Control of Black Rot in Greenhouse and Field Trials Using Organic Approved Materials, 2006

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Increasing consumer demand for organically grown food and more environmentally sustainable production practices, as well as increasing concern over the management of fungicide resistance, are creating new pest management challenges and potentially profitable marketing opportunities for growers in Pennsylvania and New York. However, organic fruit production is among the slowest growing sectors of the organic industry, largely due to the enormous risks associated with high pest pressure in humid climates (Tamm et al. 2004). Greater development of research based pest management strategies for organic fruit production can minimize the risks and help close the gap between demand and supply.

Our work with organic viticulture has focused primarily on Concord grape. Concord is the dominant variety in Pennsylvania and New York, is relatively disease resistant and well adapted to growing conditions in the east, and requires lower pesticide inputs than most other varieties. Concord is marketed and consumed for its health benefits to adults, and more importantly, to children, and demand and prices for conventionally grown Concord juice have fallen or remain stagnant, while demand for organic foods continues to expand rapidly with possible price premiums to the producer of 20 % or more. However, our findings over the past two years can be applied to wine grapes as well and our greenhouse screening work has included some wine varieties: *Vitis* interspecific hybrid ‘Aurore’ and *Vitis vinifera* ‘Chardonnay’ and ‘Riesling’.

Pesticides available to organic producers are generally less effective than conventional materials which can increase a growers’ risk of economic loss, particularly when weather conditions swing in favor of fungal pathogens and insect pests. Although there is a bewildering multitude of commercially available pesticides for organic crop management, thorough testing of these products by universities is very limited and the efficacy of many of them is largely unknown, particularly with respect to black rot, a very important disease of grapes in the wetter climates of the eastern U.S. The pest management guidelines available to conventional grape growers have evolved through years of research and experience, and are essential to the sustainability of the industry. But there are relatively few proven management recommendations for the use of organic pesticides. Organic growers often rely on limited observations or information from sales representatives rather than research-based information to make management decisions.

This project focuses on the evaluation and development of integrated organic disease management strategies in order to provide more reliable options for organic grape production and develop research-based pest management guidelines for organic viticulture in Pennsylvania and New York. This report focuses on the development of effective fungicide programs.

1) Greenhouse screening trials for efficacy on black rot using potted grapevine leaves and clusters:
Black rot can be a major barrier to profitable organic grape production in the eastern U.S. Copper formulations currently provide the best control, but will not prevent serious crop loss under high disease pressure. With restrictions on copper use in organic agriculture (Europe is actually phasing out the use of copper in organic viticulture), and the high susceptibility of varieties grown in our region, finding alternatives to copper will improve the outlook on sustainability of organic production. The Organic Materials Review Institute (OMRI) has compiled an extensive list of commercially available, organic approved, crop management materials, but their efficacy on grape black rot is unknown. In 2005, we developed a simple assay to screen materials for black rot control. This assay has been applied to OMRI listed materials over the last two years using potted *Vitis labrusca* ‘Concord’ and *Vitis* interspecific hybrid ‘Aurore’. In 2006, some tests from 2005 were repeated and new materials were screened for the first time. All materials are commercially available as fungicides or wetting agents

on various crops. They include plant extracts and oils, potassium bicarbonates, biologicals, lime sulfur, copper, and others. Wetting agents were also tested because spores of the black rot fungus germinate poorly on hydrophilic surfaces (Kuo and Hoch, 1996).

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. Materials that showed evidence of good activity were bumped to the next level of scrutiny, field trials. 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.

Results: Table 1 summarizes the results achieved (% black rot control) under these conditions. Most pesticides and the yucca wetting agent provided good to excellent (90 % or better) control on leaves when applied 4-6 hours before inoculation, suggesting potential activity against the black rot fungus.

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 a water sprayed 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
Milstop 2.5 lb		95		
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

To determine a possible mechanism for the efficacy of the wetting agent , 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 %.

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 (check) 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 under these experimental conditions.

CONCLUSIONS:GREENHOUSE TRIALS. Greenhouse trials have shown that many OMRI listed materials have activity against the black rot pathogen when applied immediately before infection, and have the potential to provide some control of the disease in the field. Unfortunately, most of these materials provided little or no control of black rot in subsequent field trials (below).

2) Evaluate greenhouse screened materials for grape disease control in the field.
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 2). 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 3a 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.

Table 2. 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	39.0 cd	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 ($P \leq 0.05$).

Table 3a. 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 3b.

		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 ($P \leq 0.05$).

CONCLUSIONS:FIELD TRIALS. Under the severe infection conditions created in these experiments, product performance was modest to poor. Yucca extract, which worked well in greenhouse screening trials, 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. Seasonal lime sulfur shows potential as a rotational partner with copper for black rot control in relatively dry years, when combined with thorough removal of fruit mummies and other inoculum sources 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 just 4 days on expanding leaves (data not shown). Materials like lime sulfur, serenade, milstop, and GC-3 are 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 in this trial (under high and low disease pressure) and we have seen similar results in other tests. However, 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 in the greenhouse, 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. At this time, no other material can be recommended for control of these diseases in organic viticulture. Unfortunately, some grape varieties can be damaged by copper sprays, and lime may need to be tank mixed with some copper formulations (read the label). When well timed copper/lime sprays are 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.

References cited

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