Organic Grape Disease Control:
Control of Black Rot in Greenhouse and Field Trials Using Organic Approved Materials, 2005

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Evaluation of foliar applications of organically approved materials for grape black rot control.
I. Greenhouse assays on leaves of potted grapevines: In 2005, an efficient protocol was developed to screen materials on the OMRI (Organic Materials Review Institute) list for efficacy against black rot of grape using potted vines in the greenhouse. In most cases, OMRI listed materials were compared to a conventional protectant (Penncozeb), an organic standard (Champion (fixed copper)), and a water check. Materials listed in table 1 were selected for initial screening because they are specifically sold as fungicides (except wetting agent NuFilm-P) for controlling a number of plant diseases on various crops. Wetting agents (tables 2 and 3) were tested because spores of the black rot fungus (*Phyllosticta ampelicida*) germinate poorly on hydrophilic surfaces (Fungal Genetics and Biology 20:18-29, 1996) and trials have shown that wetting agents can suppress this disease (Fungicide and Nematicide Tests 55:118 (1999) and 56:SMF34 (2000)).

In potted vine experiments, leaves (2-3 youngest leaves per shoot) of potted grapevines (*Vitis x labrusca* 'Concord' and *Vitis* interspecific hybrid 'Aurore') were sprayed with treatments until runoff. Leaves were then inoculated 2-6 hours later with a conidial suspension (10^5 conidia per ml) of *Phyllosticta ampelicida*, the black rot pathogen. To satisfy conditions needed for infection, inoculated grapevines were immediately placed inside a mist chamber for 14-48 hours at room temperature before return to the greenhouse. Symptoms on Concord and Aurore leaves were observable 10-14 days after infection and were usually most severe on the youngest leaves. Symptom development was recorded 2-4 weeks after infection. Disease was rated using the Barratt-Horsfall scale and was converted to % area infected using Elanco conversion tables. Inoculum for the trials came from 2 isolates of the pathogen from Concord mummies collected in two Erie county Pennsylvania vineyards. Isolates of the fungus were maintained on half strength PDA under continuous fluorescent light at 25C. Conidia for inoculations were harvested from 14 day old cultures. The pathogen was regularly re-isolated from fresh leaf lesions onto agar media to insure a potent source of inoculum.

Results: Champion (copper hydroxide) plus lime, when applied shortly before inoculation, appears to provide excellent control of leaf infections on Aurore and Concord under these inoculation conditions. There is also evidence of some activity against black rot leaf infection by GC-3 (a combination of cottonseed and corn oil and garlic extract), Serenade (Bacillus subtilis) and Armicarb O (organic formulation of potassium bicarbonate). Sonata (Bacillus pumilus), Sporan (rosemary and wintergreen oil), and NuFilm-P did not appear to provide any control of the disease on leaves (Table 1) in these initial trials. We occasionally saw light phytotoxicity with 1 % solution of Sporan on grape leaves.

Table 1: Control of black rot on leaves of potted Aurore and Concord grapevines with organic approved (OMRI listed) materials. Vines remained in mist chamber for 14-22 hours.

	Aurore		Concord	
Treatment/rate per 100 gal	% Area Infected[y]	% Control[z]	% Area Infected[y]	% Control[z]
Penncozeb 75 DF 4 lb (sprayed check)	0.1a[x]	100	0.0a[x]	100
Champion WP 4 lb + 8 lb lime	0.9a	96	0.2ab	98
Champion WP 2 lb + 4 lb lime	1.6ab	94	0.0a	100
Serenade ASO (QRD 143) 4 qts	7.6 bc	70	7.0 cd	39.5
Armicarb O 5 lb	9.4 bc	63	4.9abc	58
GC-3 1 %	14.7 c	42	7.1 bcd	39
Sonata ASO (QRD 288) 4 qts	32.5 de	0	20.3 cd	0

Sporan EC 1 %	39.8	e	0	17.4	d	0
Nufilm P – 8 oz	43.7	e	0	11.6	cd	0
Water check	25.5	d		11.6	cd	

[z]Percent control = control of disease severity on berries over that of the check.
[y]Actual data are shown. Data were transformed by arcsinsqrt before statistical analysis.
[x]Means followed by the same letter within columns are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$).

Previous research has shown that spores of the pathogen germinate poorly on hydrophilic surfaces and past trials have shown some efficacy of wetting agents in reducing black rot. There was a wide range of efficacy among the wetting agents tested here. Yucca, Penex, and Raingrow superflow significantly reduced black rot and may enhance disease control as tank mixes with other products in the field. Yucca was superior to Penex which was superior to the Raingrow product. Other wetting agents tested provided little or no suppression of black rot on leaves (Table 2). Milstop, a potassium bicarbonate product very similar to Armicarb O, provided excellent control of leaf infections and was statistically equal to Penncozeb and Champion plus lime (table 3). The efficacy of Penex on black rot leaf infection fell dramatically when the infection period was increased from 20 to 48 hours, but Yucca was relatively unaffected (compare tables 2 and 3). Combining Penex and GC-3 significantly improved control over either product alone. However, adding Penex to Champion plus lime or Serenade did not improve control over either pesticide alone. Yucca, by itself, was very effective on black rot, and combining it with pesticides did not improve control. This may reflect a limitation of the leaf inoculation assay to produce differences among the best organic treatments and the conventional material, Penncozeb. Tank mixes of pesticides and wetting agents need to be examined more thoroughly on clusters in the field to see if efficacy and length of protective interval of organic treatments can be increased. There was no phytotoxicity associated with the application of any of these treatments involving wetting agents.

Table 2: Control of black rot on leaves of potted Aurore and Concord grapevines with organic approved wetting agents. All wetting agents were applied at the rate of 16 oz per 100 gallons water. Immediately after inoculation, vines were placed in a mist chamber for 20 hours.

	Aurore		Concord	
Treatment	% Area Infected[y]	% Control[z]	% Area Infected[y]	% Control[z]
Yucca (Ag-Aide 50)	0.7a[x]	98	0.8a[x]	99
Penex	8.8 b	78	10.3a	85
Raingrow superflow	22.6 c	43	33.8 b	50
Foliar friend	31.7 cd	19.5	68.6 cd	0
Natural wet	41.5 d	0	44.4 bc	34
Nufilm P	46.3 d	0	57.2 bcd	15.5
Quillaja (QL-Agri)	62.7 e	0	74.0 d	0
Water check	39.4 d		67.7 cd	

[z]Percent control = control of disease severity on berries over that of the check.
[y]Actual data are shown. Data were transformed by arcsinsqrt before statistical analysis.
[x]Means followed by the same letter within columns are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$).

Table 3: Control of black rot on leaves of potted Aurore grapevines with combinations of organic approved wetting agents and pesticides. All wetting agents were applied at the rate of 16 oz per 100 gallons water. Immediately after inoculation, vines were placed in a mist chamber for 48 hours.

Treatment/rate per 100 gallons water	% Area Infected[yx]	% Control[z]
Champion WP 2 lb + 4 lb lime	1.3ab	98
Champion WP 2 lb + 4 lb lime + Penex	1.3ab	98
Champion WP 2 lb + 4 lb lime + Yucca (Ag-Aide 50)	2.3ab	97
GC-3 1 %	30.4 ef	54
GC-3 1 % + Penex	8.0 bcd	88

GC-3 1 % + Yucca (Ag-Aide 50)	4.8 bc	93
Serenade ASO 4 qts	18.2 cde	73
Serenade ASO 4 qts + Penex	19.6 def	70
Serenade ASO 4 qts + Yucca (Ag-Aide 50)	1.5ab	98
Penex	34.4 f	48
Yucca (Ag-Aide 50)	1.6ab	98
Milstop 5 lb	3.9ab	94
Penncozeb 75 DF 4 lb	0.0a	100
Water check	66.4 g	

[z]Percent control = control of disease severity on berries over that of the check.
[y]Actual data are shown. Data were transformed by arcsinsqrt before statistical analysis.
[x]Means followed by the same letter within columns are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$).

II. Field trial: To examine organic fungicides in the field, a trial was conducted in a mature vineyard of *Vitis labrusca* 'Concord' at the Lake Erie Regional Grape Research and Extension Center in North East, PA (Table 4). Vines were trained to a single-curtain, high-wire cordon system. Treatments were applied to 3-4 vine plots with 4 replications. Fungicide applications were made with a Friend covered-boom plot sprayer at 100 psi and 100 gal/A. To enhance disease in plots and standardize disease pressure between plots, wire cages containing five black rot fruit mummies each were hung from the trellis wire at three locations within each plot (15 mummies per plot). In addition, 50 mummies were scattered on the soil under the row in each plot. Rainfall for May, June, July, August, and September was 2.7, 1.95, 8.24, 6.71, and 9.12 in., respectively. Almost all fruit disease occurred on clusters within a two foot wide zone centered beneath mummies hung in the trellis. Therefore, black rot incidence (percent infected) and severity (percent area infected) were determined only from clusters within this zone (75 clusters per plot on 1 August and all clusters per plot (within the zone) on 2 September).

Concord clusters in the field remained susceptible to black rot for at least 5 weeks after bloom. Disease pressure was light early in the season, becoming more intense after mid July. Most disease recorded on 1 August was the result of a low infection risk period on 4-5 July, about 2 weeks after bloom. Heavy rainfall during the 3rd and 4th week of July created conditions for numerous infection periods 4-5 weeks after bloom. At 1 August, only programs that included three applications of Champion (copper hydroxide) + lime were effective at controlling the incidence and severity of black rot. Armicarb O (organic) provided no control of the disease on fruit and three applications of the 5 lb rate produced unacceptable marginal necrosis on leaves. The NuFilm-P treatment significantly reduced the severity of black rot by 2 September. NuFilm-P, added to the 2 lb Champion rate improved control slightly, but the improvement was not significant (Table 4). The Champion rate could not be reduced from 4 lb to 2 lb with the addition of NuFilm-P, without sacrificing control.

Surprisingly, in limited preliminary Concord cluster inoculations, NuFilm P provided no control, Champion (at 4 lb/A) plus lime performed poorly (about 40 % control), and Armicarb O (at 5 lb/A) performed rather well (about 80 % control) at controlling fruit infections. This contrasts with results in the 3-4 vine field plots (Table 4). More detailed future tests will be needed to examine the length of the protection period afforded by various materials to better define their effective use in the field.

Table 4: Field evaluation of organic fungicides for control of black rot of Concord grapes.

		1 August			2 September		
Treatment and rate/A	Timing[z]	% infected[y]	% area infected[y]	% Control	% infected[y]	%area infected[y]	% Control
Champion WP 4 lb + Lime 8 lb	1-3	7.0a[w]	0.43a[w]	92	31.1a[w]	3.88a[w]	82
Champion WP 2 lb + Lime 4 lb	1-3	12.2a	0.87a	83	53.3b	10.28b	52
NuFilm P 8 oz	1-3	30.5b	3.76b	26	67.0bc	12.15b	43

Champion WP 2 lb + Lime 4 lb + NuFilm P 8 oz	1-3	9.7a	0.52a	90	61.2bc	8.94b	58
Armicarb O 5 lb	1-3	37.6bc	5.73bc	0	no data	no data	
Armicarb O 5 lb + Nufilm P 8 oz	1-3	36.8bc	4.60bc	9	no data	no data	
Armicarb O 2.5 lb + Champion 2 lb + Lime 4 lb + Nufilm P 8 oz	1-3	12.6a	1.03a	80	no data	no data	
Champion WP 2 lb + Lime 4 lb GC-3 0.5% + Nufilm P 8 oz Sporan 0.5 % + Nufilm P 8 oz	1 2 3	55.0c	8.28c	0	no data	no data	
Water check	1-3	41.1bc	5.07bc		83.0c	21.37c	

[z] Timing. 1 = 7 June (pre-bloom); 2 = 17 June (mid bloom); 3 = 29 June (post bloom)

[y] Actual data are shown. Data were transformed by sqrt transformation before statistical analysis

[x] Severity was rated using the Barratt-Horsfall scale and was converted to % area infected using Elanco conversion tables.

[w] Means followed by the same letter within columns are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$).