Stik 6SC 1.5 pt + Rovral 50WG 1 lb (2,4,6,8)	1.8 ab	4.8 abc	1.5	55.9 abc	42.6 bcd	59.0 abcd
KP 481 50WG 0.5 lb + Manzate 75DF 3 lb (1,3,5,7) Manzate 75DF 3 lb (2,4,6,8)	1.3 ab	2.8 a	0.4	26.0 e	73.6 a	66.6 abc
KQ 677 68.75WG 2 lb (1,3,5,7) Bravo Weather Stik 6SC 1.5 pt (2,4,6,8)	2.0 abc	6.5 bcd	1.7	60.1 abc	38.2 cd	55.0 bcd
Bravo Weather Stik 6SC 1.5 pt + Rovral 50WG 1 lb (1-8)	1.8 ab	6.5 bcd	1.0	58.1 abc	40.9 bcd	56.8 abcd
Manzate 75WG 3 lb (1-8)	1.3 ab	3.3 a	1.0	35.5 cde	63.6 ab	71.2 a
Ridomil Gold MZ 68WP 2.5 lb (1,3,5,7) Manzate 75WG 2.5 lb (2,4,6,8)	1.0 a	2.5 a	0.8	31.3 de	68.0 a	68.6 ab
Ridomil Gold Bravo 76.5WP 2 lb (1,3,5,7) Aliette 80WDG 2.5 lb (2,4,6,8)	2.0 abc	7.0 cd	1.2	55.4 abcd	43.4 bcd	59.0 abcd
710-145f 0.14% w/v 45.5 fl oz (1-8)	4.0 c	8.5 d	2.6	69.8 ab	27.6 cd	52.0 cd
710-145f 0.14% w/v 91 fl oz (1-8)	2.5 abc	8.5 d	1.5	60.2 ab	38.3 cd	48.6 d
Bravo Weather Stik 6SC 1.19 pt (1,3,5,7) 710-145f 0.14% w/v 91 fl oz (2,4,6,8)	3.0 abc	8.5 d	1.8	75.6 a	22.6 d	50.6 d
Quadris 2.08F 0.77 pt (1,3,5,7) 710-145f 0.14% w/v 91 fl oz (2,4,6,8)	2.3 abc	8.5 d	1.8	71.3 ab	27.0 cd	51.2 d
Bravo Weather Stik 6SC 1.19 pt (1,4,7) 710-145f 0.14% w/v 91 fl oz (2,5,8) Quadris 2.08F 0.77 pt (3,6)	3.3 bc	8.8 d	2.1	66.1 ab	31.7 cd	47.3 d

[z] Application sequence: 1 = 17 Jul; 2 = 24 Jul; 3 = 30 Jul; 4 = 7 Aug; 5 = 14 Aug; 6 = 22 Aug; 7 = 28 Aug; 8 = 5 Sep.
[y] Foliar downy mildew evaluated using the following scale: 1 = no disease to 10 = complete defoliation.
[x] Variable could not be transformed to normality.
[w] Means within a column followed by the same letter or no letter are not significantly different according to Tukey's Studentized Range Test (P=0.05).

Downy Mildew of Onion



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Evaluation of a biopesticide to control rust and purple spot on asparagus, 2003.

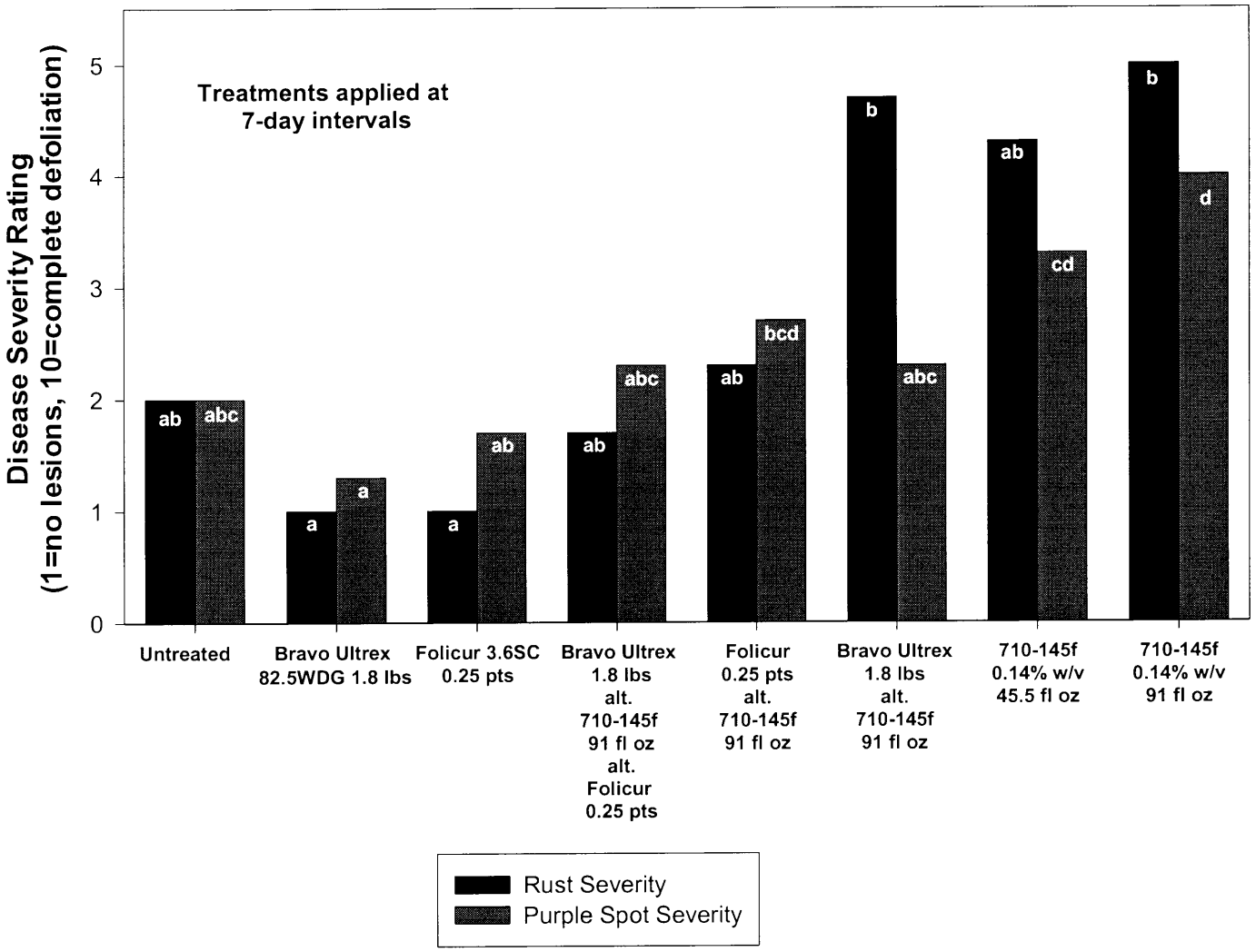
This study was conducted at the Plant Pathology Farm at Michigan State University in an established asparagus field planted in a sandy loam soil. Crowns in each row were spaced 12 inchs apart and rows were spaced 5 ft apart. Treatments consisted of one 20-ft section row with a 5-ft buffer section between treatments in a row. Treatments were replicated four times in a randomized block design. Weeds were controlled with an application of Gromoxone Extra (2.0 qt/Acre) on 30 Apr, Sandea (1.0 oz/A) on 30 Jun and Touchdown (1.0 qt/Acre), Sencor (1.0 lbs/Acre) and Direx (1.5 lbs/Acre) on 23 May. Insects were controlled with an application of Seven XLR (1.0 qt/Acre) on 30 Jun. Fungicide applications were applied 17, 24, 31 Jul, 7, 13 21 Aug, and 3 Sep with a CO_2 backpack boom sprayer equipped with three 1002XR nozzles spaced 19-inchs apart, operating at 50 psi, and calibrated to deliver 50 gal/A. Plots were evaluated for purple spot and rust severity (1=no disease, 10=complete defoliation) on 29 Sep.

Disease pressure in this experiment was moderate with the untreated receiving a disease severity rating of 2.3 for both purple spot and rust. Bravo Ultrex, Folicur, and Bravo Ultrex alternated with the biopesticide 710-145f were the only treatments to limit purple spot to a level less than the untreated (<2.3). When Bravo Ultrex or Folicur were applied every seven days, rust infection was completely prevented. Bravo Ultrex, 710-145f, and Folicur when alternated in a spray program limted rust severity compared to the untreated and received a rating of 1.5. When 710-145f was applied alone, activity against purple spot or rust was not observed. Differences in efficacy between the rates of 710-145f were not apparent.

Treatment and rate/50 gal applied at seven day intervals	Purple spot severity[z]		Rust severity[y]	
	29 Sep		29 Sep	
Untreated	2.3	abc	2.3	ab
Bravo Ultrex 82.5WDG 1.8 lbs	1.3	a	1.0	a
Folicur 3.6SC 0.25 pts	1.8	ab	1.0	a
710-145f 0.14%w/v 45.5 fl oz	3.3	cd	3.5	ab
710-145f 0.14%w/v 91.0 fl oz	4.0	d	4.0	b
Bravo Ultrex 82.5WDG 1.80 lbs alt. 710-145f 0.14%w/v 91.0 fl oz	2.0	abc	4.0	b
Folicur 3.6SC 0.25 pts alt. 710-145f 0.14%w/v 91.0 fl oz	2.8	bcd	2.0	ab
Bravo Ultrex 82.5WDG 1.8 lbs alt. 710-145f 0.14% 91.0 fl oz alt. Folicur 3.6SC 0.25 pts	2.3	abc	1.5	ab

[z]Purple spot severity scale is 1-10, where 1=no disease, 10=complete defoliation.
[y]Rust severity scale is 1-10, where 1=no disease, 10=complete defoliation.
[x]Column means with a letter in common are not significantly different (LSD; P=0.05).

Evaluation of a biopesticide to control rust and purple spot on asparagus, 2003.



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Evaluation of a biopesticide and fungicides for managing late blight of celery, 2003.

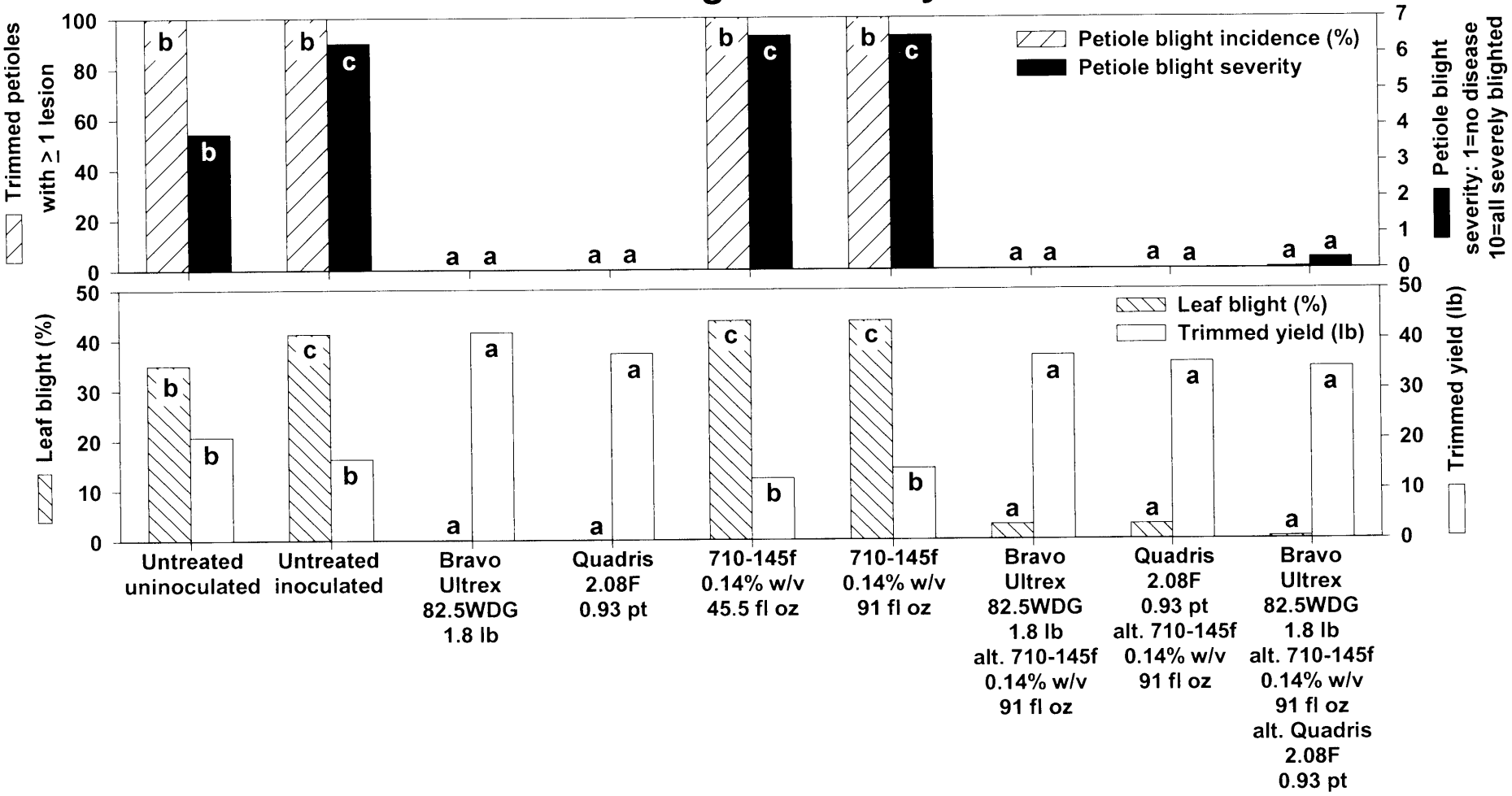
This study was conducted at the Michigan State University Muck Soils Research Farm in Laingsburg, MI on a Houghton muck field previously planted to potato. Celery 'Dutchess' transplants were planted 7.0 in. apart in rows spaced 32 in. apart on 29 May. Treatment plots consisted of one row 22.5 ft long with 5 ft of unsprayed buffer between plots in the same row. Two buffer rows were left unsprayed between each treatment row. Nine treatments were replicated four times in a randomized complete block design. The field was fertilized with applications of 8-21-29 (400 lb/A on 22 May) plus micronutrients (0.5% Cu, 1% Mn, and 0.5% Zn), 0-0-62 (400 lb/A on 22 May), 46-0-0 (100 lb/A on 23 Jun), Tech Mag (4 lb/A on 2 Jul), and calcium nitrate (10 lb/A on 14 Jul). Insects were controlled with applications of Sevin XLR Plus (0.5 qt/A on 2 Jul), Sevin 80S (1.5 lb/A on 14 Jul), Vydate C-LV (4 pt/A on 19 Jul), and Lannate LV (3 pt/A on 9 Aug). Weeds were controlled with applications of Lorox 50DF (2 lb on 16 Jun) and Caparol 4L (1 qt on 8 Jul); supplemental hand weeding was performed as needed. *Septoria* inoculum (1 x 10^6 spores/ml) was prepared by soaking dried infected celery leaves for 10 min in water and straining through two layers of cheesecloth. Unsprayed buffer rows were inoculated 30 Jul, and all rows except the untreated uninoculated plots were inoculated on 8 Aug. Inoculum was applied with a hand-pump backpack sprayer using one hollow cone nozzle that delivered 12 gal/A. Fungicides were applied with a CO_2 backpack sprayer equipped with three XR8003 flat fan nozzles spaced 18 in. apart and calibrated to deliver 50 gal/A at a nozzle pressure of 52 psi. Seven applications were made at weekly intervals on 18 and 30 Jul; 8, 15, 22, and 29 Aug; and 5 Sep. Leaf blight severity was evaluated and ten plants from the middle of each treatment row were hand-harvested and trimmed to fresh market specifications (14 in. length) on 11 Sep. Petiole disease incidence and severity were assessed, diseased petioles were removed from the plants, and yields were recorded. No phytotoxicity was observed for any of the treatments.

Disease symptoms appeared in inoculated buffer rows on 15 Aug. Leaf blight severity of the uninoculated untreated plants at harvest was 35%, indicating substantial disease spread. The incidence of petiole blight in both the untreated and 710-145f 0.14% w/v only treatments was 100%. All treatments with Bravo Ultrex 82.5WDG or Quadris 2.08F provided excellent disease control and significantly reduced disease on petioles and leaves and increased marketable yield when compared with the untreated or 710-145f 0.14% w/v only treatments.

Treatment and rate/A (application sequence[z])	Petiole blight		Leaf blight (%)[w]	Trimmed yield (lb)[v]
	Incidence (%)[y]	Severity[x]		
Untreated uninoculated	100.0 b[u]	3.8 b	35.0 b	20.7 b
Untreated inoculated	100.0 b	6.3 c	41.3 c	16.3 b
Bravo Ultrex 82.5WDG 1.8 lb (1-7)	0.0 a	0.0 a	0.0 a	41.6 a
Quadris 2.08F 0.93 pt (1-7)	0.0 a	0.0 a	0.0 a	37.3 a
710-145f 0.14% w/v 45.5 fl oz (1-7)	100.0 b	6.5 c	43.8 c	12.3 b
710-145f 0.14% w/v 91 fl oz (1-7)	100.0 b	6.5 c	43.8 c	14.3 b
Bravo Ultrex 82.5WDG 1.8 lb (1,3,5,7) 710-145f 0.14% w/v 91 fl oz (2,4,6)	0.0 a	0.0 a	3.0 a	36.8 a
Quadris 2.08F 0.93 pt (1,3,5,7) 710-145f 0.14% w/v 91 fl oz (2,4,6)	0.0 a	0.0 a	3.0 a	35.4 a
Bravo Ultrex 82.5WDG 1.8 lb (1,4,7) 710-145f 0.14% w/v 91 fl oz (2,5) Quadris 2.08F 0.93 pt (3,6)	0.5 a	0.3 a	0.5 a	34.4 a

[z] Application sequence: 1 = 18 Jul; 2 = 30 Jul; 3 = 8 Aug; 4 = 15 Aug; 5 = 22 Aug; 6 = 29 Aug; 7 = 5 Sep.
[y] Percentage of trimmed plants with at least one petiole lesion. Variable could not be transformed to normality.
[x] Severity of petiole blight evaluated using a 1-10 scale where 1 = no disease to 10 = all petioles severely blighted.
[w] Evaluated using a leaf blight assessment key representing the percentage of diseased foliage.
[v] Ten plants from the center of each plot were hand-harvested, trimmed to 14 in. length, and stripped of diseased petioles prior to weighing.
[u] Means within a column followed by the same letter are not significantly different according to Tukey's Studentized Range Test (P=0.05).

Late Blight of Celery



CARROT (*Daucus carota* 'Bolero')
Cercospora blight; *Cercospora carotae*
Alternaria blight; *Alternaria dauci*

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Evaluation of a biopesticide and fungicides for managing Cercospora and Alternaria blights of carrot, 2003.

This study was conducted at the Michigan State University Muck Soils Research Farm in Laingsburg, MI on a Houghton muck field previously planted to carrot. 'Bolero' carrot seeds were planted at a density of 22.8 seeds/ft of row on 19 May in three seed lines per row with rows centered 18 in. apart on three-row beds centered 64 in. apart. Treatment plots consisted of one row 15 ft long with 2.5 ft of unsprayed buffer between plots in the same row. Eight treatments were replicated four times in a randomized complete block design. The field was fertilized with applications of 8-21-29 (500 lb/A on 1 May) plus micronutrients (0.5% Cu, 1% Mn, and 0.5% Zn) and top-dressed with chelates (4% Zn, 1% Cu, 1% Mn, and 1% Mg at 2 qt/A on 9 Aug). Insects were controlled with applications of Sevin 80S (1.25 lb/A on 9 Jul), Vydate C-LV (4 pt/A on 19 Jul) and Lannate LV (3 pt/A on 9 Aug). Weeds were controlled with applications of Lorox 50DF (2 lb on 27 May; 1 lb on 19 Jun; 1.5 lb on 7 Jul) and Poast (1.5 pt on 4 Aug) mixed with 1 qt crop oil; supplemental hand weeding was performed as needed. Fungicides were applied with a CO_2 backpack sprayer equipped with three XR8003 flat fan nozzles spaced 18 in. apart and calibrated to deliver 50 gal/A at a nozzle pressure of 55 psi. Nine applications were made at weekly intervals on 17 and 28 Jul; 4, 11, 18, and 25 Aug; and 2, 9, and 16 Sep. Disease assessments were recorded from plants in the center 10 ft of the middle row of each plot on 25 Sep. Carrots in the center 10 ft of the middle row were hand-harvested, the foliage was removed with a mechanical topper, and root yields were recorded on 26 Sep. No phytotoxicity was observed for any of the treatments.

Cercospora and Alternaria blight symptoms were detected during mid-Jul and mid-Aug, respectively. Leaving plots untreated resulted in 17.5% leaf blight and nearly all plants had petiole lesions. Treatment programs that included Bravo Ultrex 82.5 WDG or Cabrio 20WG were highly effective in limiting disease on leaves and petioles and resulted in significantly healthier petioles ($\leq$ 3.3) when compared with the untreated (6.8) or 710-145f 0.14% w/v ($\geq$ 6.8) treatments. Treatments of 710-145f 0.14% w/v applied at 45.5 or 91 fl oz/A did not limit disease on leaves or petioles and did not differ from the untreated control. Cabrio 20WG applied alone resulted in a significantly higher yield when compared with the 710-145f 0.14% w/v 45.5 fl oz/A treatment.

Treatment and rate/A (application sequence[z])	Petiole blight		Petiole health[w]	Leaf blight (%)[v]	Yield (lb)
	Incidence (%)[y]	Severity[x]			
Untreated	98.5 b[u]	3.8 b	6.8 b	17.5 b	27.5 ab
Bravo Ultrex 82.5WDG 1.8 lb (1-9)	5.3 a	2.0 a	2.8 a	1.0 a	32.8 ab
Cabrio 20WG 0.5 lb (1-9)	4.3 a	2.0 a	3.0 a	1.0 a	33.7 a
710-145f 0.14% w/v 45.5 fl oz (1-9)	100.0 b	3.5 b	6.8 b	17.5 b	25.1 b
710-145f 0.14% w/v 91 fl oz (1-9)	100.0 b	3.8 b	7.0 b	17.5 b	25.8 ab
Bravo Ultrex 82.5WDG 1.8 lb (1,3,5,7,9) 710-145f 0.14% w/v 91 fl oz (2,4,6,8)	10.2 a	2.0 a	3.3 a	1.0 a	31.7 ab
Cabrio 20WG 0.5 lb (1,3,5,7,9) 710-145f 0.14% w/v 91 fl oz (2,4,6,8)	6.0 a	2.0 a	2.8 a	1.0 a	30.8 ab
Bravo Ultrex 82.5WDG 1.8 lb (1,4,7) 710-145f 0.14% w/v 91 fl oz (2,5,8) Cabrio 20WG 0.5 lb (3,6,9)	5.3 a	2.0 a	2.8 a	1.0 a	31.4 ab

[z] Application sequence: 1 = 17 Jul; 2 = 28 Jul; 3 = 4 Aug; 4 = 11 Aug; 5 = 18 Aug; 6 = 25 Aug; 7 = 2 Sep; 8 = 9 Sep; 9 = 16 Sep.

[y] Percentage of plants from 10 ft of the center row with at least one petiole lesion.

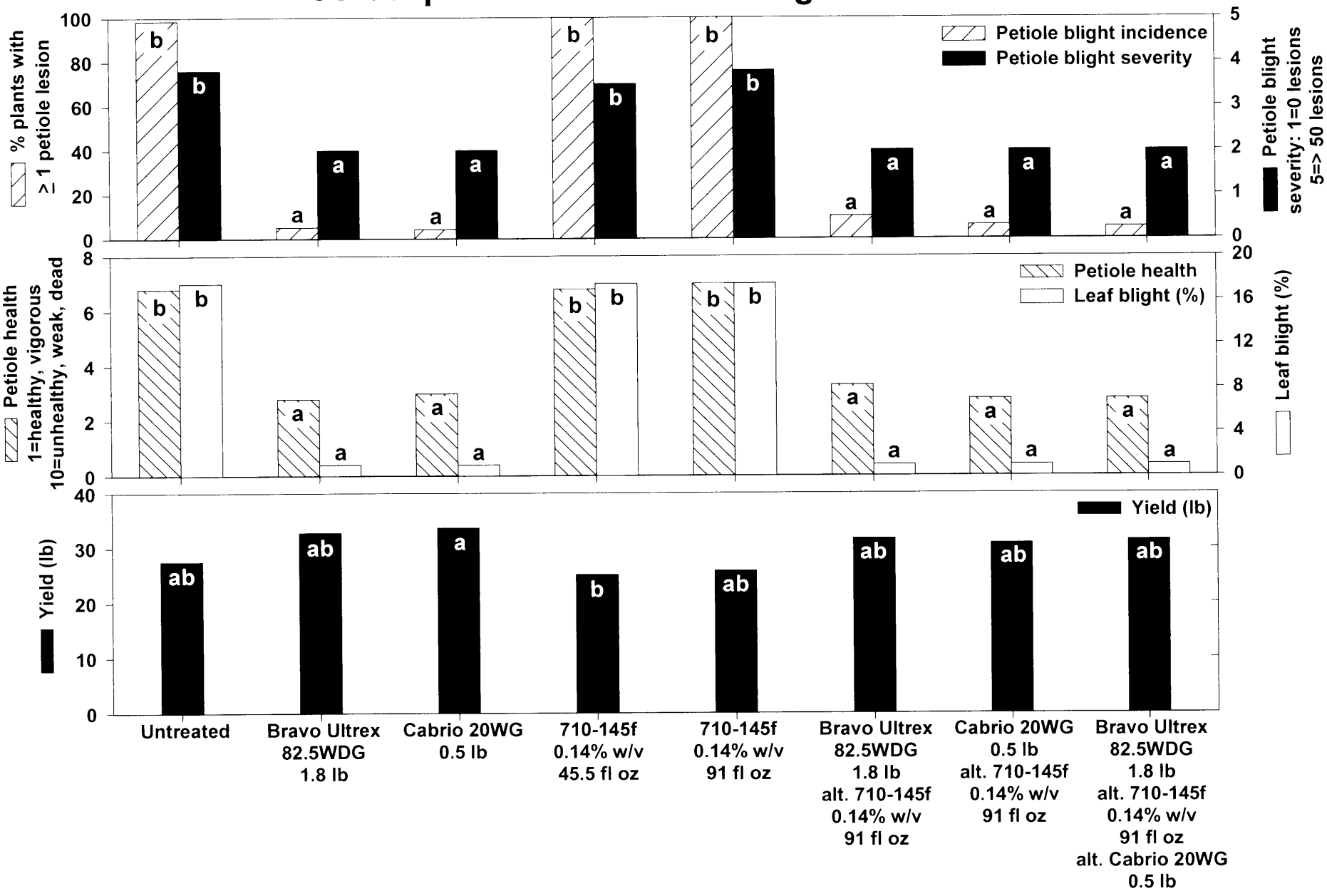
[x] Severity of petiole blight rated on a 1 to 5 scale; where 1 = 0 petiole lesions per plant, 2 = 1-10, 3 = 11-21, 4 = 21-50, and 5 = > 50. Variable could not be transformed to normality.

[w] Petiole health rated on a 1 to 10 scale; where 1 = healthy and vigorous to 10 = unhealthy, weak, or dead.

[v] Evaluated using a leaf blight assessment key representing the percentage of disease foliage. Variable could not be transformed to normality.

[u] Means within a column followed by the same letter are not significantly different according to Tukey's Studentized Range Test (P=0.05).

Cercospora and Alternaria Blights of Carrot



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Evaluation of a biopesticide and fungicides for managing powdery mildew of pumpkin, 2003.

This study was conducted at the Plant Pathology Farm of Michigan State University on a clay loam soil that was previously planted to pumpkins and cucurbits. The field was chisel plowed and field cultivated on 20 May. Twenty-seven raised beds, 1.5 mil black-plastic mulch and drip-irrigation tube, were formed on 22 May. The drip tube had an emitter spacing of 12 in. and delivered 0.25 gal/min per 100 ft of tube. Raised beds were spaced 12 ft apart and were 6 in. height and 24 in wide at the top. Fertilizer was incorporated at the time of bed formation (600 lbs 6-24-24 and 400 lbs 46-0-0). Planting holes were punched in the tops of the beds using a water wheel with a hole spacing of 24 in. on 10 Jul. 'Aspen' pumpkin seeds were hand planted 1 in. deep in each hole on 19 Jun. Treatments were replicated four times and arranged in a randomized block design. Insects were controlled with an application of Asana (10.6 fl oz/Acre) on 5 Jul through the drip tubes. Weeds were controlled with an application of Gramoxone Extra (45.0 fl oz/Acre). The plot received applications of 20-20-20 through the drip tube weekly. Plots were irrigated four hours three times per week. Fungicide applications were applied 22, 30 Jul and 6, 13, 20, 25 Aug using a CO_2 backpack sprayer with four 11002 nozzles spaced 19 in. apart. The sprayer was operated at 50 psi and delivered 50 gal/A. Plots were evaluated for foliar powdery mildew infection (% of foliage infected) and disease severity (1=no disease, 10=complete defoliation) was recorded on 18, 28 Aug. A handle quality rating (1=healthy, 10=rotted) was taken on 28 Aug.

Disease pressure was severe in this trial with the untreated control having 98.8% of the foliage infected with powdery mildew on the last rating date. Treatments that included Pristine in alternation with Bravo Ultrex and/or Nova were very effective and the only treatments to limit foliar infection to <25%. Additional treatments were also effective and limited foliar infection to <50% and included Bravo Weather Stik alternated with either Microthiol Disperss, Flint, or Nova. Disease was also limited by Cabrio alternated with either Bravo Ultrex alone or Bravo Ultrex + Nova. All other treatments with the exceptions of Captan, Endorse, 710-145f, and Nova or Flint alternated with 710-145f significantly reduced infection compared to the untreated control. Only Cabrio alternated with Nova + Bravo Ultrex (2.0) received a disease severity rating (1=no disease, 10=complete defoliation) significantly better than the untreated control (4.5). Treatments that included Pristine, Cabrio alternated with Nova, and Nova alternated with 710-145f and Flint limited disease severity to <3.0. Since pumpkin handles are important to the fresh market, treatments were evaluated for their ability to keep the handles healthy. Although no treatments were significantly better than the untreated control (handle rating of 9.0), Pristine alternated with Bravo and/or Nova and Cabrio alternated with Nova reduced handle rot severity to <5.0. No phytotoxicity was observed by any treatment in this trial.

PUMPKIN (*Curcurita Pepo* var. *Pepo* 'Aspen')
Powdery Mildew; *Sphaerotheca fulignea*

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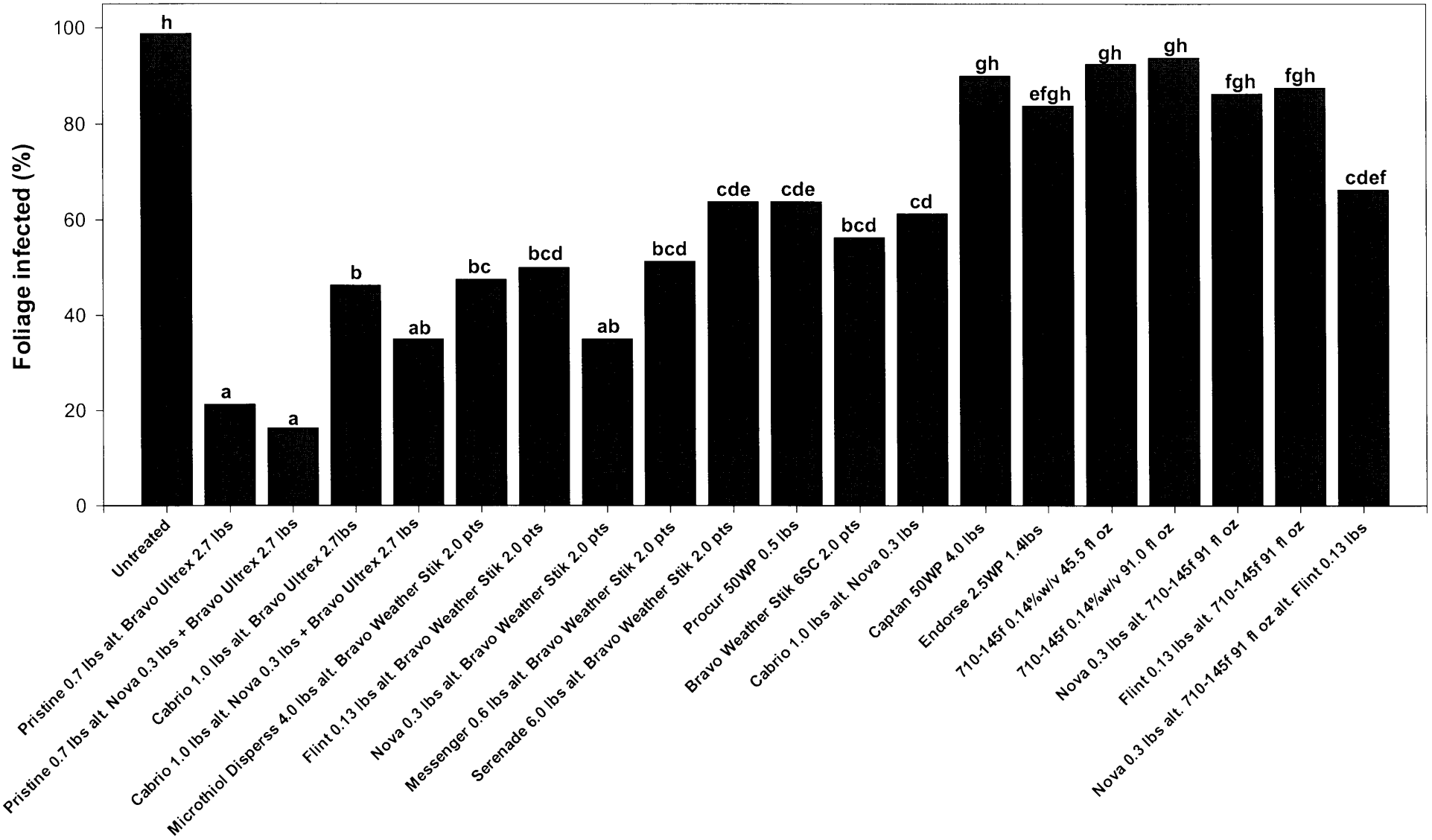
Evaluation of a biopesticide and fungicides for managing powdery mildew of pumpkin, 2003.

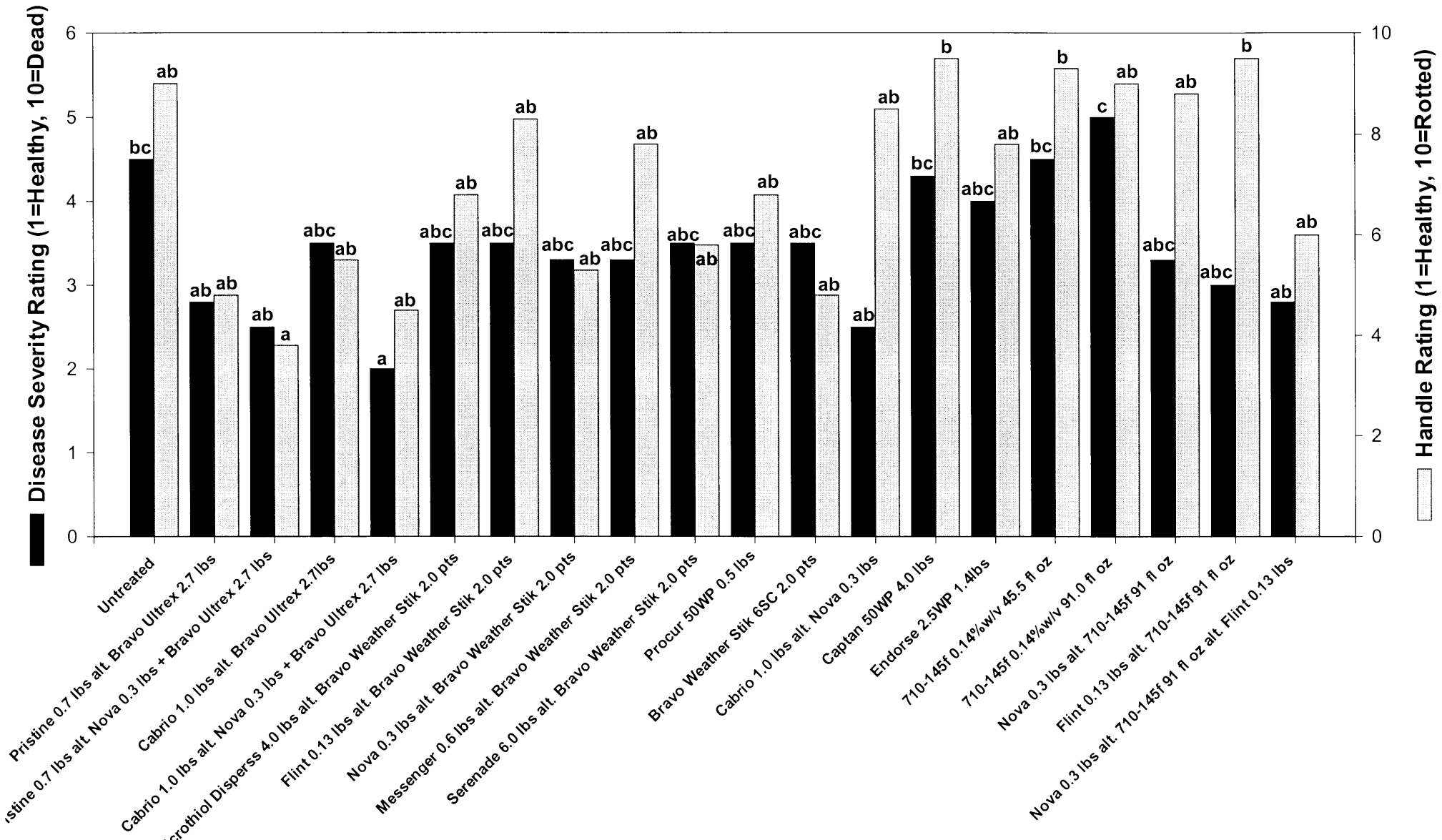
Treatment and rate/50 gal applied at 7 day intervals	Foliage infected (%)		Disease severity rating[z]		Handle rating[y]
	18-Aug	28-Aug	18-Aug	28-Aug	28-Aug
Untreated	55.0 d[x]	98.8 h	2.3	4.5 bc	9.0 ab
Pristine 38WG 0.7 lbs alt. Bravo Ultrex 82.5WDG 2.7 lbs	25.0 ab	21.3 a	2.5	2.8 ab	4.8 ab
Pristine 38WG 0.7 lbs alt. Nova 40WP 0.3 lbs +Bravo Ultrex 82.5WDG 2.7 lbs	22.5 a	16.3 a	2.0	2.5 ab	3.8 a
Cabrio 20WG 1.0 lbs alt. Bravo Ultrex 82.5WDG 2.7 lbs	27.5 ab	46.3 b	2.5	3.5 abc	5.5 ab
Cabrio 20WG 1.0 lbs alt. Nova 40WP 0.3 lbs +Bravo Ultrex 82.5WDG 2.7 lbs	22.5 a	35.0 ab	2.0	2.0 a	4.5 ab
Microthiol Disperss 80WG 4.0 lbs alt. Bravo Weather Stik 6SC 2.0 pts	26.7 ab	47.5 bc	2.5	3.5 abc	6.8 ab
Flint 50WG 0.13 lbs alt. Bravo Weather Stik 6SC 2.0 pts	30.0 ab	50.0 bcd	2.8	3.5 abc	8.3 ab
Nova 40WP 0.3 lbs alt. Bravo Weather Stik 6SC 2.0 pts	30.0 ab	35.0 ab	3.0	3.3 abc	5.3 ab
Messenger 3WDG 0.6 lbs alt. Bravo Weather Stik 6SC 2.0 pts	30.0 ab	51.3 bcd	2.3	3.3 abc	7.8 ab
Serenade 10WP 6.0 lbs alt. Bravo Weather Stik 6SC 2.0 pts	35.0 abc	63.8 cde	3.0	3.5 abc	5.8 ab
Procur 50WP 0.5 lbs	40.0 abcd	63.8 cde	2.5	3.5 abc	6.8 ab
Bravo Weather Stik 6SC 2.0 pts	25.0 ab	56.3 bcd	2.0	3.5 abc	4.8 ab
Cabrio 20WG 1.0 lbs alt. Nova 40WP 0.3 lbs	25.0 ab	61.3 cd	2.5	2.5 ab	8.5 ab
Captan 50WP 4.0 lbs	45.0 bcd	90.0 gh	2.5	4.3 bc	9.5 b
Endorse 2.5WP 1.4 lbs	40.0 abcd	83.8 efgh	2.8	4.0 abc	7.8 ab
710-145f 0.14%w/v 45.5 fl oz	50.0 cd	92.5 gh	2.3	4.5 bc	9.3 b
710-145f 0.14%w/v 91.0 fl oz	53.3 d	93.8 gh	2.8	5.0 c	9.0 ab
Nova 40WP 0.3 lbs alt. 710-145f 0.14%w/v 91.0 fl oz	42.5 abcd	86.3 fgh	1.8	3.3 abc	8.8 ab
Flint 50WG 0.13 lbs alt. 710-145f 0.14%w/v 91.0 fl oz	35.0 abc	87.5 fgh	2.3	3.0 abc	9.5 b
Nova 40WP 0.3 lbs alt. 710-145f 0.14%w/v 91.0 fl oz alt. Flint 50WG 0.13 lbs	30.0 ab	66.3 cdef	3.3	2.8 ab	6.0 ab

[z]Disease severity rating scale is 1-10, where 1=no disease and 10=complete defoliation.
[y]Handle rating scale is 1-10, where 1=healthy, 10=rotted.
[x]Column means with letter in common or no letter are not significantly different (SNK, P=0.05).

Evaluation of fungicides and biopesticides for managing powdery mildew on pumpkin, 2003.



Evaluation of fungicides and biopesticides for managing powdery mildew on pumpkin, 2003.



Progress Report – Field Data 2003

Bio-Nematicides for Management of Nematodes in Grapes

by **Ekaterini Riga[1], and Harold Collins[2]**

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Work performed during 2003 field season:

The effect of LCF, SLS, Castor Oil, Dominator and DiTera on their own and in combination with Nemacur on plant parasitic nematodes of grapes and free-living nematodes was assessed in field trials. The following nematodes were present in this particular field used: beneficial free-living nematodes, and *Meloidogyne hapla* (the root-knot nematode), *Xiphinema* spp. (the dagger nematode – a virus vector), and *Pratylenchus penetrans* (the lesion nematode). Each of the bio-nematicidal treatments was applied according to Table 1. The synthetic nematicide, Nemacur was applied using the conventional rates given in Table 1. In addition, Nemacur was applied in combination with all of the above bio-nematicides at half of the recommended rate. Controls consisted of plots that received no treatments. Sampling of plant parasitic and free-living nematodes took place three times: spring (pre-treatment, PS), mid-season (MS) and harvest (H). Sampling consisted of ten cores from the top 12 inches of soil collected randomly from each field plot. Nematodes were extracted from the soil using the elutriator. Each field plot consisted of 8.5 x 25 feet, i.e. 3 potato rows. Each treatment was repeated 5 times.

Detailed information of the above field trials can be found in the 2003 submitted proposal titled: "Bio-Nematicides for Management of Nematodes in Grapes"

Table 1. Application rates of bio-nematicides, and synthetic nematicides

Treatment	Grapes
Dominator[1]	2 quarts / acre
SLS/CA Enhanced Nematicide[2]	1 quart / acre at 1% solution
Castor Oil Nematicide with Surfactants[3]	1 quart / acre at 1% solution
Liquid Compost Factor[4](LCF)	1 quart / acre at 1:500 dilution (LCF:water) – 2 applications
DiTera®[5]	25 and 50 pounds / acre
Nemacur[6]	1 gallon/ acre, 2 applications

[1] Dominator will be applied in the field just prior to root flush

[2] SLS/CA Enhanced Nematicide will be applied in the field just prior to root flush

[3] Castor Oil Nematicide with Surfactants will be applied in the field just prior to root flush

[4] LCF will be applied as soil drench (6 inch soil drench) at bud break and at flowering

[5] DiTera® ES will be applied via drip irrigation at root flush

[6] Two applications of Nemacur will be applied via drip, first at bud break, and the second 30 days later

Results – 2003 field season:
Nematode and yield data is presented below, except the pruning weight data which will be collected in February 2004. All plant parasitic and free-living nematode data from pre-season (PS), mid-season (MS) and harvest (H) is presented in Figure 1, 2, 3 and 4. Figure 5 contains the berry yield data.
None of the treatments in Fig. 1 are significantly different than the control, in terms of increasing the numbers of the free-living nematodes. However, Castor oil significantly increased the numbers of free-living nematodes in both mid-season and harvest periods in comparison to Nemacur. Similarly, LCF mid-season, and Dominator mid-season increased the numbers of the free-living nematodes in comparison to Nemacur.
There was a significant reduction of the numbers of *M. hapla,* the root-knot nematode, when it was treated with LCF+Nemacur, and DiTera+Nemacur in comparison to Nemacur (Fig. 2). Castor Oil and LCF performed well till mid-seasons but did not provide control in the end fop the season (Fig. 2). SLS provided similar control as Nemacur (Fig. 2).
In the end of the season, LCF, LCF+Nemacur, SLS+Nemacur, Castor Oil+Nemacur, Dominator+Nemacur provided the same control against *P. penetrans,* the lesion nematode, as Nemacur (Fig. 3). Castor Oil and DiTera+Nemacur provided good control at mid-season (Fig. 3).
All treatments provided the same control as Nemacur at mid-season against the dagger nematode, *Xiphinema* spp. (Fig.4). However, Dominator, Dominator+Nemacur, and DiTera provided all season control against the dagger nematode (Fig. 4).
Fig. 5 shows the berry yield for all trials. None of the treatments have had a significant increase in berry yield in comparison to the control. However, the trends show that LCF+Nemacur, Castor Oil+Nemacur, Dominator and DiTera have increased berry yield in comparison to the control. However, perennials respond slowly to treatments (Fig. 5).

Conclusion: In the first field season the bio-nematicides on their own and in combination with Nemacur have provided encouraging results. Often perennials need more than one season to show significant responses to treatments, especially to bio-nematicides. Therefore, this field trial needs to be repeated. The pruning weight which will be collected in February will add more information to this trial.

Figure 1. The effect of Organic and/or Synthetic Nematicides on Free-living, soil beneficial nematodes – 2003 Grape Field data

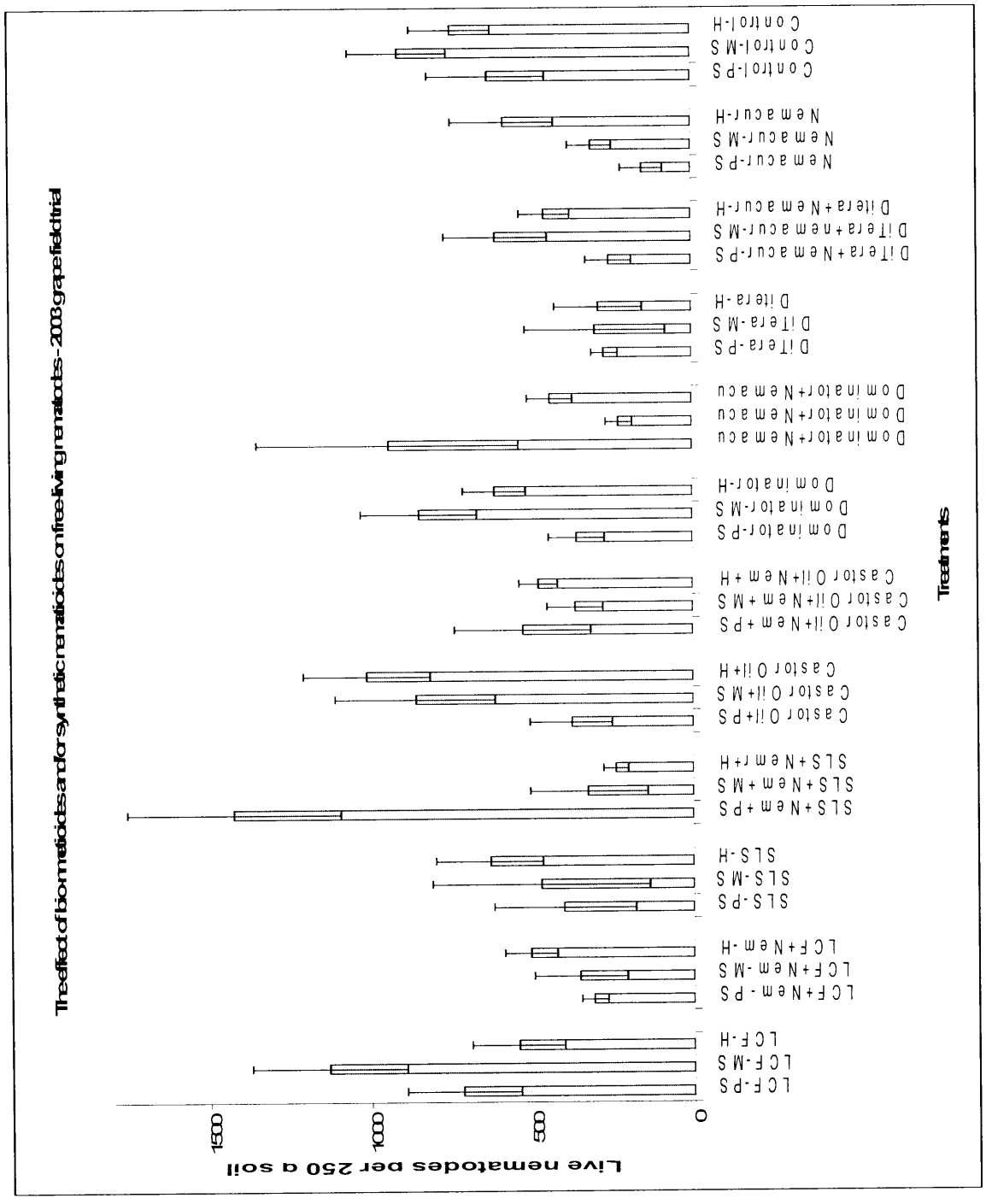


Figure 2. The effect of Organic and/or Synthetic Nematicides on *Meloidogyne hapla*, the root-knot nematode – 2003 Grape Field data

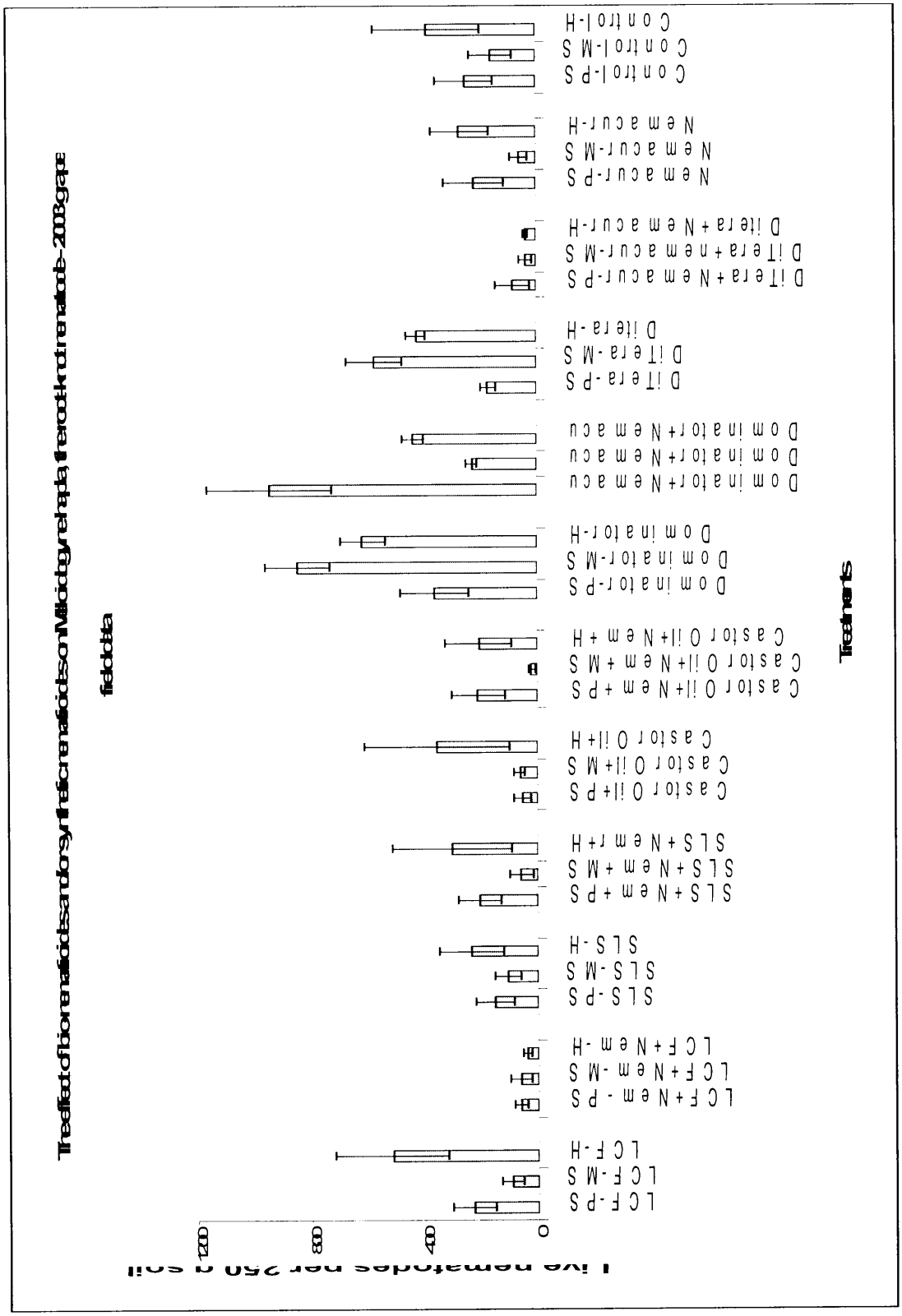


Figure 3. The effect of Organic and/or Synthetic Nematicides on *Pratylenchus penetrans*, the lesion nematode – 2003 Grape Field data

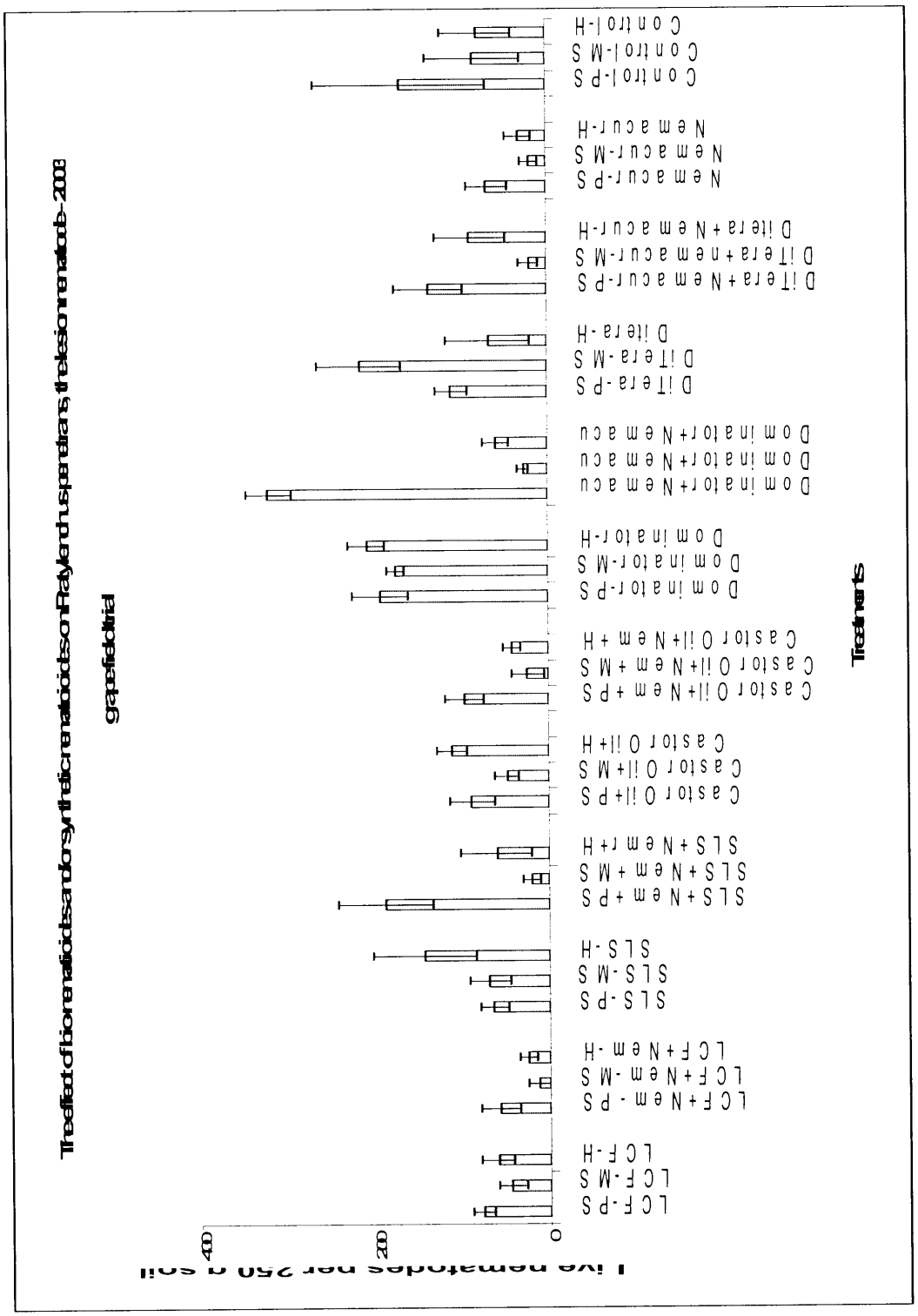


Figure 4. The effect of Organic and/or Synthetic Nematicides on *Xiphinema* spp., the dagger nematode – 2003 Grape Field data

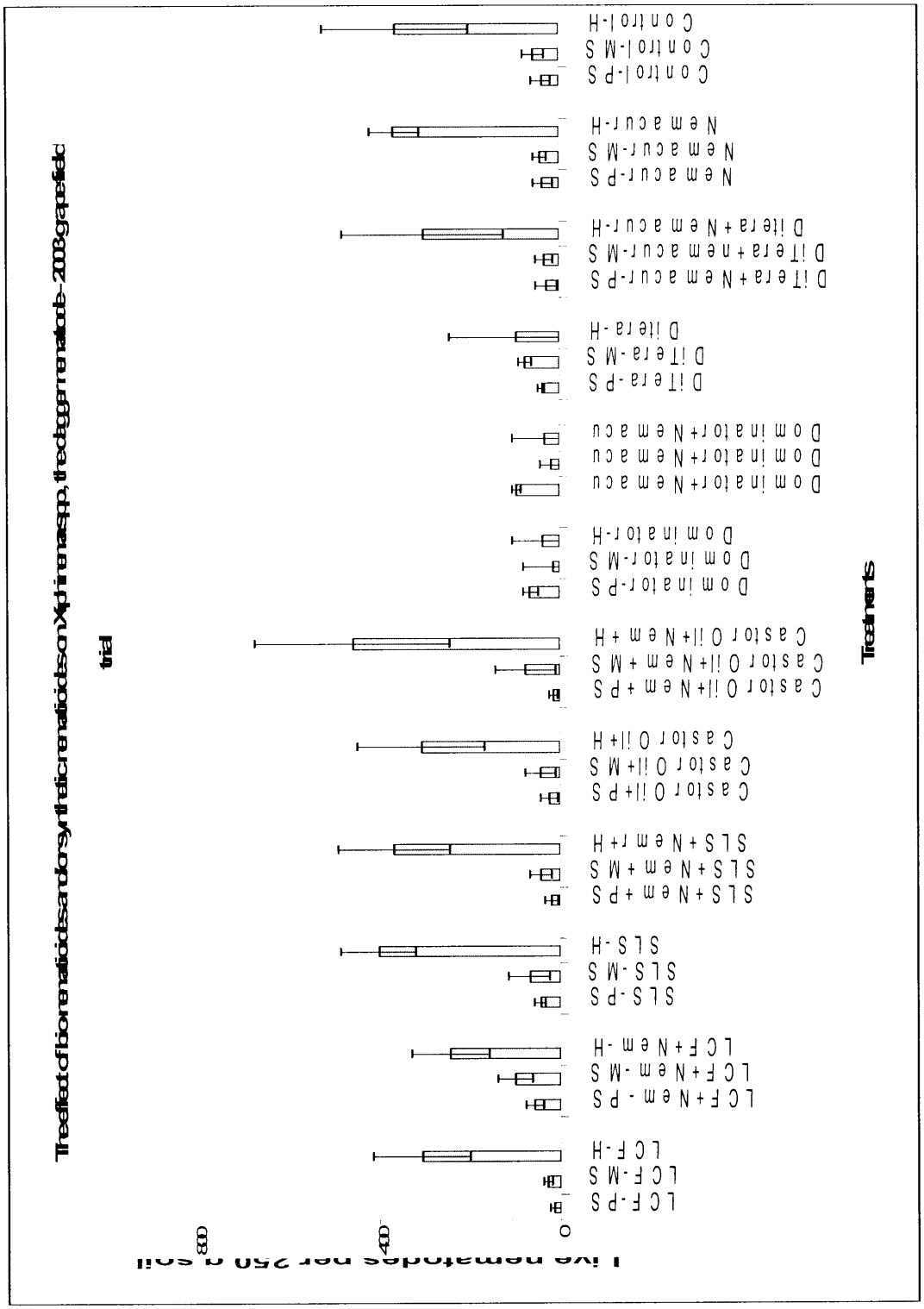
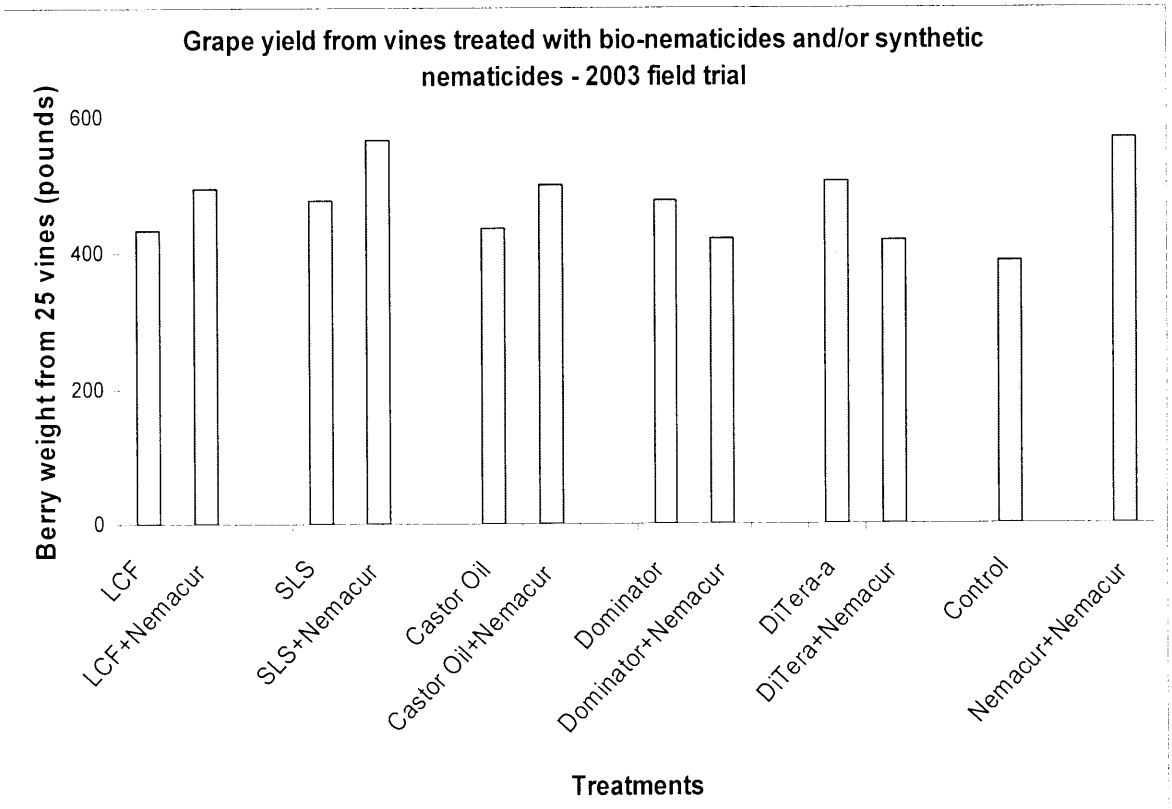


Figure 5. Berry yields from grapevines treated with bio-nematicides and/or organic nematicides – 2003 grape field trial



2002 - 2003 Easter Lily Research Trial (Dr. Westerdahl) **(Visual Ratings)**

REATMEN	SOIL TREATMENTS		Visaul Rating of Foliage		Bulb
NUMBER	Preplant	In Furrow	Midseason	At Harvest	Survival
1	**METAM**	**THIMET 8**	**5.0 ab**	**4.7 ab**	**76.0 bc**
2	**METAM**	**THIMET 6**	**4.7 a**	**3.3 a**	**72.0 a**
3	METAM	NONE	6.0 abc	5.0 abc	73.0 ab
6	**NONE**	**NONE**	**5.7 ab**	**6.0 bcd**	**72.7 ab**
7	TELONE	NEMACUR	7.7 cd	8.0 de	73.3 ab
15	METAM	DITERA	6.0 abc	6.3 bcde	74.7 abc
16	METAM	TERA SPLIT	6.7 bc	5.7 abcc	73.0 ab
25	UNIROYAL 1	THIMET	5.7 ab	4.3 ab	72.0 a
26	UNIROYAL 1	NONE	6.3 abc	7.3 cde	74.0 ab
27	UNIROYAL 2	THIMET	5.3 ab	5.0 abc	73.7 ab
28	UNIROYAL 2	NONE	6.7 bc	8.0 de	74.0 ab
29	METAM	INIROYAL1	6.0 abc	5.3 abc	73.3 ab
30	METAM	INIROYAL2	5.7 ab	6.0 bcde	73.7 ab
38	**METAM**	**ILLAJA 35%**	**6.7 bc**	**6.0 bcd**	**74.0 ab**

TOMATO TRIALS - 2003

STATE: CALIFORNIA

2003 Quillaja Tomato Trial (Dr. Westerdahl)

	Treatment	At Harvest (Yield per 5 Plts) Plant Weight	Red Fruit Weight	At Harvest (Average) Nematode Gall Ratings
1	**UNTREATED**	**10.02 ab**	**8.08 ab**	**7 a**
2	QUILLAJA 1.25GPA	10.35 ab	7.10 a	6 a
3	**QUILLAJA 2.5GPA**	**11.41 ab**	**9.73 ab**	**5 a**
4	MEADOWFOAM	13.42 ab	10.57 ab	7 a
5	**QUILLAJA 1.25 PLUS MEADOWFOAM**	**15.92 b**	**12.91 b**	**6 a**
6	NEEM CAKE 600LB	11.03 ab	8.93 ab	6 a
7	DITERA 50LB	11.99 ab	8.83 ab	5 a
8	TELONEII 9GPA	8.80 a	6.96 a	1 b

* Transplanted Processing Tomatoes = UC 82

Each figure is the mean of 5 replicates.
Means not followed by the same letter are not signficantly differen from each other (P=0.10)
significantly different from each other (P = 0.10)
according to Fisher's Protected Least Significant Difference Test

2003 Quillaja Tomato Trial (Dr. Westerdahl)

	Treatment	At Harvest (Yield per 5 Plts) Plant Weight	Red Fruit Weight
1	UNTREATED	**10.02 ab**	**8.08 ab**
2	QUILLAJA 1.25GPA	10.35 ab	7.10 a
3	QUILLAJA 2.5GPA	**11.41 ab**	**9.73 ab**
4	MEADOWFOAM (MSM)	13.42 ab	10.57 ab
5	QUILLAJA 1.25 + (MSM)	**15.92 b**	**12.91 b**
6	NEEM CAKE 600LB	11.03 ab	8.93 ab
7	DITERA 50LB	11.99 ab	8.83 ab
8	TELONEII 9GPA	8.80 a	6.96 a

* Transplanted Processing Tomatoes = UC 82

2002 - 2003 Easter Lily Research Trial.

TREATMENT	SOIL TREATMENTS		BULBLET TREATMENTS	Bulblets		Visaul Rating of Foliage	
NUMBER	Preplant	In Furrow	Additive/Ozone	Number	Weight (gr)	Midseason	At Harvest
1	METAM	THIMET 8	NONE	8.7 abcdef	26.3 abc	5.0 ab	4.7 ab
2	METAM	THIMET 6	NONE	10.3 bcdef	42.3 abcd	4.7 a	3.3 a
3	METAM	NONE	NONE	10.0 abcdef	41.3 abcd	6.0 abc	5.0 abc
4	NONE	THIMET 8	NONE	10.0 abcdef	43.3 abcd	5.0 ab	4.3 ab
5	NONE	THIMET 6	NONE	14.0 f	65.3 d	5.3 ab	5.7 abcd
6	NONE	NONE	NONE	6.7 abc	36.7 abcd	5.7 ab	6.0 bcde
7	TELONE	NEMACUR	NONE	10.7 bcdef	50.3 bcd	7.7 cd	8.0 de
8	TELONE	NONE	NONE	8.0 abcde	36.7 abcd	8.7 d	8.3 e
9	METAM	THIMET 8	OZ 0.6% X 45 MIN	4.3 a	18.0 a	5.3 ab	5.0 abc
10	METAM	NONE	OZ 0.6% X 45 MIN	11.3 cdef	44.3 abcd	6.3 abc	6.7 bcde
11	METAM	THIMET 8	OZ 0.3% X 45 MIN	7.3 abcd	31.0 abc	6.3 abc	5.0 abc
12	METAM	NONE	OZ 0.3% X 45 MIN	8.3 abcdef	31.0 abc	5.7 ab	5.7 abcd
13	METAM	THIMET/DITERA	NONE	7.7 abcd	28.3 abc	5.7 ab	4.7 ab
14	METAM	THIMET/DITERA SPLIT	NONE	7.0 abcd	27.0 abc	5.3 ab	4.7 ab
15	METAM	DITERA	NONE	7.3 abcd	38.7 abcd	6.0 abc	6.3 bcde
16	METAM	DITERA SPLIT	NONE	11.7 cdef	47.7 abcd	6.7 bc	5.7 abcd
17	METAM	THIMET/NEEM CAKE	NONE	6.7 abc	23.3 ab	6.0 abc	5.0 abc
18	METAM	NEEM CAKE	NONE	8.7 abcdef	43.7 abcd	6.0 abc	5.7 abcd
19	METAM	THIMET/NEEM LIQUID	NONE	7.7 abcd	34.0 abc	5.3 ab	5.0 abc
20	METAM	NEEM LIQUID	NONE	8.3 abcdef	36.3 abcd	6.3 abc	6.0 bcde
21	NONE	THIMET/NEEM CAKE	NONE	9.3 abcdef	52.0 bcd	5.7 ab	4.3 ab
22	NONE	NEEM CAKE	NONE	9.0 abcdef	42.0 abcd	5.7 ab	5.0 abc
23	NONE	THIMET/NEEM LIQUID	NONE	10.0 abcdef	42.0 abcd	6.3 abc	6.3 bcde
24	NONE	NEEM LIQUID	NONE	12.7 def	52.3 bcd	4.7 a	5.0 abc
25	UNIROYAL 1	THIMET	NONE	8.0 abcde	33.0 abc	5.7 ab	4.3 ab
26	UNIROYAL 1	NONE	NONE	9.7 abcdef	49.3 bcd	6.3 abc	7.3 cde
27	UNIROYAL 2	THIMET	NONE	13.7 ef	50.0 bcd	5.3 ab	5.0 abc
28	UNIROYAL 2	NONE	NONE	9.7 abcdef	40.7 abcd	6.7 bc	8.0 de
29	METAM	UNIROYAL1	NONE	8.3 abcdef	34.7 abc	6.0 abc	5.3 abc
30	METAM	UNIROYAL2	NONE	7.3 abcd	32.7 abc	5.7 ab	6.0 bcde
31	METAM	THIMET/HAWAII 1	NONE	5.3 ab	24.0 ab	5.7 ab	5.0 abc
32	METAM	HAWAII 1	NONE	8.0 abcde	38.3 abcd	6.3 abc	5.7 abcd
33	METAM	THIMET/HAWAII 2	NONE	7.3 abcd	29.0 abc	6.3 abc	5.3 abc
34	METAM	HAWAII 2	NONE	8.3 abcdef	42.7 abcd	6.3 abc	6.0 bcde
35	METAM	THIMET/HAWAII 3	NONE	9.0 abcdef	36.7 abcd	5.7 ab	4.3 ab
36	METAM	HAWAII 3	NONE	10.0 abcdef	48.0 abcd	6.3 abc	6.0 bcde
37	METAM	THIMET/BASF	NONE	8.3 abcdef	50.3 bcd	6.7 bc	5.3 abc
38	METAM	QUILLAJA 35%	NONE	11.0 bcdef	55.3 cd	6.7 bc	6.0 bcde
39	METAM	THIMET	CINNAMITE/SAFER	11.0 bcdef	51.7 bcd	6.0 abc	5.3 abc
40	METAM	NONE	CINNAMITE/SAFER	7.7 abcd	31.0 abc	6.0 abc	6.0 bcde

Each figure is the mean of three replicates.
Means not followed by the same letter are significantly different from each other (P = 0.05) according to Fisher's Least Significant Difference Test.

2002 - 2003 Easter Lily Research Trial.

TREATMENT	SOIL TREATMENTS		BULBLET TREATMENTS	Bulb	Circumference
NUMBER	Preplant	In Furrow	Additive/Ozone	Survival	(inches)
1	METAM	THIMET 8	NONE	76.0 bc	5.9 abcdef
2	METAM	THIMET 6	NONE	72.0 a	6.0 abcdefg
3	METAM	NONE	NONE	73.0 ab	6.0 defghijk
4	NONE	THIMET 8	NONE	73.0 ab	5.9 abcd
5	NONE	THIMET 6	NONE	73.7 ab	5.9 abcde
6	NONE	NONE	NONE	72.7 ab	5.9 abcdef
7	TELONE	NEMACUR	NONE	73.3 ab	6.2 ghijk
8	TELONE	NONE	NONE	74.3 abc	6.3 k
9	METAM	THIMET 8	OZ 0.6% X 45 MIN	73.0 ab	6.1 defghijk
10	METAM	NONE	OZ 0.6% X 45 MIN	74.7 abc	6.1 defghijk
11	METAM	THIMET 8	OZ 0.3% X 45 MIN	73.7 ab	6.3 k
12	METAM	NONE	OZ 0.3% X 45 MIN	74.0 ab	6.2 ijk
13	METAM	THIMET/DITERA	NONE	73.0 ab	6.1 defghijk
14	METAM	THIMET/DITERA SPLIT	NONE	73.3 ab	6.0 cdefghij
15	METAM	DITERA	NONE	74.7 abc	6.2 fghijk
16	METAM	DITERA SPLIT	NONE	73.0 ab	6.1 efghijk
17	METAM	THIMET/NEEM CAKE	NONE	73.3 ab	6.2 ijk
18	METAM	NEEM CAKE	NONE	74.0 ab	6.1 efghijk
19	METAM	THIMET/NEEM LIQUID	NONE	74.7 abc	6.0 cdefghijk
20	METAM	NEEM LIQUID	NONE	73.7 ab	6.2 fghijk
21	NONE	THIMET/NEEM CAKE	NONE	73.7 ab	6.0 cdefghi
22	NONE	NEEM CAKE	NONE	75.0 abc	5.7 ab
23	NONE	THIMET/NEEM LIQUID	NONE	73.3 ab	6.2 fghijk
24	NONE	NEEM LIQUID	NONE	72.3 a	5.8 abc
25	UNIROYAL 1	THIMET	NONE	72.0 a	5.7 a
26	UNIROYAL 1	NONE	NONE	74.0 ab	5.8 abc
27	UNIROYAL 2	THIMET	NONE	73.7 ab	6.0 bcdefgh
28	UNIROYAL 2	NONE	NONE	74.0 ab	6.2 fghijk
29	METAM	UNIROYAL1	NONE	73.3 ab	6.2 ghijk
30	METAM	UNIROYAL2	NONE	73.7 ab	6.2 hijk
31	METAM	THIMET/HAWAII 1	NONE	77.7 c	6.2 fghijk
32	METAM	HAWAII 1	NONE	74.0 ab	6.3 jk
33	METAM	THIMET/HAWAII 2	NONE	73.7 ab	6.2 fghijk
34	METAM	HAWAII 2	NONE	73.3 ab	6.2 hijk
35	METAM	THIMET/HAWAII 3	NONE	72.7 ab	6.1 efghijk
36	METAM	HAWAII 3	NONE	74.0 ab	6.1 defghijk
37	METAM	THIMET/BASF	NONE	73.0 ab	6.2 fghijk
38	METAM	QUILLAJA 35%	NONE	74.0 ab	6.3 k
39	METAM	THIMET	CINNAMITE/SAFER	74.0 ab	6.2 fghijk
40	METAM	NONE	CINNAMITE/SAFER	73.7 ab	6.2 fghijk

Each figure is the mean of three replicates.
Means not followed by the same letter are significantly different from each other (P = 0.05) according to Fisher's Least Significant Difference Test.

2002 - 2003 Easter Lily Research Trial.

TREATMENT	SOIL TREATMENTS		BULBLET TREATMENTS	Visual Ratings of Bulbs		
NUMBER	Preplant	In Furrow	Additive/Ozone	Basal Root	Stem Root	Stem Lesion
1	METAM	THIMET 8	NONE	8.3 fg	7.3 hi	9.3 f
2	METAM	THIMET 6	NONE	7.7 defg	7.0 ghi	9.0 f
3	METAM	NONE	NONE	7.0 cde	6.3 efghi	8.0 ef
4	NONE	THIMET 8	NONE	6.3 abc	5.0 abcdefg	3.0 a
5	NONE	THIMET 6	NONE	6.7 bcd	4.3 abcde	5.3 bcd
6	NONE	NONE	NONE	6.3 abc	5.0 abcdefg	6.7 de
7	TELONE	NEMACUR	NONE	6.7 bcd	5.3 bcdefgh	6.3 cde
8	TELONE	NONE	NONE	8.3 fg	7.7 i	6.3 cde
9	METAM	THIMET 8	OZ 0.6% X 45 MIN	8.0 efg	7.7 i	7.7 ef
10	METAM	NONE	OZ 0.6% X 45 MIN	7.0 cde	6.7 fghi	7.7 ef
11	METAM	THIMET 8	OZ 0.3% X 45 MIN	6.7 bcd	5.0 abcdefg	7.7 ef
12	METAM	NONE	OZ 0.3% X 45 MIN	6.3 abc	6.0 defghi	7.3 def
13	METAM	THIMET/DITERA	NONE	7.0 cde	7.0 ghi	7.3 def
14	METAM	THIMET/DITERA SPLIT	NONE	7.0 cde	6.0 defghi	7.3 def
15	METAM	DITERA	NONE	7.3 cdef	6.7 fghi	7.7 ef
16	METAM	DITERA SPLIT	NONE	6.7 bcd	7.7 i	8.0 ef
17	METAM	THIMET/NEEM CAKE	NONE	8.0 efg	7.7 i	7.3 def
18	METAM	NEEM CAKE	NONE	7.0 cde	6.3 efghi	8.0 ef
19	METAM	THIMET/NEEM LIQUID	NONE	7.0 cde	6.3 efghi	7.7 ef
20	METAM	NEEM LIQUID	NONE	7.7 defg	6.7 fghi	6.3 cde
21	NONE	THIMET/NEEM CAKE	NONE	7.0 cde	6.3 efghi	7.3 def
22	NONE	NEEM CAKE	NONE	5.7 ab	3.0 a	4.0 ab
23	NONE	THIMET/NEEM LIQUID	NONE	5.7 ab	4.0 abcd	4.0 ab
24	NONE	NEEM LIQUID	NONE	5.3 a	3.7 abc	3.7 ab
25	UNIROYAL 1	THIMET	NONE	5.3 a	4.7 abcdef	4.3 abc
26	UNIROYAL 1	NONE	NONE	5.7 ab	3.3 ab	2.7 a
27	UNIROYAL 2	THIMET	NONE	5.7 ab	4.0 abcd	2.7 a
28	UNIROYAL 2	NONE	NONE	6.7 bcd	4.0 abcd	4.3 abc
29	METAM	UNIROYAL1	NONE	8.0 efg	6.0 defghi	6.7 de
30	METAM	UNIROYAL2	NONE	7.7 defg	7.7 i	8.3 ef
31	METAM	THIMET/HAWAII 1	NONE	8.7 g	6.0 defghi	7.3 def
32	METAM	HAWAII 1	NONE	7.7 defg	6.7 fghi	7.7 ef
33	METAM	THIMET/HAWAII 2	NONE	7.7 defg	5.7 cdefghi	7.3 def
34	METAM	HAWAII 2	NONE	7.3 cdef	7.0 ghi	7.7 ef
35	METAM	THIMET/HAWAII 3	NONE	7.7 defg	6.7 fghi	7.7 ef
36	METAM	HAWAII 3	NONE	8.3 fg	7.0 ghi	9.3 f
37	METAM	THIMET/BASF	NONE	7.7 defg	6.3 efghi	8.3 ef
38	METAM	QUILLAJA 35%	NONE	7.7 defg	6.7 fghi	8.3 ef
39	METAM	THIMET	CINNAMITE/SAFER	7.7 defg	7.3 hi	9.3 f
40	METAM	NONE	CINNAMITE/SAFER	8.0 efg	7.3 hi	9.3 f

Each figure is the mean of three replicates.
Means not followed by the same letter are significantly different from each other (P = 0.05) according to Fisher's Least Significant Difference Test.

Interregional Research Project No. 4

BIOACT WG-A biological nematicide final report June 3, 2004

Susan Schenck

Executive Summary

A project testing the efficacy of BioAct (*Paecilomyces lilacinus* strain 251) for control of nematodes on tomato (Burpee "Orange Pixie" hybrid) and cucumber (Ferry-Morse "Marketmore 76") in Hawaii was installed in February, 2003. BioAct WG-A is being introduced to the US as "MeloCon WG". There were three treatments with four replicates in a randomized complete block. The treatments were 1) BioAct, 2) Vapam, 3) untreated check. Cucumber plots were harvested in nine rounds. Harvest yield was recorded as number and weight of small, medium, and large fruits per plot per harvest date. The results were summarized by totals per treatment and as averages per plant, which would negate the effect of any missing plants per plot. There were no apparent yield differences between treatments so statistical analysis was not performed. Postharvest evaluation of plant roots showed severe nematode damage in all treatments. Soil populations of root-knot (*Meloidogyne* sp.) and reniform (*Rotylenchulus reniformis*) nematodes were low to moderate for all treatments. This is probably due to the severe root damage having drastically reduced nematode feeding sites and then leading to falling nematode populations. It appears from the results that the cucumbers were so susceptible and intolerant of the nematodes present in this study that neither the Vapam soil fumigant nor the BioAct were able to overcome the damage.

The tomatoes were harvested in three rounds and data taken were numbers and weight of small and medium fruits. The tomato variety was a cherry tomato and the fruits were essentially all the same size with a few small ones. Results were compiled as totals per plot and averages per plant. Data were analyzed using Statistix 7 computer program giving ANOVA for each total and average. Comparison of means was performed using LSD at the 95% level (significant difference greater than 0.050). The means were consistant for every total in that the BioAct treatment fruit yield was greatest, Vapam a close second and the untreated check lower. Due to the rather large variation in the test, only the medium size average fruit weight showed a significant difference between means. However, the consistency of the results indicates that there was a very real effect of BioAct in protecting tomato plants against nematode damage. The visual root galling ratings bear this out. The soil nematode counts at harvest show high numbers of root-knot nematodes and low to high numbers of reniform nematodes.

The overall results indicate that BioAct is as effective as Vapam soil fumigant and significantly better than no treatment for control of nematodes in tomato. The BioAct active component is a naturally-occurring soil fungus and could be used to replace toxic chemical nematicides for tomato, and presumably other vegetable crop, production. Use of BioAct in an integrated pest management system may prove to be an economic solution to the loss of methyl bromide as a tool for nematode control. It will also be suitable for use in organic farms once it is registered and certified organic.

Compliance Narative

A project testing the efficacy of BioAct WG (MeloCon WG) (*Paecilomyces lilacinus* strain 251) for control of nematodes on tomato (Burpee "Orange Pixie" hybrid) and cucumber (Ferry-Morse "Marketmore 76") in Hawaii was installed in February, 2003. The test site was the Hawaii Agriculture Research Center farm at Kunia, Oahu island, Hawaii. The field plots location, layout and all field event dates were recorded as they occurred. The project was unfortunately affected by severe, unexpected storms, wind and flooding, but was nonetheless carried through and data were taken.

Procedures

Importation

Although *Paecilomyces* ssp. are listed by the Hawaii State Quarantine Branch as 'non-restricted' microorganisms, its formulation as a commercial product and application in field plots necessitated obtaining a state import permit and registration. A permit was therefore applied for and obtained from the State of Hawaii Plant Quarantine Branch for *Paecilomyces lilacinus* strain 251. The product arrived on November 26, 2003 and was placed in storage at -20°C in a secured, certified laboratory.

Field installation

The field plots were installed at the Hawaii Agriculture Research Center farm, Kunia Rd. Oahu, HI. Mulch and drip tubing were laid on February 3, 2004. Plots were measured, staked and tagged on 2/5/04 and preplant soil nematode counts were taken. There were four replicate plots per treatment. Tomato plots were two rows of 10 ft each and containing 8 plants at 18 in spacing. Cucumber plots were one row, 20 ft and contained 6 plants at 24 in spacing.

Treatments

There were three treatments: 1) BioAct, 2) Vapam HL, 3) untreated check. Vapam HL (sodium methyldithiocarbamate 42%) was applied to the treatment 2 plots 2/10/04. Application was by injection under mulch at the rate of 65 ml per plot (37.3 gal/A). BioAct was applied to the treatment 1 plots 2/18/04. Application rate was 0.2 g BioAct/ 500 ml water/ plant. Tomato (Burpee "Orange Pixie") and cucumber seedlings were transplanted from greenhouse flats to the field plots on 3/9/04. Treatment 1 seedlings received a drench of BioAct at the rate of 1 g per 100 seedlings. The cucumbers died from wind damage and possible herbicide spray drift. Cucumber (Ferry-Morse "Marketmore 76") were reseeded directly into the planting holes on 3/15/04. Success insecticide was applied at 5 lb/A by overhead spray on 3/24/04 along with 15-15-15 fertilizer. Asana insecticide was applied at a rate of 8 oz/A on 4/5/04. Malathion was sprayed at a rate of 20 ml/gal water over the project area on 4/12/04. A second application of BioAct was applied at a rate of 0.2 g / 200 ml water per plant on 4/21/04. All treatments were applied following label directions and safety requirements. No Entry sign was placed in the field for required prohibited reentry time.

Data collection

Harvesting of cucumbers began on 4/30/04. The numbers and total weight (kg) per plot

of small (< 7 in), medium (7 to 10 in), and large (> 10 in) cucumbers were recorded. Harvest rounds occurred on 4/30/04, 5/3/04, 5/5/04, 5/7/04, 5/10/04, 5/12/04, 5/14/04, 5/17/04, and 5/19/04. Root damage evaluation was done on 5/19/04. Soil samples for nematode counts and *Paecilomyces* reisolation were taken on 5/19/04. Continued sampling for *Paecilomyces* will continue in order to determine the length of time it takes for soil populations to decline below detectable levels.

Tomatoes were harvested in three rounds: 5/14/04, 5/17/04, and 5/21/04. The numbers and total weight (kg) per plot of small and medium fruits were recorded. Root damage evaluation and soil sampling took place on 5/24/04.

Results

Cucumber harvest yield was recorded as number and weight of small, medium, and large fruits per plot per harvest date. The results were summarized by totals per treatment and as averages per plant, which would negate the effect of any missing plants per plot (Table 1). There were no apparent yield differences between treatments so statistical analysis was not performed. Postharvest evaluation of plant roots showed severe nematode damage in all treatments (Table 2). Soil populations of root-knot (*Meloidogyne* sp.) and reniform (*Rotylenchulus reniformis*) nematodes were low to moderate for all treatments (Table 3). This is probably due to the severe root damage having drastically reduced nematode feeding sites and then leading to falling nematode populations. *Paecilomyces* was isolated after harvest from the BioAct-treated plots at the rate of roughly 1×10^6 cfu/g soil, and also in lower numbers from the untreated plots. It appears from the results that the cucumbers were so susceptible and intolerant of the nematodes present in this study that neither the Vapam soil fumigant nor the BioAct were able to overcome the damage.

Tomatoes were harvested in three rounds and data taken were numbers and weight (kg) of small and medium size fruits. The tomato variety was a cherry tomato and the fruits were essentially all the same size with a few small ones. Results were compiled as totals per plot and averages per plant (Table 4). Data were analyzed using Statistix 7 computer program giving ANOVA for each total and average. Comparison of means was performed using LSD at the 95% level (significant difference greater than 0.050). The results were consistant in that fruit numbers and weights in the BioAct treatment yield was greatest in every case. Vapam was a close second and the untreated check lower. Due to the rather large variation in the test, only the medium size average fruit weight showed a significant difference between means. However, in my opinion, the consistency of the results indicates a very real effect of BioAct in protecting tomato plants against nematode damage. The visual root galling ratings bear this out (Table 5). The soil nematode counts at harvest show high numbers of root-knot nematodes and low to high numbers of reniform nematodes in all treatments (Table 6). For some reason, the replicate 1 plots had lower numbers of root-knot nematodes in all three treatments. *Paecilomyces* was isolated after harvest from the BioAct-treated plots at the rate of roughly 1×10^5 cfu/g soil and also, in lower numbers, from the untreated plots. No phytotoxicity was observed.

The overall results indicate that BioAct is as effective as Vapam soil fumigant and significantly better than no treatment for control of nematodes in tomato.

Table 1. Cucumber Yield

	total fruit number				average fruit number per plant			
treatment	small	med.	large	total	small	med.	large	total
BioAct	54	89	27	170	2.7	4.5	13.5	8.5
Vapam	58	118	23	199	2.9	5.9	12.4	10.0
control	48	99	27	174	2.7	5.5	12.8	9.7

	total fruit weight (kg)				average fruit weight per plant			
treatment	small	med.	large	total	small	med.	large	total
BioAct	7.6	21.0	13.5	42.2	0.4	1.1	0.7	2.1
Vapam	6.9	22.4	12.4	41.6	0.3	1.1	0.6	2.1
control	6.1	23.6	12.8	42.5	0.3	1.3	0.7	2.4

Table 2. Cucumber Root Damage Ratings at Harvest 5/19/04

	total plant no.	ave. knots rating / plant	ave. feeder root rating / plant
treatment 1	20	2.55	3.45
treatment 2	20	2.65	3.20
treatment 3	18	3.50	3.11

root-knot rating: 1 = none, 2 = few, 3 = many, 4 = very severe galling
feeder root rating: 1 = extensive, 2 = some, 3 = few, 4 = very few to none

Table 3. Cucumber Nematode Counts at Harvest 5/18/04

BioAct		
rep 1	root-knot - 6,	reniform - 5
rep 2	root-knot - 8,	spiral - 3
rep 3	root-knot - 15	
rep 4	root-knot - 134,	reniform - 65
Vapam		
rep 1	root-knot - 1,	reniform - 11
rep 2	root-knot - 5,	reniform - 11
rep 3	root-knot - 8	
rep 4	root-knot - 1,	reniform - 1
Control		
rep 1	root-knot - 82,	reniform - 34
rep 2	root-knot - 6,	reniform - 1
rep 3	root-knot - 23,	reniform - 99
rep 4	root-knot - 1,	reniform - 3

Table 4. Tomato Yield

comparison of means of average fruit weights (kg) per plant

treatment	small	medium	total wt. / trt.
BioAct	0.18 a	1.35 a	43.25
Vapam	0.15 a	1.16 ab	41.75
control	0.11 a	0.92 b	32.50

comparison of means of average fruit number per plant

treatment	small	medium	total no. / trt.
BioAct	8.3 a	36.5 a	1274
Vapam	7.0 a	31.1 a	1219
control	4.4 a	25.7 a	964

* means in the same column followed by the same letter do not differ at the 95% level.

Table 5. Tomato Root Damage Ratings at Harvest 5/24/04

	total plant no.	ave. knots rating / plant	ave. feeder root rating / plant
BioAct	28	2.07	2.39
Vapam	32	2.06	2.15
control	32	2.25	2.25

root-knot rating: 1 = none, 2 = few, 3 = many, 4 = very severe galling
feeder root rating: 1 = extensinve, 2 = some, 3 = few, 4 = very few to none

Table 6. Tomato Nematode Counts at Harvest 5/24/04

BioAct			
rep 1	root-knot - 6,	reniform - 9,	pin - 3
rep 2	root-knot - 379,	reniform - 421	
rep 3	root-knot - 496,	reniform - 12	
rep 4	root-knot - 296,	reniform - 186,	spiral - 1
Vapam			
rep 1	root-knot - 18,	reniform - 47	
rep 2	root-knot - 52,	reniform - 40,	pin - 3
rep 3	root-knot - 210,	reniform - 2	
rep 4	root-knot - 116,	reniform - 7	
control			
rep 1	root-knot - 80,	reniform - 33	
rep 2	root-knot - 382,	reniform - 120	
rep 3	root-knot - 392,	reniform - 44	
rep 4	root-knot - 208,	reniform - 8	

AuxiGro Efficacy Trial – Highbush Blueberries, 2003

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Site: Twelve year-old 'Bluecrop' bushes at the Southwest Michigan Research and Extension Center, Benton Harbor, MI.

Treatments:

		Growth stage		
		Early bloom	Full bloom	Early fruit set
1	Surfactant[y]	X	X	X
2	Surfactant + AuxiGro[y]	X	X	X
3	Surfactant + AuxiGro	X	X	
4	Surfactant + AuxiGro	X		X
5	Surfactant + AuxiGro		X	X

[y]Silicone surfactant, 0.5 ml/liter
[z]AuxiGro, 0.6 g/liter

Early bloom sprays applied on 6 May (1-2% of flowers open), volume - 180 ml/bush.
Full bloom sprays applied on 14 May (50 % flowers open), volume – 200 ml/bush
Early fruit set sprays applied on 23 May, volume – 200 ml/bush

Design: Treatments were replicated 4 times in a RCB design, with 5 bushes per plot.

Data collection: The middle three bushes in each plot were harvested three times at 7-10 day intervals. Before each harvest, 1 quart samples were collected by hand for later rot assessments and average berry weight measurements. Whole bushes were then picked for total fruit yield determinations.
Rot levels were determined after holding 1 pt of fruit in clamshell containers in a cooler at 2°C for 5-7 days, moving them to a 18°C lab for 1 day, then sorting the samples and recording the number of intact fruit and fruit showing symtoms of alternaria and anthracnose infections. Additional fruit (25 per sample) from the first picking were arranged singly in sealed containers and held at 100% humidity and 18°C for 12 days. Rot levels associated with different fungi were then recorded.

Results.
Treatment had no effect on yield (Table 1) and only affected average fruit weight during the second picking, when two late applications of AuxiGro appeared to reduce berry weight (Table 1). Treatments had little effect on fungal rot levels. Berries from each picking were packed in pint clamshell containers and held in a cooler, then at room temperature (to simulate commercial handling conditions). One AuxiGro treatment resulted in significantly more alternaria rot in fruit from the third picking, but no other treatment effects were seen (Table 2). Additional fruit from the first picking were incubated in high humidity to determine total infection levels. Again, there were no effects of treatments on rot levels (Table 3). The incubation procedure is viewed as more critical test in that berries with minor infections that may not cause visible rot in commercial storage usually develop symptoms during incubation.

Table 1. Effect of AuxiGro treatments on yield and average berry weight of 'Bluecrop'.

	Yield (kg/plot)				g/berry		
Treatment	Pick 1	Pick 2	Pick 3	Total	Pick 1	Pick 2	Pick 3
Control	2.8	3.7	1.8	8.3	2.49	2.22a	2.00
AG 1,2,3	3.0	4.1	2.6	9.7	2.42	2.20a	1.99
AG 1,2	3.2	3.2	2.4	8.8	2.47	2.19a	2.01
AG 1,3	3.5	3.9	2.9	10.3	2.56	2.11ab	1.96
AG 2,3	3.2	3.7	2.9	9.9	2.41	2.02b	1.85
Sign	ns	ns	ns	ns	ns	0.05	ns

Table 2. Effect of AuxiGro treatments on levels Alternaria and Anthracnose in 'Bluecrop' blueberries after one week storage.

	Alternaria (%)			Anthracnose (%)			Total rot (%)		
Treatment	Pick 1	Pick 2	Pick 3	Pick 1	Pick 2	Pick 3	Pick 1	Pick 2	Pick 3
Control	0.9	0	0.3b	0.5	2.2	5.1	1.5	2.5	5.2
AG 1,2,3	0	0	0b	1.7	3.6	5.1	1.7	3.9	5.2
AG 1,2	1.8	0	1.4a	2.2	1.2	3.1	2.2	1.3	4.5
AG 1,3	0.5	0.5	0b	2.0	3.5	6.8	2.0	4.2	6.8
AG 2,3	0.9	0	0b	2.1	3.0	4.8	2.1	3.1	4.8
Sign	ns	ns	0.05	ns	ns	ns	ns	ns	ns

Table 3. Effect of AuxiGro treatments on rot levels in 'Bluecrop' blueberries from harvest 1, incubated singly at 100 % RH and 18°C for 12 days.

Treatment	Anthracnose (%)	Alternaria (%)	Botrytis (%)
Control	25	3	3
AG 1,2,3	29	7	4
AG 1,2	50	5	2
AG 1,3	50	5	2
AG 2,3	39	7	1
Sign	ns	ns	ns

IR-4 and Emerald BioAgriculture Corporation

RESEARCH REPORT

Title: Evaluating the efficacy of AuxiGro on apples for enhanced yield and improved skin color

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Objectives:
To evaluate the effect of AuxiGro on yield and quality of McIntosh apples growing under Wisconsin conditions.

Approach:
This trial was conducted in a commercial apple orchard in Richland County, Wisconsin. The block used was McIntosh on M.7 rootstock that was planted in 1983. The trees were well pruned with open canopies. The cooperating growers managed the block according to their normal practices for insect, weed, and disease control. We saw virtually no insect damage or scab lesions. A hail storm made a glancing blow at this block in early August, 2003. We noted a little bit of hail injury on fruit in the tops of the trees at harvest.

The seven treatments used were assigned at random to blocks of three trees in the orchard. Replications one and two were on one row and the third replication was two rows further into the orchard to avoid any chance for overspray or drift. Treatments were made on the dates indicated in Table 1. The treatments were applied with a handgun to individual trees at 40 psi. The sprayer was powered by an electric pump. About one gallon of solution was applied to each tree.

Fruit were harvested by hand on September 15 and 16, 2003 from the middle tree of each three tree treatment. Individual harvest bags were weighed and summed per tree. A subsample of 20 fruit was taken from each tree for subsequent individual fruit weight. These fruit were stored at about 5°C for 6 weeks and then evaluated for bitter pit development. Bitter pit data represent the number of apples per 20 that had any evidence of bitter pit. Color data are a visual rating of skin color from 1 to 5.

Table 1. Treatments used in Wisconsin research on the effect of Auxigro on McIntosh apples

Treatment	Materials	Timing
1	Untreated check. Water + 0.05% surfactant	All dates
2	Auxigro @ 2 oz/a + 0.05% surfactant	Pink, full bloom, petal fall
3	Auxigro @ 4 oz/a + 0.05% surfactant	Pink, full bloom, petal fall
4	Auxigro @ 6 oz/a + 0.05% surfactant	Pink, full bloom, petal fall
5	Auxigro @ 4 oz/a + 0.05% surfactant	Initial color development
6	Auxigro @ 4 oz/a + 0.05% surfactant	2 weeks after initial color development
7	Auxigro @ 4 oz/a + 0.05% surfactant	Initial color development and 2 weeks later

Table 2. Timing of applications

Treatment	Date
Pink bud	2 May 2003
Full bloom	8 May 2003
Petal fall	16 May 2003
Initial color development	5 August 2003
Initial color development + 2 weeks	21 August 2003

Results

We found no effect of Auxigro on either yield per tree or fruit size of McIntosh apples grown under Wisconsin conditions (Table 3). There was no statistically significant difference in color data. Statistically there was a treatment effect on the incidence of bitter pit. Treatments 3 and 4 had less bitter pit than treatments 1, 2, or 6; but not different than treatment 5 or 7. The overall incidence of bitter pit within the sampled fruit was very low. Also, the trees had sustained a little bit of hail damage and in some cases resolving hail injury from bitter pit was difficult.

Table 3. Effects of application with Auxigro on yield and individual fruit weight of McIntosh apples growing in Richland county Wisconsin.

Treatment	**Yield per tree (Kg)**	**Weight per fruit (g)**	**Color Rating**	**Bitter pit** (incidence per 20 fruit)
1	182.3	137	2.3	2.7
2	195.7	143	2.7	2.7
3	198.5	144	3.3	1.3
4	175.6	153	3.3	1.3
5	156.6	135	3	2.0
6	177.3	136	2.7	2.7
7	184.9	129	3	2.0
Significance	ns	ns	ns	p= 0.026

IR-4 and Emerald BioAgriculture Corporation

RESEARCH REPORT

Title: Evaluating AuxiGro® to enhance cranberry yields in Wisconsin

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Objectives:
To determine the effects of AuxiGro on the yield of cranberries growing in Wisconsin using standard commercial production practices.

Approach:
This research was conducted on a commercial cranberry marsh in Juneau County Wisconsin. The beds were planted to 'Stevens' vines, the dominant cultivar in Wisconsin. Vines were managed according to the growers normal practices.

Three by five meter plots were established with eight replications per treatment. Treatments were randomized within blocks. Treatments were as shown in Table 1 with treatment dates as shown in Table 2. Sprays were applied with a CO_2 powered back pack sprayer at 40 psi using a three nozzle boom with flat fan nozzles at a rate of 20 gallons per acre.

Plots were harvested on 23 September 2003. A square of dimensions 30 x 30 cm was thrown at random into each plot. All vines were cut from within each square, placed in a plastic bag and brought to the lab. These samples were sorted into fruiting and non-fruiting uprights. For fruiting uprights the number of fruit and the number of pedicels were counted. This allowed calculating percent fruit set. The number of fruit and yield were determined for each sample. Individual fruit size was calculated.

Table 1. Treatments used in Wisconsin research on the effect of Auxigro on Stevens cranberries.

Treatment	Materials	Timing
1	Untreated check. Water + 0.05% surfactant	All dates
2	Auxigro @ 2 oz/a + 0.05% surfactant	Hook, full bloom, fruit set
3	Auxigro @ 4 oz/a + 0.05% surfactant	Hook, full bloom, fruit set

Table 2. Timing of applications

Treatment	Date
Hook	26 June 2003
Full bloom	9 July 2003
Fruit set	23 July 2003

Results

We found no effect of Auxigro on yield, fruit set, fruit number or fruit size of cranberries (Table 3). We didn't expect to see any difference in the number of fruiting and nonfruiting uprights as fruit sampled this year were based on buds set in 2002. The data are included for completeness. My experience suggests that the data are extremely tight for cranberry research. Variability is usually great, but the means for each variable are very tight and would not be biologically or economically significant.

Table 3. Effects of application with Auxigro on yield and yield components of 'Stevens' cranberries grown in Juneau County Wiconsin. n=8.

Treatment	**Yield (g)**	**Fruit set (%)**	**Fruit number**	**Fruit size (g)**	**Fruiting uprights**	**Nonfruiting uprights**
1	216.3	42.8	150.6	1.44	86	412
2	222.2	41.4	150.6	1.48	91	397
3	201.3	39.5	142.0	1.42	86	398
Significance	ns	ns	ns	ns	ns	ns