Research report submitted to:

Organic Farming Research Foundation
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Title: Alternative Methods of Raspberry Production and Root Rot Control

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Locations:
Pitman Farm, Nisqually (organic site) and WSU R&E Center, Vancouver, WA

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This report contains data from two years of on-farm trials and one year at the Washington State University Vancouver Research and Extension Unit. The Organic Farming Research Foundation provided funding only for the first year of the on-farm trial. The research station trial was funded by a grant from the Washington State Commission for Pesticide Registration (WSCPR), and this work continues with funding from the Washington Raspberry Commission as well as WSCPR. Distribution of this full report is possible with the kind permission of primary investigator Carol Miles.

INTRODUCTION

Root rot *(Phytopthora fragriae* var. *rubi)* is of primary concern to all raspberry growers in Washington, and is of particular concern to organic growers who have fewer options for disease control. This trial is focused on organic root rot control, however all raspberry growers will benefit from new disease management strategies.

Our study builds upon research led by Dr. Pete Bristow from 1995 to 1998. That work demonstrated that raised beds reduced the habitat for *Phytopthora* by increasing drainage, but were not sufficient to control root rot. In spring 1999, in cooperation with Jan Pigman at Pigman's Organic Produce Patch, and with the funding support of the Organic Farming Research Foundation, we began to study six organic treatments for the control of raspberry root rot. In the summer of 1999, we were able to match OFRF funds with funding from the Washington State Commission for Pesticide Registration (WSCPR). We established raspberry research plots at the WSU Vancouver Research and Extension Unit, and included five organic treatments, one chemical treatment, and a control. It is our goal to use the WSU research station site to compare the effectiveness of organic disease control treatments to the standard chemical control treatment.

STUDY OBJECTIVES

- Analyze and compare performance of organic methods to control raspberry root rot at Vancouver REU and in an organic growers' field.

- Observe and compare growth and fruit production of raspberry under conventional and organic farming systems.

PROCEDURES AND METHODS

Pigman's Farm - 1999-2000. Research design is a split-plot where the main plot treatment is soil level (flat or raised) and sub-plot treatments and application rates in 1999 and 2000 were:

	April 1999	**April 2000**
1. *Trichoderma* (T-22)	4 g (2.4 lbs/acre)	75g (20 lbs/acre)
2. Gypsum	7.5 lb (1 ton/acre)	7.5 lbs (1 ton/acre)
3. Chicken manure	31 lbs (4 tons/acre)	57 lbs (8 tons/acre)
4. Horse manure	61 lbs (8 tons/acre)	57 lbs (8 tons/acre)
5. Horse manure + T-22	61 lbs and 4 g, respectively	57 lbs and 75 g, respectively
6. Control	no application	no application

Chicken manure is typically used on the farm and was included to evaluate this available resource for disease suppression. Horse manure was included because soil microbiologists (who were consulted) felt it it's high C:N ratio may be conducive to disease suppression, and it may enhance the activity of *Trichoderma.* Manure application rates in 1999 were based on actual nutrient analyses, whereas in 2000, application rates were based on estimated analyses. All sub-plots, except those that received chicken manure, were fertilized with blood meal at the rate of 1 00 lbs N per acre both years. Chicken manure

had a high nitrogen content and a good C:N ratio and was therefore felt to be an adequate source of nitrogen.

The raspberry variety at this site is Chilliwack. The study includes 2 rows of newly established plants and 4 rows of 4-10 year old plants. Plots are 1 row wide 16 feet long. On April 20, 1999, the new raspberries were planted and *Trichoderma* was applied in the root zone. At that time, raised beds were created in the study area. On May 11 1999, all other treatments were applied in four-foot wide bands, centered on the row. *Trichoderma and* gypsum were lightly incorporated. Chicken and horse manure, and horse manure inoculated *with Trichoderma,* were applied as mulch. In 2000, all treatments were applied on April 20. We increased the application rate of *Trichoderma* based on manufacturer recommendations.

In 1999, raspberries were harvested in the center 5-feet in each plot. Whole-plant samples were collected for disease analysis from the area immediately adjacent to the yield-collection area. Disease analysis indicated that crown gall and *Armillaria* (shoe string) root rot were present in the field along with *Phytophthora* root rot. In 2000, raspberries were harvested in the center 3 feet in each plot and fruiting canes were evaluated for root rot incidence.

WSU Vancouver Research and Extension Center - 1999-2000. In the fall of 1999, research plots were established at the WSU Vancouver Research station. The raspberry variety at this site is Meeker, and the planting is 4 years old. The study is a randomized complete block design with 4 replications. Each row is 175 feet long and plot length is 25 feet. All raspberry rows in the study area are on raised beds. Treatments were applied November 29, 1999 and again on April 3, 2000. All treatments except gypsum were applied on both dates:

	November 1999	**April 2000**
1. *Trichoderma* (T-22)	1 1 7g (20 lbs/acre)	117g (20 lbs/acre)
2. *Gliocladium* (G-41)	117g (20 lbs/acre)	117g (20 lbs/acre)
3. Dairy manure t	24 lbs (1.75 tons/acre)	24 lbs (1.75 tons/acre)
4. Dairy manure + T-22	24 lbs + 1 1 7g, respectively'	24 lbs + 117g, respectively
5. Ridomil	recommended rate	recommended rate
6. Gypsum	24 lbs (1.75 tons/acre)	no application
7. Control no	application	no application

Treatments were applied in four-foot wide bands centered on the row and were not incorporated. The *Trichoderma and Gllocladium* granules were mixed with potting soil to aid in spreading, and sprinkled on top of the raised beds. Ridomil was applied in liquid form using a backpack sprayer. Manure was applied as mulch, For plots that received manure *plus Trichoderma,* the manure was applied first and the *Trichoderma* was sprinkled on top. Gypsum was applied only in the fall as we felt that a fall application would be most effective. On April 13, 2000 blood meal was mechanically banded near the root zone at a rate of 60 lbs N per acre. On June 9, an additional 40 lbs N per acre was applied.

Root rot incidence and number of primocanes were evaluated in a three-foot area in each plot in May 2000. Yield was collected by hand harvest, and disease incidence of floricanes was evaluated using a visual rating scale. Photosynthetic rate and chlorophyll content of fruiting and primocanes were also measured.

RESULTS AND DISCUSSION

In 1999, the efficacy of the treatments to control raspberry disease differed between the raised and flat beds at Pigman's Farm (Table 1). On raised beds, chicken manure produced the highest yield while on

flat beds, horse manure produced the highest yield. *Trichoderma* produced the second highest yield on both raised and flat beds. *Trichoderma* appeared to have a beneficial effect in both the raised and flat bed rows, while chicken and horse manure appeared to work well in one or the other, but not both.

In 2000, fruit yield in raised beds was higher than on flat beds at Pigman's Farm, but this difference was not significant. Dairy and horse manure treatments produced the highest yields (significantly) at each site (Table 2). At Vancouver REU, yields in response to dairy manure, *Trichoderma, and Gliocladium* were comparable to yield in response to Ridomil. Manure + T-22 produced lower yield than manure or T-22 alone at both sites, indicating a possible negative interaction. Benefits of manure may be due to suppression of root rot pathogen and enhancement of beneficial fungi, as well as improved plant nutrition. There were no differences in root rot ratings of fruiting canes due to any of the treatments (Table 3). Fruiting canes at mid-harvest at Vancouver REU were chlorotic as compared to fruiting canes in adjacent conventional plots (Table 4). Plants began to show nitrogen stress symptoms in early June, when hot temperatures caused rapid plant growth. Nitrogen stress was likely due

to the slow release activity of the organic fertilizer (blood meal) under low soil temperatures in the spring. T-22 and G-41 produced the lowest photosynthetic rates in primocanes following harvest while primocanes in adjacent conventional plots had the highest rates.

Raspberry plots at Pigman's Produce are limited due to the overall size of the raspberry planting at this farm. Small plots have led to a lack in replications and we believe this has limited the scientific conclusions of this study at that location. To improve our on-farm experimental design, we will establish new on-farm plots with Sakuma Farms in Skagit County, Sakuma Farms have established 30 acres of 'transition to organic' raspberries and have made a portion of this planting available to us for this study.

OUTREACH

A brief article announcing funding for this project and an outline of the study appeared in the Washington Tilth Journal, Summer 1999, Volume 7, Issue 3.

A preliminary report was presented at the Washington State University Master Gardener conference in Seattle, October-1999.

In November 1999, Anne Schwartz, Jan Pigman, Carol Miles, and Dawn Youmans, presented an overview of the study at the Washington State Tilth Producers Conference in Port Townsend.

An article discussing the study outline and preliminary results appeared in the Western Fruit Grower, September 2000.

A photograph of this study appeared on the cover of HortTechnology OctoberDecember 2000 and the accompanying article briefly discussed the organic component of this study.

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

Table 1. Weight (g) and number of marketable and unmarketable raspberry fruit harvested at Pigman's Produce in 1999.

	Treatment	Wt. of marketable	SE	Wt. of marketable	SE	Wt. of unmarketable	SE	Wt. of unmarketable	SE
Raised bed	*Trichoderma* (T-22)	168.22	(25.46)	58.53	(9.51)	41.23	(9.37)	27.84	(6.71)
	Gypsum	165.51	(28.45)	52.79	(10.82)	41.67	(11.39)	23.65	(8.45)
	Chicken Manure	217.44	(25.46)	79.81	(9.51)	61.09	(9.66)	36.44	(6.95)
	Horse Manure	54.71	(27.35)	13.03	(10.33)	15.35	(9.70)	11.51	(6.98)
	Horse Manure + T-22	137.41	(25.46)	42.60	(9.51)	36.47	(9.70)	22.55	(6.98)
	Control	78.86	(26.36)	23.94	(9.89)	41.37	(9.70)	44.21	(6.98)
Flat bed	*Trichoderma* (T-22)	234.90	(26.36)	91.81	(9.51)	62.15	(9.70)	42.06	(6.71)
	Gypsum	95.36	(25.46)	30.02	(9.51)	35.85	(9.37)	27.41	(6.71)
	Chicken Manure	137.97	(19.11)	10.67	(4.72)	16.11	(6.96)	9.17	(3.54)
	Horse Manure	241.48	(25.46)	97.74	(9.51)	59.87	(9.37)	38.48	(6.71)
	Horse Manure + T-22	131.42	(25.46)	62.24	(9.51)	47.00	(9.66)	33.51	(6.95)
	Control	143.58	(25.46)	66.67	(9.51)	53.91	(9.37)	45.70	(6.71)
	Significance	*0.01*		*0.01*		*0.01*		*0.01*	

Table 2. Fruit size and yield (hand harvest) of raspberries in 2000.

Location	Treatment	Berry yield (g)	% Increase over control	Berry weight (g)	% Increase over control
Pigman's Produce	Horse manure	1137 A*	87.4	2.83 AB	19.9
	T-22	1057 B	74.2	2.67 AB	13.1
	Chicken manure	963 B	58.8	3.43 A	46.6
	G-41	877 B	44.5	2.61 AB	10.6
	Horse manure + T-22	737 B	28.8	2.34 B	-0.7
	Control	607 B		2.36 B	
	Raised bed	996 A	25.0	2.76 A	4.2
	Flat bed	797 A		2.65 A	
Vancouver REU	Dairy manure	3307 A	32.9	1.90 A	9.8
	Ridomil	3012 AB	21.1	1.93 A	11.6
	G-41	2878 AB	15.7	1.86 A	7.5
	T-22	2819 AB	13.3	1.90 A	9.8
	Dairy manure + T-22	2619 B	5.3	1.91 A	10.4
	Gypsum	2618 B	5.2	1.81 A	4.6
	Control	2488 B		1.73 A	

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

Table 3. Visual rating of root rot disease on.fruiting canes at the beginning of harvest in 2000.

Location	Treatment	Root rot rating of fruiting canes (visual scale:1-9*)
Pigman's Produce	T-22	3 A**
	Chicken manure	3.2 A
	Horse manure	3.3 A
	Control	3.5 A
	Horse manure + T-22	3.7 A
	Gypsum	3.8 A
Vancouver REU	Ridomil	2.5 A
	G-41	3 A
	Dairy manure	3.3 A
	T-22	3.5 A
	Dairy manure + T-22	3.5 A
	Control	3.5 A
	Gypsum	4.3 A

* Visual rating scale of 1-9 where 1 is the least amount of disease.
**Treatments with different letters are significant at p=0.05 level by Turkey's multiple range test.

Table 4. Photosynthetic rate and chlorophyll content of raspberries at WSU Vancouver REU in 2000.

Treatment	Fruit canes measured at the middle of fruit harvesting		Primocanes measured after fruit harvesting	
	Photosynthetic rate ($\mu mol.m.s^{-1}$)	Chlorophyll content (mg/dm^{-2})	Photosynthetic rate ($\mu mol.m.s^{-1}$)	Chlorophyll content (mg/dm^{-2})
T-22	23 A*	2.82 B	10 B	2.92 A
Dairy manure	22.5 A	2.87 B	12.1 AB	2.88 A
Dairy manure + T-22	22.4 A	2.73 B	13.3 AB	2.7 A
Gypsum	22.2 A	3.11 B	11.3 AB	3 A
Ridomil	21.4 A	2.49 B	12.5 AB	2.78 A
Control	20.8 A	2.47 B	12.2 AB	2.88 A
G-41	20.4 A	2.53 B	9.9 B	3.06 A
Conventional production**	21.8 A	4.72 A	14.6 A	3.22 A

* Treatments with different letters are significant at p=0.05 level by Turkey's multiple range test.
** Leaf samples of the conventional production were taken from rows next to the trial in the same field but under conventional management.