Final Research Report Submitted to:
The New York Wine/Grape Foundation
The Viticulture Consortium-East
For work conducted in 2006

Integrated Management of Organic Concord Grape Production in the Lake Erie Region

Principal Investigator:

Dr. James W. Travis (2 % time committed)
Department of Plant Pathology
The Pennsylvania State University Fruit Research and Extension Center
290 University Drive, Biglerville, PA 17307-1330
jwt2@psu.edu
Phone: 717-677-6116
Fax: 717-677-4112

Cooperators:

Dr. Michael Saunders[1] (1% time committed), Bryan Hed[2] (25 % time commitment); Andrew Muza[3] (2 % time commitment), Jody Timer[4] (20 % time committed), Dr. Wayne Wicox[5] (2 % time commitment)

[1]Department of Entomology, Pennsylvania State University, 514 Ag Sciences & Industries Building, University Park, PA 16802, phone 814-863-2979, fax 814-865-3048, mcs5@psu.edu

[2]Department of Plant Pathology, [4]Department of Entomology, The Pennsylvania State University, Lake Erie Regional Grape Research and Extension Center; 662 Cemetery Road, North East, PA 16428; phone 814-725-4601; fax 814-725-8135; [2]bxh38@psu.edu [4]jht10@psu.edu

[3] Erie County Cooperative Extension; The Pennsylvania State University; 850 E. Gore Road, Erie, PA; phone 814-825-0900; fax 814-825-4783; ajm4@psu.edu

[5]Department of Plant Pathology, Cornell University, New York State Agricultural Experiment Station, Geneva, NY 14456; phone 315-787-2335; fax 315-787-2389; wfw1@cornell.edu

Funding period: July 1, 2006 to June 30, 2007

Increasing consumer demand for organically grown foods and more environmentally sustainable production practices, are creating new pest management challenges and potentially profitable marketing opportunities for grape growers in Pennsylvania and New York. This project is designed to develop integrated pest management strategies that provide reliable options for organic grape producers in Pennsylvania and New York.

Objective 1. Evaluate organic approved materials for efficacy against grape diseases (with emphasis on black rot in greenhouse screening and field trials.

A) Greenhouse screening trials using potted grapevine leaves and clusters: In 2006, some tests from 2005 were repeated and new materials were screened for the first time. All materials are commercially available as fungicides for controlling plant disease on various crops. They include plant extracts and oils, potassium bicarbonates, biologicals, and others. Wetting agents were also tested because spores of the black rot fungus (*Phyllosticta ampelicida*) germinate poorly on hydrophilic surfaces (Fungal Genetics and Biology 20:18-29).

To test materials for efficacy on leaves, the 2-3 youngest leaves per shoot of potted grapevines (*Vitis labrusca* 'Concord', *Vitis* interspecific hybrid 'Aurore') were sprayed with treatments until runoff, inoculated 4-6 hours later with a conidial suspension (10^5 conidia per ml) of the black rot fungus, and immediately placed inside a mist chamber for 20 hours at room temperature before return to the greenhouse. Disease was rated 2-3 weeks later. The fungal isolate used for all inoculations was maintained in the laboratory on half strength PDA under continuous fluorescent light at 25C. Conidia for inoculations were harvested from 10-14 day old cultures. Table 1 summarizes the results achieved (% black rot control) under these conditions. Most pesticides and the yucca wetting agent provided good to excellent control on leaves when applied 4-6 hours before inoculation, suggesting potential activity against the black rot fungus. To determine a possible mechanism for the efficacy of yucca, we treated grape leaves with yucca or water (check) before inoculation and infection as above. Leaf tissue samples were then cleared in glacial acetic acid:ethanol (1:1) for 24 hours and examined with light microscopy (400x) for appresoria (fungal attachment/penetration structures). Yucca had reduced appresorium formation by about 94 %.

Three of the most effective materials were tested for loss of residual activity against black rot over time on leaves of potted Concord vines in the greenhouse and mature vines in the field (table 2). Materials were applied either one day or four days before inoculation (as above). Lime sulfur, EF400, and citrex provided good to excellent control on leaves when applied one day before infection, but efficacy dropped an average of 8, 13, and 15 % respectively, from one to four days after application, dropping much more rapidly in the field than in the greenhouse, despite an absence of rainfall. This suggests that these materials may need to be applied at very short intervals or within 24 hours before an infection period to achieve acceptable results.

Some materials were tested for post infection activity against black rot on leaves. Leaves were sprayed with Milstop (2.5 lb/100 gal), Armicarb O (2.5 lb/100 gal), or GC-3 (1 %), 4 hours before or after inoculation. Control with protective treatment by Milstop, Armicarb, and GC-3 was 95, 62, and 90 % respectively. Control with post infection treatment by Milstop, Armicarb, and GC-3 was 39, 72, and 38 %, respectively. Control with Milstop and GC-3 dropped sharply when applied shortly after infection, whereas control with Armicarb O remained unchanged or actually increased when applied post infection. This work will be expanded in 2007.

Greenhouse cluster inoculations: Clusters of potted grapevines (3-6 clusters/vine x 4, *Vitis* interspecific hybrid 'Aurore', *Vitis vinifera* 'Chardonnay' and 'Riesling') were sprayed with treatments until runoff, then inoculated 26-28 hours later, and sealed inside plastic bags for 14 hours at room temperature. In all trials, water sprayed clusters were destroyed (93-100% severity). Champion (2 lb/100 gal) + lime (4 lb) + yucca (32 oz), yucca alone, and potassium bicarbonate products, Milstop (2.5 lb) and Armicarb O (2.5 lb), provided 70, 68, 75, and 69 % control, respectively. EF400 (0.25 %) and Citrex (0.1 %) provided little or no control.

CONCLUSIONS:GREENHOUSE TRIALS. Many materials provided good to excellent control of black rot on grape leaves (tables 1 and 2), but were less effective or ineffective on fruit in the greenhouse. They may be best used in the field to control leaf and shoot infections early in the season, when applied just before a predicted infection period. Testing in 2007 will examine this hypothesis in the field on both shoots and clusters.

<u>B) Evaluate greenhouse screened materials for black rot and powdery and downy mildew control in the field.</u>
1. Field trials: Field trials were conducted in a mature vineyard of *Vitis* labrusca 'Concord' and 'Niagara' at the Lake Erie Regional Grape Research and Extension Center in North East, PA. Treatments were applied to 3-4 (Concord) or 8-12 (Niagara) vine plots with 4 replications. Applications were made with a Friend covered-boom plot sprayer at 100 psi and 100 gal/A. To enhance black rot disease in plots and standardize disease pressure between plots, black rot fruit mummies were hung from the trellis wire within each plot. Niagara plots were further subdivided: the upwind half without mummies, the downwind half with mummies. The heaviest black rot fruit disease occurred on clusters within a two foot wide zone centered beneath mummies. In Concord and the downwind subplot in Niagara, black rot incidence (percent infected) and severity (percent area infected) were determined from 50 clusters/plot within these zones. In the upwind subplot in Niagara, black rot, and powdery and downy mildew were assessed from 50 clusters selected randomly from the center of the subplot. Powdery mildew was assessed in Concord from 50 clusters selected randomly from the center of plot.

Results: Concord (table 3). Weather conditions were very conducive to black rot, and severity of fruit rot was 71 % on check clusters. Champion (copper hydroxide) at 2 and 4 lbs/100 gal + lime was only modestly effective and lime sulfur (0.5 %) was poor, at controlling the severity of black rot on clusters (49, 63, and 18 % control, respectively). Powdery mildew disease pressure was moderate and lime sulfur was most effective on powdery mildew berry infections (89 % control), whereas Champion (2 and 4 lb), Serenade (1 %), Milstop (2.5 lb), and GC-3 (1 %) provided moderate to fair control (67, 73, 65, 59, and 54 %, respectively). Adding Yucca Ag Aide to lime sulfur, champion + lime, or GC-3 did not improve control over these materials alone. Citrex, EF400, and Yucca Ag Aide provided little or no control of black rot or powdery mildew on fruit. Concord grape is sensitive to sulfur. By early September, five applications of lime sulfur had caused some burning of leaves, mostly at nodes one to four (leaves receiving all 5 applications), with some loss of the oldest three leaves on canes.

Results: Niagara (tables 4a and b). Where black rot infected mummies were hung in the trellis, the severity of black rot fruit infection was almost 80 % on check vines. Champion (2 lb) + lime (4 lb) and lime sulfur (1 %), though providing significant control, only suppressed black rot on fruit by 31 and 28 %. However, in subplots without mummies, black rot severity on check clusters dropped to 15 % and the efficacy of some materials improved dramatically. For example, control with champion + lime and lime sulfur jumped from 31 to 97 % and 28 to 71 %, respectively (lime sulfur was still statistically less effective than Champion + lime). This demonstrates the critical importance of removing fruit mummies from the trellis in vineyards under organic management. Downy mildew disease pressure was high. Champion + lime provided excellent control (97 %) of downy mildew on fruit and lime sulfur appeared to provide some suppression of downy mildew (29 %). Powdery mildew disease pressure was moderate. Champion + lime and lime sulfur provided good control (91 and 84 %, respectively) and Quillaja (a wetting agent) provided poor, but significant control (44 %) of powdery mildew fruit disease. Citrex and Yucca Ag Aide were ineffective at reducing black rot (with or without mummies in the trellis), and powdery and downy mildew fruit disease. Interestingly, Prophyt (not organic, but considered low impact) also tested in this trial, provided good to excellent control of black rot (81 % control with mummies, 97 % without mummies), and provided 59 and 83 % control of powdery and downy mildew on fruit, respectively.

2. Concord cluster inoculations (Table 5): The experiment was conducted at 1 (Experiment 1) and 3 (Experiment 2) weeks post bloom at each of two locations: the Lake Erie Regional Grape Research and Extension Center (LERGREC) in North East PA and the New York State Agricultural Experiment Station (NYSAES) in Geneva, NY. The best performing pesticide from greenhouse screenings (Champion (copper hydroxide) + lime), best wetting agent (yucca ag-aide 50), and a tank mix of the two were applied to Concord clusters at either 1 or 7 days prior to inoculation with the black rot pathogen (5×10^4 conidia per ml) at LERGREC, or 4 and 7 (Experiment 1) and 1 and 6 days (Experiment 2) prior to inoculation (1×10^4 conidia per ml) at NYSAES. Treatments were compared to an unsprayed control. There were 4 replicate plots/treatment and 10 clusters/plot.

<u>Results at LERGREC :</u> Inoculated check clusters were completely destroyed in both experiments. In Experiment 1, yucca (32 oz/100 gal) and yucca + champion (4 lb/100 gal) + lime (8 lb/100 gal), applied one day prior to inoculation, provided significant control (67 and 64 % relative to the check, respectively). When treatments were subjected to 7 days of weathering, and 0.72" rainfall, all treatments provided little or no control. In Experiment 2, all treatments were relatively ineffective except that yucca + champion/lime applied 7 days prior to inoculation provided some suppression of disease (32 %).

<u>Results at NYSAES:</u> The yucca extract provided no control of black rot in either test, regardless of the time elapsed between application and inoculation. In contrast, the copper-containing material (Champion) provided up to 65% control (relative to the unsprayed check) in Experiment 1 and up to 45% control in Experiment 2. With one anomalous exception, there were no significant differences among any of the four Champion treatments within either experiment, regardless of the pre-inoculation spray timing or addition of the yucca extract. In addition to these experiments, fruit of potted vines (Pinot noir), were sprayed 7 days before inoculation and half of the vines were subjected to 1 inch of artificial rainfall 1 day before inoculation to determine the role of rainfall in dissipation of efficacy over time. Results were inconclusive due to lack of infection on clusters, but the experiment will be repeated in 2007.

CONCLUSIONS:FIELD TRIALS. Under the severe infection conditions created in these experiments, new product performance was modest to poor. Yucca was ineffective in the field at controlling black rot on fruit under heavy and moderate pressure when applied to whole vines at 10 day intervals and when applied to clusters 7 days before artificial infection. It provided fair control on fruit (67 %) when applied 24 hours prior to infection, but only when not subjected to any rainfall before inoculation. <u>The protective capacity of yucca extract on fruit appears to diminish rapidly with even small amounts of rainfall (0.28"). These results appear to show little practical fit for this material in commercial grape black rot control.</u>

In field inoculations, efficacy of champion/lime at LERGREC differed sharply from that at NYSAES. A difference in spray equipment used to apply pesticides before inoculations offers an explanation: at NYSAES a back pack sprayer was used and at LERGREC, a hand pump sprayer. The hand pump sprayer applied larger droplets that may have left gaps in coverage in copper/lime treatments that weren't a problem in yucca treatments with superior wetting/spreading properties. Alternatively, efficacy of copper/lime at NYSAES harmonized with efficacy in whole vine field trials at LERGREC where a covered boom sprayer applied materials at high pressure.

Seasonal sprays of lime sulfur may provide a rotational alternative to copper for black rot control in relatively dry years, when combined with thorough removal of fruit mummies from the trellis, but sulfur phytotoxicity will limit this option on Concord. Extensive use of seasonal lime sulfur would be more feasible in Niagara, but then copper would be critical for downy mildew control. Tests of residual activity of lime sulfur, EF400, and Citrex on Concord leaves tend to show some loss of efficacy (without any rainfall) after 4 days on expanding leaves. Materials like lime sulfur, serenade, milstop, and GC-3 were potential alternatives to copper for powdery mildew control, but these and all other organic materials tested had little impact on black rot or downy mildew under these severe infection conditions. These products may be useful under lower disease pressure (such as that resulting from strict implementation of cultural controls) as rotational partners with copper in more integrated systems. The active ingredient in Prophyt (not organic; labeled for downy mildew control) has demonstrated some obvious activity against black rot and powdery mildew in this trial (under high and low disease pressure) and we have seen similar results in other tests. More research is needed to better define its spectrum of grape disease control for 'low impact' disease management. We have demonstrated that several commercially available materials have activity against the black rot pathogen on leaves, but could not control the disease on fruit under field trial conditions. Future efforts will focus on optimizing the activity of these potential alternatives by field testing them as early season materials, at shorter spray intervals, and as rotational partners with copper.

From the whole vine field trials, copper still appears to be the best choice for disease management in organic viticulture, particularly with respect to control of black rot and downy mildew. When combined with removal of black rot mummies from the trellis, high levels of black rot control are possible (97 % on Niagara) even in a wet year.

Objective 2. Evaluate organic approved materials in the laboratory and in the field for efficacy against Grape Berry Moth. Organic insecticides were screened for activity against grape berry moth (GBM) *Paralobesia viteana* (*Endopiza viteana) (Clemens)* using a laboratory bioassay and field trial. Evaluations included commercially available formulations of pyrethrum (Pyganic), neem (Aza Direct), essential oils (EF300), a biological (Dipel 2x), and Spinosad (Entrust). In the laboratory, label rates of materials were applied to grape clusters bearing eggs using a hand-held sprayer. Clusters were moved to emergence cylinders in a growth chamber, and 32 days after egg hatch, adult emergence was counted and analyzed. In the field, Concord clusters with about 30 berries each were sprayed with test materials as above, enclosed in mesh bags with ten moths of the same age (from the in-house colony) for 14 days to allow for mating and maximum egg laying. One week later, the clusters were placed into individual growth cylinders held in growth chambers. Fifteen days later, the clusters were removed and adult moth hatch assessed.

<u>Results</u> (tables 6 and 7) Under laboratory conditions, all of the insecticides tested reduced development of adults and berry infestation, Entrust showing the greatest efficacy in this experiment. In the field experiments, Aza Direct appeared to have repellent properties, (egg deposition was reduced) and it showed efficacy equivalent to Entrust. Dipel, and EF300 did not show significant efficacy when compared to the control clusters, although they did outperform the control. Further field studies are needed to determine the most effective pest management program integrating phenology timed sprays and organic pesticide applications.

Objective 3. Determine the effects of compost, compost tea, and timing of mummy drop on over-wintering inoculum (Figures 1-3). The removal of black rot mummies from the trellis is critical to black rot control in organic systems. Once on the ground, their ability to release spores for infection in spring can further be impacted to improve control. We examined organic soil amendments and the length of time that over-wintering black rot mummies were in contact with the soil, for impacts on their viability. After harvest, small plots of vineyard soil were treated with either compost (10 tons/A), tea from the compost (50 gal/A), or no treatment (check). Compost and tea were applied twice (Oct 2005 and April 2006), as banded applications. Black rot mummies were placed on the surface of plots just before initial applications (10/17/05), just after dormancy (11/15/05), or on 3/13/06 to simulate removal from the trellis during harvest operations, and early and late pruning, respectively. Each treatment combination was replicated 4 times. Subsequently, mummies were evaluated for spore release in spring: 20 mummies/plot were collected on May 10 (10 days after bud break), June 6 (one week before bloom), and July 7 (12 days after bloom). Samples were briefly washed with tap water and placed in distilled water (1 ml/mummy) for 2 hours to induce spore release. Counts of released spores were made with a hemacytometer.
SUMMARY AND CONCLUSION: Mummy drop date had a greater effect than soil amendment, on spore release (ascospores and conidia) the following season. The earlier mummies were dropped to the ground, the greater the reduction in spores released later in spring. For example, at 10 days after bud break (Fig. 1), dropping

mummies in mid November or mid October, significantly ($P \leq 0.05$) reduced the total number of spores released by 67 and 92 %, respectively, when compared to mummies dropped in mid March. Compost tea (CT) application provided small additional reductions in spore release to mummy drop time at all drop dates, increasing reduction to 85 (Nov drop) and 93 % (Oct drop) when compared to non treated mummies dropped in mid March. Among mummies dropped in March, CT treatment reduced spore release by 19 % (not significant) over non treated. Compost (C) treatment *significantly increased* spore release compared to non treated mummies, when the effects of drop time were minimized (March). This effect may be related to elevated moisture retention in compost plots.

When comparing mummy spore release just before bloom (Fig. 2), mummies dropped the previous November or October released 74 and 86 % fewer spores, than mummies dropped later in mid March (significant, $P \leq .05$). Organic amendments improved those reductions from 86 % to 93 (CT) and 93 % (C) for the October drop date, and from 74 % to 92 (CT) and 80 % (C) for the November drop date, when compared with non treated mummies dropped in March. None of the amendments significantly improved reductions in spore release over non treated within a given drop date except compost applied in March, when the effects of drop time were minimized.

Spore counts were lowest in all treatments in the early July sample (Fig. 3). Non-treated mummies dropped the previous November or October released 71 and 75 % fewer spores, than mummies dropped later in mid March, but the reduction was not significant. Compost application improved those reductions from 75 to 94 % for the October drop date, and from 71 to 75 % for the November drop date, when compared with non treated mummies dropped in March. CT applications failed to reduce spore release at all drop dates over non treated in the July sample, and resulted in significantly higher spore counts over non treated and composted mummies dropped in March. It must be noted that all treatments were set up directly under mature Concord vines and that these vines were accidentally sprayed with fungicides after the May 10 mummy sample (mancozeb on May 30 and mancozeb + tebuconazole on June 11). It is unknown how much contact these fungicides had with plots below vines, or how they affected spore release by mummies or efficacy of the soil amendments.

Mummies that remain in the trellis after machine harvest operations are most cost effectively removed during dormant hand pruning. The timing of dormant pruning may be an important factor in black rot management. Early pruning (rather than late) and the application of compost or compost tea amendments to the soil may result in fewer spores available (from mummies on the ground) for infection in spring. This effect will be reexamined in more detail in 2007.

Technology Transfer:

1. A spring meeting held on May 24, 2006 at Lake Erie Regional Grape Research and Extension Center (LERGREC) discussed with growers the highlights of organic research conducted at LERGREC.

2. A one acre demonstration block of mature Concord vines at LERGREC has undergone its first year of transition to organic and was compared to an adjacent block of conventionally managed Concord vines. The conventional program reduced black rot severity on fruit to 0.2 % whereas severity in the organic block was at 16.1 %. A JMS Stylet oil/Armicarb O rotation in the transition block did not control black rot, but provided better control of powdery mildew than the conventional program (19 versus 56 % incidence on fruit). Bloom petiole tests revealed N P K levels in desirable range but Ca and Mg deficient for both conventional and transition blocks. Late summer petioles revealed that N, Ca, and Mg were in desirable range, but that P and K were deficient for conventional and transition blocks.

3. A mock inspection and demonstration of the transition block at LERGREC will be the platform for a pre season 2007 meeting to discuss certification and disease management with interested growers.

4. The results of the 2005 research trials have been posted on the LERGREC website at http://research.cas.psu.edu/erie/plant_path.htm The development of organic guidelines is also underway that, along with the 2006 results, will be loaded onto the website and linked to the Lake Erie Regional Grape Program.

Appendix

Impact Statement: Support from the Viticulture Consortium and the NY State Wine and Grape Foundation has provided the means for developing a growing body of research based information that will help growers interested in organic to make more informed pest management decisions. One of the greatest obstacles to organic viticulture in the east is the threat of black rot. We have shown that high levels of black rot control are possible even in wet years, when existing organic pesticides are integrated with cultural methods that reduce inoculum pressure. We are continuing to expand the knowledge base targeted at further reductions in black rot inoculum pressure while examining pesticide programs that reduce reliance on restricted materials.

Publication: The results of field trials with Concord and Niagara grapevines have been submitted for publication in Plant Management Reports (American Phytopathological Society).

Data tables referred to in the text.

Table 1. Percent control of black rot on leaves of potted Aurore and Concord grapevines. Percent control = control of disease severity on leaves over that of the check.

Treatment/rate per 100 gal	Aurore	Concord	Treatment/rate per 100 gal	Aurore
PESTICIDES			**PESTICIDES**	
Champion WP 2 lb + 4 lb lime	95	97	Lime Sulfur 0.25 %	96.5
Serenade ASO (QRD 143) 4 qts	81	71	Lime Sulfur 0.50 %	98
Armicarb O 5 lb	63	94	Lime Sulfur 1.00 %	100
GC-3 1 %	91	78	EF 400 0.25 %	93
Sonata ASO (QRD 288) 4 qts	32	7	EF 400 0.50 %	97
Sporan EC 1 %	27	16	EF 400 1.00 %	97
Citrex 0.10 %	88		Vineyard Magic 0.25 %	95
Citrex 0.08 %		96	Vineyard Magic 0.50 %	94
Citrex 0.04 %		88	Vineyard Magic 1.00 %	99
Citrex 0.02 %		66	Fungastop 0.10 %	91
Trilogy 1 %		24	Fungastop 0.25 %	90
WETTING AGENTS (16 oz)				
Yucca (Ag-Aide 50)	96	98		
Raingrow superflow	84	66		
Foliar friend	40	7	**PESTICIDE + WETTING AGENT**	
Natural wet	51	45	Champion WP 2 lb + 4 lb lime + Yucca 16 oz/A	98
Nufilm P	0	3	GC-3 1 % + Yucca 16 oz/A	98
Quillaja (QL-Agri)	22	18	Serenade ASO 4 qts + Yucca 16 oz/A	97

Table 2. Control of black rot on leaves of potted and field grown Concord grapevines. Percent control = control of disease severity on leaves over that of the check.

Treatment/rate per 100 gallons water	% Area Infected greenhouse	% Control	% Area Infected field	% Control
Lime Sulfur 0.25 %, one day prior to inoculation	0.29	99	0.0	100
Lime Sulfur 0.25 %, four days prior to inoculation	0.93	97	0.59	85
EF 400 0.25 %, one day prior to inoculation	0.83	97	0.0	100
EF 400 0.25 %, four days prior to inoculation	1.51	95	0.88	77
Citrex 0.10 %, one day prior to inoculation	0.30	99	0.39	90
Citrex 0.10 %, four days prior to inoculation	3.61	88	1.07	72
Unsprayed check	31.20		3.81	

Table 3. Control of black rot and powdery mildew on Concord clusters in the field

		Black Rot on Clusters: 11 Aug			Powdery Mildew on Berries: 7 Sep		
Treatment and rate/A	Timing[z]	% Infected[y]	% Area[w] infected[y]	% Control[x]	% Infected[y]	% Area[w] infected[y]	% Control[x]
Champion WP 4 lb + Lime 8 lb……………..	1-5……	86.5 a[v]	26.44 a[v]	63	40.0 bc[v]	0.96 bc[v]	67
Champion WP 2 lb + Lime 4 lb……………..	1-5……	90.5 a	36.10 ab	49	30.0 bc	0.80 abc	73
Champion WP 2 lb + Lime 4 lb + Yucca Ag Aide 16 oz	1-5……	96.0 b	42.34 b	40	29.0 bc	0.68 abc	77
Lime Sulfur 0.5 %……….	1-5……	99.0 c	58.31 c	18	14.0 ab	0.33 ab	89
Lime Sulfur 0.5 % + Yucca Ag Aide 16 oz...	1-5……	99.5 c	66.83 cd	6	12.0 a	0.28 a	90
Citrex 0.1 %.......................	1-5……	100.0 c	65.53 cd	8	73.0 fg	2.55 e	13
Serenade AS 4 qts + Yucca Ag Aide 16 oz...	1-5……	98.5 c	71.41 d	0	41.0 cde	1.03 c	65
Milstop 2.5 lb.....................	1-5……	100.0 c	71.60 d	0	39	1.19 cd	59
EF 400 0.25 %...................	1-5……	100.0 c	73.38 d	0	60.0 ef	2.13 de	27
GC-3 1 %...........................	1-5……	100.0 c	75.46 d	0	53.0 de	1.36 cd	54
GC-3 1 % + Yucca Ag Aide 16 oz...	1-5……	100.0 c	75.77 d	0	43.0 cde	1.31 cd	55
Yucca Ag Aide 32 oz.........	1-5……	99.5 c	70.06 cd	1	88.0 h	4.34 f	0
Yucca Ag Aide 16 oz.........	1-5……	99.5 c	75.99 d	0	81.0 gh	3.29 ef	0
Water-treated check………	1-5……	99.5 c	70.99 d		84.0 gh	2.93 ef	

[z] Spray timing. 1 = 30 May (pre-bloom); 2 = 8 June (pre-bloom); 3 = 20 June (1st post-bloom); 4 = 30 June; 5 = 11 July.
[y] Actual data are shown. Data were arcsinsqrt transformed before statistical analysis.
[x] Percent control = control of disease severity over that of the water-treated check.
[w] Severity was rated using the Barratt-Horsfall scale and was converted to % area infected using Elanco conversion tables.
[v] Means followed by the same letter within columns are not significantly different: Fisher's Protected LSD ($P \le 0.05$).

Table 4a. Control of black rot and downy and powdery mildew on Niagara clusters in the field.

		Black Rot on Clusters					
		Natural inoculum plus mummies			Natural inoculum only		
Treatment and rate/A	Timing[z]	% Infected[y]	% Area[w] infected[y]	% Control[x]	% Infected[y]	% Area[w] infected[y]	% Control[x]
Prophyt 0.3 %…………….	1-5……	88.5 a[v]	15.21 a[v]	81	6.0 a	0.40 a[v]	97
Champion WP 2 lb + Lime 4 lb……………..	1-5……	92.0 a	54.91 b	31	6.5 a	0.40 a	97
Lime Sulfur 1 %…………	1-5……	94.3 a	56.90 b	28	26.5 b	4.33 b	71
Citrex 0.1 %.......................	1-5……	100.0 b	85.38 c	0	47.5 c	12.79 c	14
Yucca Ag Aide 32 oz.........	1-5……	100.0 b	83.77 c	0	47.5 c	12.89 c	14
Quillaja 32 oz.....................	1-5……	100.0 b	84.40 c	0	52.5 c	13.64 c	9
Water-treated check………	1-5……	100.0 b	79.48 c		61.0 c	14.92 c	

Table 4b.

		Downy mildew on clusters			Powdery Mildew on Clusters		
Treatment and rate/A	Timing[z]	% Infected[y]	% Area[w] infected[y]	% Control[x]	% Infected[y]	% Area[w] infected[y]	% Control[x]
Champion WP 2 lb + Lime 4 lb……………..	1-5……	9.0 a[v]	0.58 a[v]	98	6.5 a[v]	0.15 a[v]	91
Prophyt 0.3 %…………….	1-5……	46.5 b	4.18 a	83	26.5 b	0.69 ab	59
Lime Sulfur 1 %…………	1-5……	87.5 c	17.55 b	29	11.5 a	0.27 a	84
Yucca Ag Aide 32 oz.........	1-5……	96.5 d	27.61 bc	0	37.0 bcd	1.37 cd	19
Citrex 0.1 %.......................	1-5……	97.5 d	31.55 c	0	41.0 cd	1.25 bcd	26
Quillaja 32 oz.....................	1-5……	96.0 d	31.56 c	0	31.5 bc	0.95 bc	44
Water-treated check………	1-5……	96.5 d	24.89 bc		49.0 d	1.70 d	

[z] Spray timing. 1 = 31 May (pre-bloom); 2 = 9 June (pre-bloom); 3 = 19 June (1st post-bloom); 4 = 29 June; 5 = 11 July.
[y] Actual data are shown. Data were arcsinsqrt transformed before statistical analysis.

[x]Percent control = control of disease severity over that of the water-treated check.
[w]Severity was rated using the Barratt-Horsfall scale and was converted to % area infected using Elanco conversion tables.
[v]Means followed by the same letter within columns are not significantly different: Fisher's Protected LSD ($P \leq 0.05$).

Table 5. Severity of black rot on field inoculated Concord clusters treated with organically-approved materials applied at different lengths of time before inoculation.

	North East PA				Geneva NY			
	Exper 1[z]		Exper 2[z]		Exper 1[z]		Exper 2[z]	
Treatment and rate/100 gal	1d[y]	7d[y]	1d[y]	7d[y]	4d[y]	7d[y]	1d[y]	6d[y]
Yucca Ag Aide 32 oz	32.2 a	99.6 d	79.2 b	91.9 c	84.9 c	85.0 c	56.5 bc	64.7 c
Champion WP 4 lb + lime 8 lb	91.9 c	91.0 c	92.4 c	91.9 c	38.7 ab	30.4 a	30.7 a	46.9 ab
Yucca Ag Aide 32 oz + Champion WP 4 lb + lime 8 lb	35.2 a	73.7 b	91.2 c	65.9 a	50.4 b	34.4 a	38.2 a	40.0 ab
Unsprayed check	99.6 d		97.2 d		86.7 c		56.2 bc	
Rainfall, spray to inoculation[w]	0.0	0.73	0.0	0.30	0.56	0.99	0.28	0.28

[z] Experiment 1 = 1 week after bloom; Experiment 2 = 3 weeks after bloom
[y] Number of days between treatment application and inoculation.
[x]Means within an experiment not followed by a common letter are significantly different ($P = 0.05$) according to Fisher's Protected LSD (North East) or the Waller-Duncan test (Geneva).
[w] Accumulated rainfall (inches) during the time between each spray application and the subsequent inoculation.

Table 6. Results of the laboratory bioassays showing emergence of moths from eggs laid before the insecticide application and number of grapes damaged by GBM infestation.

	Eggs	Moths emerged	Infested Grapes	Total Grapes	Percent Hatched	Percent Infected
Entrust	95	9	25	151	9.47%	16.56%
Dipel	259	51	122	189	19.69%	64.55%
Pyganic	181	50	132	179	27.62%	73.74%
AZA Direct	200	45	97	111	25.50%	87.39%
EF 300	218	64	132	171	29.36%	77.19%
Control	109	79	147	165	72.48%	89.09%

Table 7. Results of the field organic insecticide experiments showing eggs laid, moths emerged and damaged berries after insecticide application.

	Damaged Berries	Total Berries	Eggs	Moths Hatched	Percent Damages
Aza Direct	4	126	2	1	3.17%
Entrust	3	143	5	1	2.10%
Pyganic	23	141	13	4	16.31%
Dipel	35	164	21	9	21.34%
EF 300	33	140	22	10	23.57%
Control	46	150	30	17	30.67%

Figure 1. 10 May (10 days after bud break):
Total spores/mummy (x 10^4) x trt x date of mummy drop.

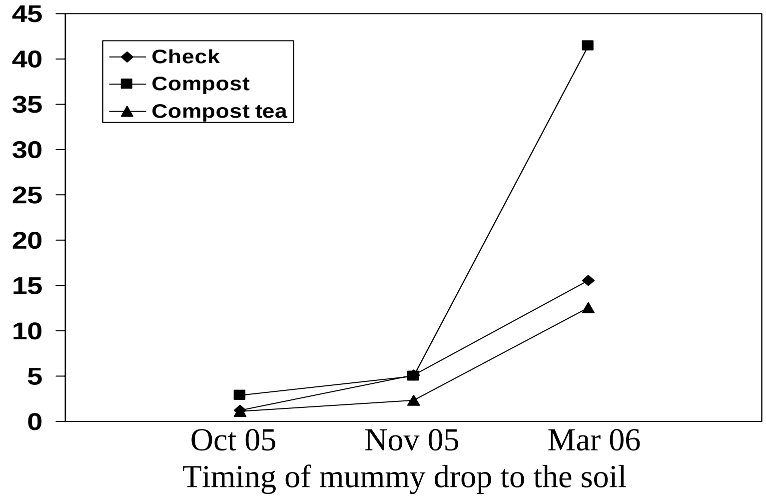

Figure 2. 6 June (one week before bloom):
Total spores/mummy (x 10^4) x trt x date of mummy drop.

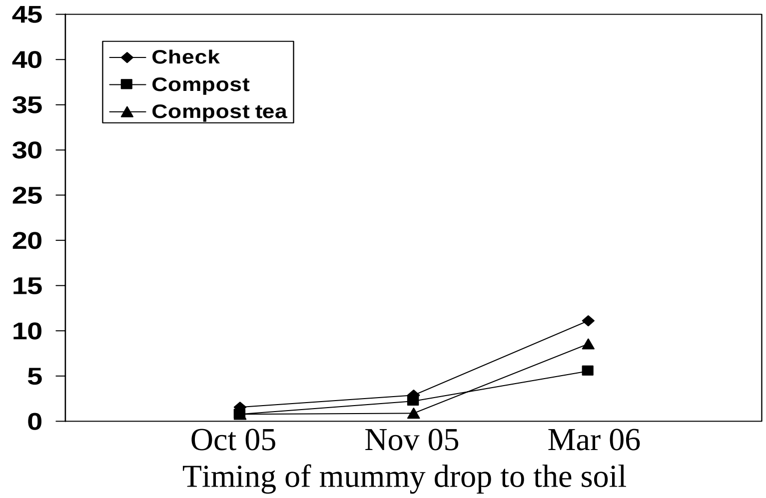

Figure 3. 7 July(12 days after bloom):
Total spores/mummy (x 10^4) x trt x date of mummy drop.