Efficacy of Biopesticides and Fungicides against Pre- and Post-emergence Damping-off of Vegetable Seedlings by *Rhizoctonia solani*

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Introduction

Rhizoctonia solani is a common soil-borne pathogen that causes seed rot, damping-off and root rot during the production of vegetable seedlings in the greenhouse. Plant crowding, variable temperatures, over-watering and high humidity favor damping-off, and there are no fungicides highly effective against damping-off pathogens that are labeled for greenhouse use. *Muscodor albus*, an endophytic fungus obtained from *Cinnamomum zeylanicum* L. in Honduras, produces a mixture of volatile organic compounds toxic to fungi, bacteria and nematodes (1, 2, 3). Rye grain cultures of *M. albus* controlled damping-off caused by *R. solani* or *Pythium ultimum* in broccoli seedlings in a potting mix in the greenhouse (4), and other formulations were also effective in other systems (5). The fungus *Trichoderma* has been shown to be particularly effective in the control of the pathogen. Various mechanisms have been proposed to explain biocontrol of *R. solani*, namely production of antibiotics (6) and hydrolytic enzymes (7, 8), mycoparasitism and hyphal disruption (9). *Trichoderma* spp. may affect the viability of sclerotia of *R. solani* (10). The *Bacillus subtilis* strain QST713, marketed as Serenade ASO and Rhapsody ASO, is advertised to have a spectrum of activity including over 40 plant diseases such as gray mold, damping-off and powdery mildews. The bacterium is presumed to work through a number of modes of action such as competition, parasitism, antibiosis, and induction of systemic acquired resistance (SAR) (11). Polyoxin D zinc salt has been effective against *Rhizoctonia* spp. in turf grass, and may be very effective against *R. solani* damping-off (12, 13). Moncut (Flutolanil), when applied in-furrow during the planting of no-till spring barley, increased seedling height and reduced the percent of crown roots with Rhizoctonia (14).

Objective

To test the efficacy of biopesticides and fungicides to control Rhizoctonia damping-off of cabbage and pepper, which serve as models for vegetable transplant production.

Materials & Methods

Twelve treatments were evaluated for efficacy against Rhizoctonia damping-off in cabbage (cv. Bravo) seedlings in 2004 **(Table 1)**, and nine treatments were evaluated in pepper (cv. California Wonder) and cabbage (cv. Bravo) in 2005 **(Table 2)**. *Trichoderma hamatum* 382 was evaluated in Fafard Superfine Germinating mix (Fafard) and peat potting mix (peat: perlite 70:30 (v:v) amended with, per L 3.8g dolomite lime, 1.3g Mississippi lime, 0.8 g potassium nitrate, 0.8g triple super phosphate and 0.8g gypsum) (peat). All treatments except Muscodor were applied at the time of sowing seeds. Muscodor (7.5 g) was mixed with inoculum (5 g) of *R. solani* isolate 122 produced on chopped potato/soil medium, Fafard mix (1 L) and sterile water (100 ml) 7 days prior to sowing seeds. A Muscodor-only control and a potting mix-only control were prepared in the same way, omitting *R. solani* 122 inoculum or both inoculum and Muscodor, respectively. For the remaining treatments, on the day of sowing, the center 48 cells of 288-cell trays were filled with *R. solani* 122-infested potting mix (0.5 g inoculum/100 ml Fafard or peat) and the remaining cells of each flat were filled with non-inoculated potting mix. Treatments were applied to the entire flat, with the exception of the Muscodor, *T. hamatum* 382 and Thiram treatments, which were only applied to the center 48 cells of each flat. The center 48 cells of each flat were seeded with cabbage or pepper. All flats were placed in the greenhouse in a randomized complete block design with four replications. Greenhouse temperatures were set to 80°F daytime and 70°F nighttime. Automatic overhead watering was set up for one pass at 4ft/min., three times daily.

Table 1. Rhizoctonia damping-off treatments, rates applied and type of potting mix used, 2004.

Treatment	*R. solani*	Rate	Potting Mix
Composted cow manure	+	10%	Peat
Untreated control	+	Water drench	Peat
Untreated control	-	Water drench	Peat
Trichoderma hamatum 382	+	0.4g/L planting mix	Fafard
T. hamatum 382	+	0.4g/L planting mix	Peat
T. hamatum 382	-	0.4g/L planting mix	Peat
Muscodor	+	7.5g/L planting mix	Fafard
Muscodor	-	7.5g/L planting mix	Fafard
Untreated control, potting mix incubated *w/o* Muscodor	-	Water drench	Fafard
Moncut	+	0.71 lb/A	Fafard
Omega Grow	+	2% drench	Fafard
Omega Grow Plus	+	2% drench	Fafard
Seacide	+	2% drench	Fafard
Phosphonate	+	1% drench	Fafard
Prestop	+	1% drench	Fafard
Mycostop	+	0.01% drench	Fafard
Pseudomonas fluorescens-Wayne1R	+	$1x10^5$ CFU/ml	Fafard
P. fluorescens-Mg1A2R	+	$1x10^5$ CFU/ml	Fafard
Untreated control	+	Water drench	Fafard
Untreated control	-	Water drench	Fafard

Table 2. Rhizoctonia damping-off treatments, rates applied and type of potting mix used, 2005.

Treatment	*R.solani*	Rate	Potting Mix
Composted cow manure	+	10%	Peat
Untreated control	-	Water drench	Peat
Trichoderma hamatum 382	+	0.4g/L planting mix	Fafard
Muscodor	+	7.5 g/L planting mix	Fafard
Muscodor	-	7.5 g/L planting mix	Fafard
Muscodor	+	3.5 g/L planting mix	Fafard
Muscodor	-	3.5 g/L planting mix	Fafard
Untreated control, potting mix incubated *w/o* Muscodor	-	Water drench	Fafard
Moncut	+	0.71 lb/A	Fafard
Omega Grow	+	2% drench	Fafard
Omega grow plus	+	2% drench	Fafard
Endorse	+	1.6 lb/100 gal	Fafard
Endorse	+	2.0 lb /100 gal	Fafard
Serenade ASO	+	0.5% drench	Fafard
Serenade ASO	+	1% drench	Fafard
Serenade ASO	+	2% drench	Fafard
Thiram	+	1tsp/1Lb	Fafard
Untreated control	+	Water drench	Fafard
Untreated control	-	Water drench	Fafard

Results

2004

Compared to the untreated, *R. solani*-inoculated control:

- Composted cow manure incorporated into peat mix significantly reduced both pre- and post-emergence damping-off **(Table 3)**.
- *Trichoderma hamatum* 382 increased the percentage of healthy plants when incorporated into Fafard mix but not into peat mix.
- Muscodor (7.5 g/L planting mix) reduced post-emergence damping-off and significantly increased the percentage of healthy plants.
- Moncut reduced pre- and post-emergence damping-off.
- Treatment with Omega Grow resulted in more post-emergence damping-off.
- Treatment with Omega Grow Plus resulted in more healthy seedlings than treatment with Omega Grow.
- Seacide and Phosphonate reduced total damping-off.
- Neither Prestop, Mycostop, nor *P. fluorescens* strains reduced total damping-off.

Table 3. Efficacy of various treatments against Rhizoctonia damping-off of cabbage 'Bravo', 2004.

Treatment	*R.solani*	Percent Healthy	Percent Damping Off	
			Pre-emergence	Post-emergence
Composted cow manure	+	64.8 bc [x]	18.5 h-k	17.3 def
Untreated control: peat mix	+	41.0 efg	32.8 e-h	26.5 a-d
Untreated control: peat mix	-	92.0 a	6.5 jkl	1.5 hi
Trichoderma hamatum 382: Fafard mix	+	51.5 de	28.3 fgh	20.8 bcd
T. hamatum 382: peat mix	+	46.0 def	28.3 fgh	26.0 a-d
T. hamatum 382: peat mix	-	93.8 a	5.8 kl	0.5 hi
Muscodor	+	72.5 b	25.5 f-i	2.0 hi
Muscodor	-	86.5 a	10.5 i-l	3.0 gh
Untreated control, Fafard potting mix incubated *w/o* Muscodor	-	97.5 a	2.5 l	0.0 i
Moncut	+	92.5 a	7.8 jkl	0.0 i
Omega Grow	+	24.3 hi	72.3 a	3.5 hi
Omega Grow Plus	+	40.3 efg	40.3 c-f	20.0 cde
Seacide	+	68.0 bc	21.3 g-j	10.5 efg
Phosphonate	+	57.8 cd	24.5 ghi	17.8 cde
Prestop	+	29.8 ghi	59.0 ab	11.3 fg
Mycostop	+	17.0 i	50.0 bc	33.3 a
Pseudomonas fluorescens-Wayne1R	+	29.5 ghi	44.3 b-e	26.0 a-d
P. fluorescens-Mg1A2R	+	25.8 hi	48.0 bcd	26.5 abc
Untreated control: Fafard mix	+	34.0 fgh	33.8 d-g	32.5 ab
Untreated control: Fafard mix	-	89.2 a	10.8 i-l	0.0 i

[x]Values are the means of four replicate flats; means followed by the same letter are not significantly different at p≤0.05

Table 4. Efficacy of treatments against Rhizoctonia damping-off of pepper 'California Wonder', 2005.

Treatment	*R.solani*	Percent Healthy	Percent Damping-off		Average Plant height (cm)
			Pre-emergence	Post-emergence	
Composted cow manure	+	95.3 a [x]	4.7 jk	0.0 b	2.88 ab
Untreated control: peat mix	-	93.8 ab	6.3 jk	0.0 b	3.14 a
Trichoderma hamatum 382	+	89.6 abc	9.4 ijk	1.1 ab	2.50 b-f
Muscodor 7.5 g/L	+	58.3 g	40.6 c	1.1 ab	2.55 b-f
Muscodor 7.5 g/L	-	59.4 g	37.0 cd	3.7 a	2.33 c-f
Muscodor 3.5 g/L	+	76.0 de	22.4 fgh	1.6 ab	2.38 c-f
Muscodor 3.5 g/l	-	84.4 bcd	13.5 hij	2.1 ab	2.31 def
Untreated control: Fafard mix incubated *w/o* Muscodor	-	97.9 a	2.1 k	0.0 b	2.22 efg
Moncut	+	78.1 de	18.8 ghi	3.1 ab	2.13 fg
Omega Grow	+	30.2 i	68.2 a	1.6 ab	2.73 a-d
Omega Grow Plus	+	82.3 cd	16.7 hi	1.1 ab	1.79 g
Endorse 1.6 lb/100 gal	+	71.4 ef	26.6 efg	2.1 ab	2.50 b-f
Endorse 2.0 lb/100 gal	+	74.5 de	22.9 fgh	2.6 ab	2.33 c-f
Serenade ASO 0.5%	+	68.2 efg	30.2 def	1.6 ab	2.47 b-f
Serenade ASO 1.0%	+	41.1 h	56.8 b	2.1 ab	2.80 abc
Serenade ASO 2.0%	+	25.5 i	74.0 a	0.5 ab	2.74 a-d
Thiram	+	88.5 abc	10.4 ijk	1.1 ab	2.28 def
Untreated control	+	64.1 fg	33.3 cde	2.6 ab	2.15 fg
Untreated control	-	98.4 a	1.6 k	0.0 b	2.65 b-e

[x]Values are the means of four replicate flats; means followed by the same letter are not significantly different at p≤0.05

2005

Post-emergence damping-off was very low in pepper **(Table 4)** and low in cabbage **(Table 5)**.

Compared to the untreated, *R. solani*-inoculated control:

- Composted cow manure incorporated into planting mix increased the total number of healthy pepper and cabbage seedlings.
- Incorporation of *T. hamatum* 382 into Fafard mix increased the number of healthy seedlings in cabbage and in pepper.
- Muscodor (3.5 g/L planting mix) reduced post-emergence damping-off in cabbage and pre-emergence damping-off in pepper.
- Moncut reduced post-emergence damping-off in cabbage and pre-emergence damping-off in pepper.
- Treatment with Omega Grow reduced the number of healthy seedlings in pepper and cabbage.
- Treatment with Omega Grow Plus reduced post-emergence damping-off in cabbage, and reduced pre-emergence damping-off in pepper.
- Endorse (2.0 lb/100 gal, drench) was effective in reducing pre-emergence damping-off in pepper but was phytotoxic to cabbage.
- Serenade ASO (1% drench) reduced post-emergence damping-off in cabbage.
- Cabbage and pepper seedlings produced in composted cow manure mix or treated with Omega Grow or Serenade ASO were taller.

Conclusions

- Incorporation of composted cow manure into potting mix was consistently effective in reducing damping-off in pepper and cabbage. This treatment also resulted in taller, healthier plants in 2005.
- Omega Grow was phytotoxic to cabbage and pepper seeds.
- Omega Grow Plus was more effective than Omega Grow for controlling Rhizoctonia damping-off.
- *Trichoderma hamatum* 382 was effective against Rhizoctonia damping-off, but was not the most effective treatment in any experiment.
- Endorse was effective against Rhizoctonia damping-off in peppers, but was phytotoxic to cabbage seedlings.
- *Pseudomonas fluorescens*-Wayne 1R, *P. fluorescens*- Mg1 A2R, Prestop and Mycostop were ineffective against Rhizoctonia damping-off in cabbage.
- Seacide and Phosphonate reduced total damping-off compared to the untreated control.
- As applied in the 2005 experiments, Muscodor appears to be phytotoxic to cabbage and pepper seeds; further studies are needed to assess appropriate treatment techniques that will be convenient for growers and also optimize Muscodor's biofumigation potential without damaging seeds.

Table 5. Efficacy of treatments against Rhizoctonia damping-off of cabbage 'Bravo', 2005.

Treatment	*R.solani*	Percent Healthy	Percent Damping-off		Average Plant height (cm)
			Pre-emergence	Post-emergence	
Composted cow manure	+	85.4 ab [x]	13.0 hgi	1.6 cd	3.47 a
Untreated control: peat mix	-	91.7 a	8.3 hi	0.0 d	3.31 a
Trichoderma hamatum 382	+	59.9 cd	34.9 def	5.2 b	3.14 ab
Muscodor 7.5 g/L	+	16.1 fg	83.9 ab	0.0 d	3.12 abc
Muscodor 7.5 g.l	-	25.5 f	74.0 b	0.5 d	2.85 a-d
Muscodor 3.5 g/L	+	34.9 ef	65.1 bc	0.0 d	3.14 ab
Muscodor 3.5 g/L	-	59.9 cd	39.6 def	0.5 d	3.13 abc
Untreated control Fafard mix incubated *w/o* Muscodor	-	96.9 a	3.1 i	0.0 d	2.79 a-d
Moncut	+	70.8 bc	28.7 e-h	0.5 d	2.63 a-d
Omega Grow	+	3.6 g	96.4 a	0.0 d	3.24 a
Omega Grow Plus	+	59.9 cd	38.5 def	1.6 cd	1.99 d
Endorse 1.6 lb/100 gal	+	65.6 bcd	33.3 d-g	1.0 cd	2.16 cd
Endorse 2.0 lb/100 gal	+	47.9 de	50.5 cd	1.6 cd	2.23 bcd
Serenade ASO 0.5%	+	57.3 cd	39.1 def	3.6 bc	3.19 ab
Serenade ASO 1.0%	+	52.6 cde	47.4 cde	0.0 d	3.46 a
Serenade ASO 2.0%	+	33.3 ef	64.6 bc	2.1 cd	3.40 a
Thiram	+	68.2 bcd	22.9 f-i	8.9 a	3.18 ab
Untreated control	+	63.5 cd	30.2 d-g	6.3 ab	3.07 abc
Untreated control	-	96.4 a	3.6 i	0.0 d	3.18 ab

[x]Values are the means of four replicate flats; means followed by the same letter are not significantly different at p≤0.05

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