Organic Management of Raspberry Root Rot

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Objectives: 1. Analyze and compare performance of organic methods to control root rot.
2. Explore the effects of manure on the suppression of the root rot pathogen and impact on raspberry plant health and fruit yield.

Procedures:
We conducted two studies to investigate an integrated program for root rot (*Phytopthora fragriae* var. *rubi*) control in raspberries that would be useful to organic and conventional growers. These two studies have been carried out on our commercial field of 'Meeker' that was established in 1997 on raised beds with drip irrigation. Soil at this site is naturally infested with the root rot pathogen, providing medium-to-high levels of disease incidence.

Study 1. Beginning in the fall of 1999 at WSU Vancouver Research and Extension Unit (VREU), we tested two biological pesticides, *Trichoderma* (T-22) and *Gliocladium* (G-41), for their potential to control root rot in raspberries. Biological methods of root rot control were compared to the conventional chemical fungicide (Ridomil) to provide all growers with a means to compare the efficacy of these options for disease management. The planting was managed organically in regards to all other aspects of plant and soil management. Plots were 1 row wide and 25 feet long, and fruit were hand harvested in 2000 and 2001, and mechanically harvested in 2002. The study was a randomized complete block design with 4 replications and 7 treatments: 1) *Trichoderma* (T-22) 44 lb granular per acre; 2) *Gliocladium* (G-41) 1 lb WP per acre; 3) gypsum 6 tons per acre; 4) dairy manure 3.75 dry tons per acre; 5) dairy manure inoculated with *Trichoderma*; 6) Ridomil Gold 1.1 pints per acre; and 7) untreated control. Manure, T-22 and G-41 were applied by hand, and Ridomil was applied with a tractor-mounted sprayer.

Study 2. The objectives of this study were: 1) explore the effects of G-41, BioVita, dairy manure and poultry manure on the suppression of the root rot pathogen and their impact on raspberry plant health and fruit yield; 2) evaluate if there is an interaction between the two types of manure and the chemical fungicide Ridomil; and 3) determine if there are any human pathogen risks due to dairy or poultry manure in raspberry production. Plots were 3 rows wide and 60 feet long, and fruit was mechanically harvested.

Established in early 2002, this study included dairy manure and poultry manure and was designed to evaluate if the type of manure affected the potential of manure to control root rot and if there was an interaction between manure and ridomil. In early 2003, *Gliocladium* (G-41) and BioVita were added as separate treatments in the study. In Study 1, *Gliocladium* showed promise as a possible organic option for

root rot control in raspberries. BioVita is a biologically active soil amendment containing a wide array of beneficial microbes, soluble humic and fulvic acid, and slow release fish fertilizer nutrients, and is believed to reduce plant stress and disease by competing with plant pathogens, increasing soil fertility, and increasing beneficial microbial activity. This study was a randomized complete block design with 4 replications and 8 treatments: 1) *Gliocladium* (G-41) 1 lb per acre; 2) BioVita 500 lb per acre; 3) poultry manure 3 dry tons per acre; 4) dairy manure 20 dry tons per acre; 5) Ridomil Gold 1.1 pints per acre; 6) poultry manure + Ridomil; 7) dairy manure + Ridomil; and 8) untreated control. G-41 and BioVita were applied by hand, manures were applied with a side-discharge bedding spreader, and Ridomil was applied with a tractor-mounted sprayer.

Progress Towards Objectives:

Study 1 In 2000 and 2001, yield was measured in 5-feet of row by hand harvest; in 2002 yield was measured in 25-feet of row by mechanical harvest. In all 3 years of this study, yields in the plots that received the biological control organisms were greater than yields in untreated plots (Table 1). Berry yield in plots that received G-41 were moderate in 2000 and high in 2001 and 2002. The dairy manure treatment produced the highest yield in 2000 and very low yields in 2001 and 2002. Dairy manure plus T-22 produced low yields in 2000 and 2001, but in 2002 yields in this treatment were high. Plots that received Ridomil or G-41 produced high yields consistently all three years of the study. Although none of these differences were statistically significant, yields in the plots that received G-41 were consistently greater than yields in untreated plots and were approximately equal to yields in plots that received Ridomil.

In 2001 the number of beneficial fungi that colonized raspberry roots in plots that received G-41 was five times greater than in the T-22 or control plots (Table 2). However, due to the large standard deviation in the samples there was no statistical significance between the treatments. There were no effects of treatment on cane height or primocane number in 2000 and 2001 (Table 3), and in 2002 we did not collect this data due to overall poor plant growth throughout the study area. In this study, the effects due to treatment were overshadowed by a location effect of root rot in the field. Plots with the highest yield were located in the center of the study area (Figure 1) and there was no correlation between yield and treatment. By fall 2002, plants throughout the study area were in severe decline and we decided to abandon the study.

Study 2. In spring 2002, 2003, and 2004, we applied dairy and poultry manure and Ridomil treatments. Dairy and poultry manure were applied at medium-high rates (3 and 20 dry tons per acre, respectively), which are rates that are commonly used on farms in our region. The nitrogen contained in the manures was low (dairy contained 1.13% N on average, while poultry contained 3.7 % N) and thus we did not adjust the nitrogen fertilizer rates applied to the plots that received manure. In spring 2003 we added G-41 and BioVita as treatments to the study, and again applied G-41 in 2004, however, BioVita was not available and therefore not applied again. We measured yield in all plots in 2002 to establish a baseline of productivity for each plot in order to compare change in yield over time due to treatments. In both 2003 and 2004 we collected weekly 50-berry sub-samples of raspberries from the mechanical harvest yield samples, and in 2004 we also collected hand-picked 50-berry samples. In 2003 and 2004, soil samples from each treatment plot were collected once every two weeks from time of manure application to final harvest. Soil and berry samples were sent to the food microbiology laboratory at Oregon State University for pathogen analysis. In 2003, the laboratory established a screening technique to evaluate raspberry samples for E-coli H0167.

Throughout the three years of this study, the control plots (fertilizer only) consistently produced the smallest berry yields, but differences in yield due to treatments were not statistically significant (Table 4). In all three years, plots treated with poultry manure without Ridomil produced the largest yields of

all of the manure-treated plots, as well as the largest 50-berry weights. Plots treated with dairy manure + Ridomil had the second highest yields of the manure treatments. These results suggest that Ridomil activity may be influenced by the type of manure. Biovita and Gliocladium both showed trends of positive influence on raspberry yield. Differences in fifty-berry weights were statistically significant in 2003, but not in 2002 or 2004. Biovita-treated plots produced the largest 50-berry weights in 2003, followed by Gliocladium. These treatments also produced large berries in 2004. Plots treated with poultry manure produced the largest 50-berry weights in 2002 and 2004. Berry yields were smaller throughout the field in 2003 as compared to 2002 and 2004 likely due to freezing rains in the spring. Yields were largest in 2004, and berry weights were highest in 2002. At this time, the soil and berry samples are in the process of being assessed for potential pathogen levels.

While these results tended not to be statistically significant, the trends observed over the course of this three-year study were consistent. These results indicate that treating raspberry plants with poultry manure can increase berry yields 38–71% over untreated plants (Table 4). The use of BioVita can increase yields 57-85%, and Gliocladium can increase yields 28-66%. Treating raspberry plants with dairy manure plus Ridomil can increase yields 35-41%, but without Ridomil, dairy manure only increases yield 11-26%. All of these treatments showed consistently larger yields than plots treated with fertilizer plus Ridomil, which only showed yields 5-17% higher than untreated plots.

In 2004, the number of raspberry canes per linear foot of row was smallest in the untreated control plots, and largest in plots treated with BioVita and Dairy Manure + Ridomil (Table 5). These differences were statistically significant. Plots treated with BioVita produced 97% more canes than control plots, and plots treated with Dairy Manure + Ridomil produced 95% more. Fertilizer + Ridomil plots produced only 11% more canes than the control plots. All treatments had fewer canes infected with root rot than the untreated control plots, however, these differences were not significant (Table 5). Plots treated with Dairy Manure had the lowest number of infected canes, with 73% fewer infected canes than the control plots. Plots treated Poultry Manure + Ridomil plot had 69% fewer infected canes than the control plots. Plots treated with Gliocladium, Poultry Manure, and Biovita produced significantly taller primocanes than the other treatment plots, and the control plots produced significantly shorter primocanes than all other plots (Table 6).

The results of this study indicate that organic and biological treatments can be successful in improving raspberry yields and decreasing the occurrence of raspberry root rot. Poultry manure, Dairy Manure + Ridomil, BioVita and Gliocladium tend to be especially successful in increasing yield and cane number, and can provide greater yield increases than the commonly used chemical fungicide, Ridomil. Dairy Manure and Poultry Manure + Ridomil, were especially successful in decreasing root rot, and all treatments were more effective than Ridomil alone.

Publications:

- Miles, Carol, Peter Bristow, Jack Pinkerton, and Martin Nicholson. 2003. Organic Management of Raspberry Root Rot. Proceedings from Northwest Center for Small Fruits Research 12th Annual Conference, Kennewick, WA, p. 58.

- Bristow, Peter R., Carol A. Miles, John N. Pinkerton and Martin Nicholson. 2002. Identifying components of an integrated program to control raspberry root rot. Proc. Northwest Symposium on Organic and Biologically Intensive Farming. Nov. 8, 2002, Yakima, WA, p. 9.

- Chen, C., and C. Miles, and S. Klauer. 2001. Alternative methods of raspberry production and root rot control. Am. Soc. Hort. Sci. Abstr. 2001:475-476.

- Research results were presented at the Small Fruit Growers Workshops in Vancouver and Lynden in 2002.

- Our annual report and photos of the study are available on the WSU Agricultural Systems website, http://agsyst.wsu.edu.

Table 1. Berry yield per plot (g), weight per berry (g), and percent change relative to the untreated control for raspberry fruit harvested at WSU Vancouver REU in 2000 through 2002.

Year	Treatment	Berry yield (kg)		% Change	1 Berry Wt (g)		% Change
2000	Dairy manure	3.3	A*	33	1.90	A	10
	Ridomil	3.0	AB	21	1.93	A	12
	G-41	2.9	AB	16	1.86	A	8
	T-22	2.8	AB	13	1.90	A	10
	Dairy manure + T-22	2.6	B	5	1.91	A	10
	Gypsum	2.6	B	5	1.81	A	5
	Untreated control	2.5	B		1.73	A	
2001	Dairy manure	2.8	A	-5	3.06	A	29
	Ridomil	4.1	A	40	3.10	A	30
	G-41	3.9	A	34	3.75	A	58
	T-22	3.5	A	21	2.87	A	21
	Dairy manure + T-22	2.7	A	-7	2.60	A	9
	Gypsum	3.6	A	24	2.75	A	16
	Untreated control	2.9	A		2.38	A	
2002	Dairy manure	2.0	A	60	1.13	A	-14
	Ridomil	3.6	A	186	1.47	A	-15
	G-41	4.1	A	227	1.78	A	2
	T-22	2.3	A	87	1.60	A	-7
	Dairy manure + T-22	3.1	A	148	1.56	A	-3
	Gypsum	2.7	A	119	1.78	A	0
	Untreated control	1.2	A		1.72	A	

Table 2. Number of beneficial fungi per gram raspberry root sample in 2001.

Treatment	CFUs/g	Treatment	CFUs/g
T-22	23,250	Manure + T-22	18,500
G-41	109,250	Control	15,275

Table 3. Average floricane height (inches) and number, and percent increase relative to the control at WSU Vancouver REU in 2001.

Treatment	Cane Ht. (In)		% Increase	Cane No.		% Increase
Dairy manure	78	A*	-3.7	154	A	-6.7
Ridomil	80	A	-0.8	161	A	-2.4
G-41	80	A	0.0	171	A	3.6
T-22	77	A	-5.0	144	A	-12.7
Dairy manure + T-22	82	A	1.9	177	A	7.3
Gypsum	78	A	-3.4	156	A	-5.5
Untreated control	81	A		165	A	

*** Treatments with different letters are significant at p=0.05 level by Tukey's multiple range test.**

Figure 1. Yield distribution in the field plots.

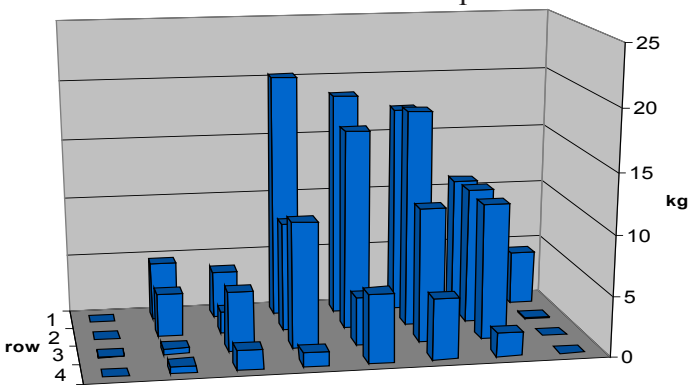

Table 4. Raspberry yield (kg) per plot, 50-berry weight (g), yield (tons) per acre, and percent increase in yield per acre over the control at WSU Vancouver REU in 2002, 2003, and 2004..

Year	Treatments	Total yield per plot (kg)		Avg 50 berry Wt (g)		Yield tons/A	Yield % of Control
2002	**Poultry manure**	37.1	A	120.3	A	5.92	38
	Dairy manure	33.9	A	111.5	A	5.41	26
	Poultry manure + Ridomil	31.4	A	117.1	A	5.01	17
	Dairy manure + Ridomil	37.9	A	114.5	A	6.05	41
	Fertilizer + Ridomil	28.2	A	110.8	A	4.50	5
	Fertilizer (control)	26.9	A	116.2	A	4.30	
	P Value	0.6252		0.7632			
2003	**Poultry manure**	14.7	A	91.3	B	2.35	71
	Dairy manure	10.4	A	80.0	C	1.66	21
	Poultry manure + Ridomil	11.4	A	87.4	BC	1.82	33
	Dairy manure + Ridomil	12.0	A	79.8	C	1.92	40
	Fertilizer + Ridomil	10.6	A	87.8	BC	1.69	13
	Gliocladium	11.0	A	108.0	A	1.76	28
	BioVita	13.5	A	116.5	A	2.16	57
	Fertilizer (control)	8.6	A	83.1	BC	1.37	
	P Value	0.6171		0.0000			
2004	**Poultry manure**	56.19	A	92.75	A	8.962	62
	Dairy manure	38.57	A	85.06	A	6.152	11
	Poultry manure + Ridomil	46.31	A	90.31	A	7.386	33
	Dairy manure + Ridomil	46.99	A	84.88	A	7.494	35
	Fertilizer + Ridomil	40.60	A	89.81	A	6.476	17
	Gliocladium	57.87	A	83.25	A	9.230	66
	BioVita	64.36	A	91.19	A	10.265	85
	Humus	50.62	A	91.92	A	8.074	46
	Fertilizer (control)	34.79	A	88.31	A	5.548	
	P Value	0.3389		0.6127			

Table 5. Number of raspberry canes per linear foot of row, and percent of canes infected with root rot in 2004.

Treatment	No. Canes per foot	DMRT	% change[x]	% Infected Canes	DMRT	% change[x]
Poultry manure	3.28	AB	57.9	1.80	A	46.2%
Dairy manure	3.22	AB	55.1	0.91	A	72.7%
Poultry manure + Ridomil	2.55	AB	22.9	1.02	A	69.4%
Dairy manure + Ridomil	4.06	A	95.3	2.00	A	40.4%
Fertilizer + Ridomil	2.30	B	10.7	2.51	A	25.1%
Gliocladium	3.15	AB	51.6	1.87	A	44.1%
BioVita	4.10	A	97.1	2.02	A	44.1%
Fertilizer (control)	2.08	B		3.35	A	
P-Value	**0.0649**			**0.3285**		

[x] Percent change as compared to control plots

Table 6. Average primocane height (inches) of raspberries grown with each treatment in 2004.

Treatment	Average primocane height (inches)	
Poultry Manure	93.44	A
Dairy Manure	82.90	AB
Poultry manure + Ridomil	89.59	AB
Dairy manure + Ridomil	80.15	AB
Fertilizer + Ridomil	84.32	AB
Gliocladium	96.10	A
BioVita	91.51	A
Fertilizer (control)	71.07	B
P Value	0.0960	