FIELD EVALUATION OF NON-FUMIGANT MEASURES FOR THE CONTROL OF APPLE REPLANT DISEASE

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Introduction

Identification of the pathogen complex that incites apple replant disease has provided the foundation to explore the development of a biologically-based management system for control of this disease. In Washington state, the causal pathogen complex is composed of several species of fungi belonging to the genera *Cylindrocarpon, Phytophthora, Pythium* and *Rhizoctonia* (Mazzola, 1998). Though the relative contribution of these elements to disease development can vary from site to site, all 4 genera consistently contributed observed replant disease incidence throughout the apple production region of central Washington. The lesion nematode, *Pratylenchus penetrans*, which has been implicated as a primary causal agent in other regions can have a significant site-specific role, but more commonly is not involved in disease development. In the conduct of these studies, cultural, biological, and fungicide control methods have been evaluated for the ability to suppress the causal pathogen complex and enhance growth and yield of apple on replant sites.

Materials and Methods

Initial field trials were established in 1997 at the Columbia View Research and Demonstration Orchard, Orondo, WA, and planted to Gala/M.26 in May 1998. Various commercial and developmental biocontrol agents, semi-selective fungicides having activity toward pythiaceous fungi or *Rhizoctonia* spp., and cultural practices including soil disturbance and establishment of the new orchard in the old orchard aisle were evaluated. Yield data were collected in August 2000 and 2001. Additional field trials were initiated at the Columbia View and Wenatchee Valley College-Auvil orchards in the fall of 2000 and spring 2001. Non-fumigant treatments examined in these trials included establishment of wheat (cv. Penawawa; 336 kg/ha) in the orchard aisle, solarization (6 mil clear plastic), *Brassica napus* seed meal soil amendment (6735 kg/ha) and integration of these methods.

Results and Discussion

Altering spatial patterns in the orchard, use of specific fungicides that targeted multiple elements of the causal fungal complex, or soil excavation in the fall prior to planting each enhanced yields at the Columbia View orchard (Table 1). Use of fungicides individually that possessed activity against only one element of the pathogen complex (e.g. difenconazole or metalaxyl) failed to enhance growth and yield of Gala/M26 at this and additional sites (Mazzola, unpublished data). Co-application of flutolanil and metalaxyl, which possess activity toward *Rhizoctonia* and pythiaceous fungi, respectively, resulted in an initial suppression of vegetative tree growth due to apparent phytotoxicity, but second-year yields (fourth growing season) were equivalent to that obtained through methyl bromide fumigation. These results suggest that a fungicide treatment may be a viable alternative to fumigation on replant sites, such as the CV orchard, where the lesion nematode does not have a role in disease development. Establishment of new trees in the old orchard drive row (aisle) rather than the old orchard tree row resulted in an initial increase in fruit yield. To allow for orchard management, trees in the orchard drive row were removed after the initial harvest.

Soil solarization during the summer prior to planting (2001) and all treatments that incorporated *B. napus* seed meal amendment significantly improved first year vegetative growth of apple at both the CV and WVC orchards (Tables 2 and 3). Surprisingly, autumn applications of seed meal during each of two years prior to planting was no more effective than a single application in the autumn prior to planting in promoting tree growth at the WVC-A orchard. This finding, in concert with the low rates applied and results from greenhouse trials (Mazzola et al., 2001), suggest that the growth response was not the result of enhanced plant nutrition. Soil solarization was less effective in improving tree growth than *B. napus* seed meal amendment at the CV orchard. Given the relatively cool summer of 2001 in central Washington, the enhanced growth in response to solarization was unexpected and suggests significant promise for the effective use of this practice in management of the microbial complex inciting apple replant disease.

As was observed in greenhouse trials, the impact of wheat cultivation in conjunction with *B. napus* meal on initial tree growth appeared to be affected by sequence of application. Although values were not statistically different, growth as defined by an increase in diameter was approximately 25% greater for trees planted in seed meal/wheat treated soils than in wheat/seed meal treated soils at the WVC-A orchard. The same results were obtained in greenhouse trials in soils lacking significant populations of parasitic nematodes. The reverse application sequence provided a superior growth response in replant soils possessing high populations of *P. penetrans* (Table 4), and this was directly associated with the impact of treatments on populations of this plant parasitic nematode (Figure 1).

A one year pre-plant cropping of wheat at either site had no significant impact on first-year vegetative growth of apple. It is plausible that this resulted from the negative impact of wheat cropping on soil fertility, as soil N content in wheat cultivated soil at the WVC-A dropped from 38 mg/kg soil prior to planting to 3 mg/kg soil. However, such an assessment awaits an examination of tree root systems to determine the impact of wheat cultivation on colonization of apple roots by the causal pathogen complex.

Results from this study suggest that the integration of certain cultural practices and narrow-spectrum biocides has significant potential as an alternativ to pre-plant soil fumigation for the control of apple replant disease. Recommendation of such methods awaits confirming yield data from field trials in progress and development of guidelines for questions such as the appropriate application sequence.

References

Mazzola, M. 1998. Elucidation of the microbial complex having a causal role in the development of apple replant disease in Washington. Phytopathology 88:930-938.

Mazzola, M., Granatstein, D. M., Elfving, D. C., and Mullinix, K. 2001. Suppresssion of specific apple root pathogens by *Brassica napus* seed meal amendment regardless of glucosinolate content. Phytopathology 91: 673-679.

Table 1. Effect of cultural, biological and chemical methods on yield of 'Gala'/M.26 planted on replant ground in 1998 at Columbia View orchard, Orondo, WA

Treatment	2000 yields (kg/tree)	2001 yields (kg/tree)
Control	4.6	20.64
Methyl bromide fumigation	7.2*[z]	27.12*
Soil excavation	5.4	25.72*
Interplanting (aisle)	6.4*	-[y]
Pseudomonas putida 2C8	4.1	21.36
RootShield® (*T. harzianum*)	4.7	22.45
Difenconazole	3.4	23.71
Metalaxyl+flutolanil	4.5	29.1*
Humic acid	3.4	19.9

[z]Means in a column followed by (*) are significantly different (*P*=0.05) from the control.
[y]Trees removed from the aisle October 2000.

Table 2. Impact of soil treatments on first-year growth of Gala/M26 on a replant site at the Columbia View Research and Demonstration Orchard, Orondo, WA

Treatment	Increase in diameter (mm)
Control	1.8c[z]
Fumigation (Telone C17)	3.0a
B. napus seed meal	3.2a
Wheat	1.8c
Solarization	2.5b

[z]Means in the same column followed by the same letter are not significantly (P=0.05) different based on the Student-Newman-Keuls test.

Table 3. Impact of soil treatments on first-year growth of Golden Delicious/M9 on a replant site at Wenatchee Valley College-Auvil Research and Demonstration Orchard, E. Wenatchee, WA

Treatment	Increase in diameter (mm)
Control	2.4c[z]
Fumigation (Telone C17)	5.8a
B. napus seed meal (2000+2001)	4.4b
B. napus seed meal (2001)	4.3b
Wheat	2.2c
Wheat + *B. napus* seed meal	3.7b
B. napus seed meal+wheat	4.6b
Solarization	3.6b
B. napus seed meal+solarization	3.6b

[z]Means in the same column followed by the same letter are not significantly (P=0.05) different based on the Student-Newman-Keuls test.

Table 4. Impact of application sequence on growth of Gala seedlings in GC orchard soil in response to wheat/*Brassica napus* seedmeal treatments.

Treatment	Root weight (g)	Shoot weight (g)	Shoot height (cm)
Control	0.75	1.74	9.9
0.1% seedmeal	0.91	1.99	11.6
Wheat/0.1% meal	1.12	2.6	14.8
0.1% meal/wheat	0.52	1.57	10.2
LSD *P*=0.05	0.15	0.74	2.9

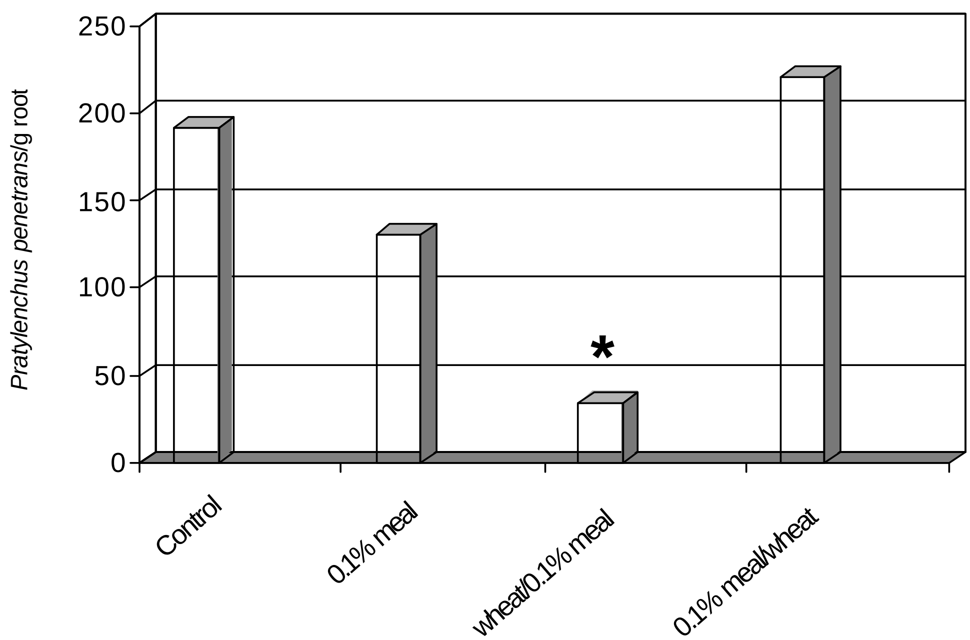

Figure 1. Populations of *Pratylenchus penetrans* recovered from roots of Gala apple seedlings grown in GC orchard (Manson, WA) replant soil. Designation with (*) indicates a population significantly different from the control.