2004
Research Project Report for the Ohio Vegetable and Small Fruit Research and Development Program

Project Title: Disease Management in Radish: Varietal, Fungicide and Biological Tactics

Principal Investigator

Sally A. Miller, Professor and State Extension Specialist/Vegetable Crop Disease Management, Department of Plant Pathology, OSU/OARDC, Wooster;
Phone 330-263-3678; FAX 330-263-3841
e-mail: miller.769@osu.edu

Project Participants

Melanie L. Lewis Ivey, Research Associate and Jhony Mera, Research Assistant Department of Plant Pathology, OSU/OARDC, Wooster; Rick Callendar, Manager, OSU-OARDC Muck Crops Experiment Station, Celeryville; Dr. Casey Hoy and Mike Dunlap, Department of Entomology, OSU-ARDC, Wooster.

Objectives of the Research

The goal of this research program is to develop integrated management tactics that will reduce the incidence and severity of diseases of radish, focusing on bunch radishes produced on muck soil. **Specific objectives for 2004 were to 1) evaluate the effects of different cover crops on incidence and severity of Rhizoctonia root rot; 2) determine the level of resistance of newer radish varieties to downy mildew, club root, and Rhizoctonia root rot; 3) evaluate fungicides for efficacy in controlling downy mildew and other diseases on radish; and 4) evaluate fungicides for management of Rhizoctonia root rot.**

Objective 1: Evaluate the Effect of Cover Crops on Rhizoctonia Disease Incidence

We hypothesized that the use of oat and rye winter cover crops, a practice adopted to reduce the overwintering populations of *Thrips tabaci*, may be a factor in the increase in Rhizoctonia root and hypocotyl rot observed in recent years. Oats and rye may be more susceptible to *R. solani* than wheat, a previously used cover crop, and thus contribute to the buildup of the pathogen, or they may be less supportive of soil microbial communities that suppress the pathogen. We established a trial initially in 2001/2002 in which we compared the development of Rhizoctonia root and hypocotyl rot on radishes grown in plots planted to different cover crops or combination of cover crops. We intended to determine if cover crops influenced the incidence or severity of Rhizoctonia disease in the following radish crop. We also re-assessed the attractiveness of the different cover crops or combinations of cover crops to thrips.

a. 2004 Experiment

The experiment was conducted at the Ohio Agricultural Research and Development Center Muck Crops Research Station in Celeryville, OH. Seven cover crop treatments were established, for the third consecutive year, at a rate of 1 bu/A on 2 Oct 03. Treatments were planted in 25 ft by 12 ft strips and arranged in a randomized complete block design with five replications. Cover crops were mowed and disked under on 21 Jun. Fertilizer (17-17-17, 500 lb/A) was incorporated into the field on 27 Apr. Plots were disked, leveled, and compacted on 17 May. Radishes (cv. RS95617 and cv. Mister Red) were direct seeded at a rate of 12 seeds/ft on 17 May using a Stan-Hay vacuum seeder. Each plot consisted of three 25 ft rows (per cultivar) with 18 in. between rows. Plots were separated by 6 ft. Dual II Magnum (1.5 pt/A) was applied on 17 May for weed control. Radishes were harvested from a 5 ft section of the center row of each plot on 11 Jun, and the number of radishes per row, percent Rhizoctonia hypocotyl rot, and the number of radishes per row with clubroot were determined. Thrips were sampled by cutting all foliage in a one square foot area at the soil line, and extracting the thrips in Berlese funnels, which use the heat from an incandescent light bulb to drive the thrips down and out of the foliage and into a collecting jar filled with preservative. Thrips populations begin to increase early in the spring, and the series of samples provide an estimate of how quickly the populations increase. The initial sample tested for differences in late fall establishment and overwintering survival. Data were analyzed by ANOVA using SAS statistical software. Means were separated using Fisher's protected least significant difference test. Average maximum temperatures for 17-31 May and 1-11 Jun were 78.2 and 76.9 °F; minimum averages were 53.9 and 58.7 °F and rainfall was 3.2 and 3.2 in., respectively.

The amount of Rhizoctonia root and hypocotyl rot that developed in the experiment was low, and there were no statistically significant differences among cover crop treatments in the amount of Rhizoctonia disease that developed. However, the stand count in 'RS95167' (number of radishes per row) was significantly higher ($p \leq 0.10$) for radishes grown in soil previously cropped to barley, oats, or oats/barley than for those in which the preceding crop was oats/rye. Clubroot was in plots cropped to oats/barley. There were strong block effects, probably the result of heavy rain that occurred during the trial and uneven drainage across the field. The oats were winter-killed in all treatments, and no foliage remained for thrips sampling during April. Thrips do not survive well on oats alone, or increase on dead foliage during spring. Wheat, rye and barley did not differ in the number of thrips per square foot, regardless of whether they were grown together with oats. Previous studies had shown lower rates of thrips increase in rye compared with wheat, and a similar trend was observed in our study although the numbers were not significantly different even for the final sample date.

Treatment	Cultivar	Stand count (number radishes/100 ft)		% Rhizoctonia		Clubroot (number radishes/100 ft)	
		cv. Mister Red	cv. RS95167	cv. Mister Red	cv. RS95167	cv. Mister Red	cv. RS95167
Wheat	Hopewell	780 a	936 ab	20.8 a	17.8 a	764 a	1084 a
Rye	Mixed cultivars	908 a	944 ab	27.0 a	25.8 a	904 a	1076 a
Oats	Ogle	868 a	1080 a	24.4 a	14.0 a	868 a	1048 a
Barley	Penco	888 a	1084 a	13.4 a	12.0 a	888 a	1004 ab
Oats:Wheat (1:1)	Ogle:Hopewell	792 a	1004 ab	19.8 a	16.2 a	792 a	936 ab
Oats:Rye (1:1)	Ogle:mixed	844 a	868 b	14.0 a	10.2 a	836 a	932 ab
Oats:Barley (1:1)	Ogle:Penco	944 a	1048 a	26.2 a	21.6 a	928 a	856 b
p value		0.23	0.10	0.81	0.65	0.23	0.07

April 7

Cover crop	Avg no. thrips/ft^2	Fresh wt	Dry wt
Wheat “Hopewell”	0.900	24.610	5.593
Rye	1.200	36.312	8.573
Barley “Penco”	1.100	23.790	6.669
Oats/Wheat	1.700	21.200	5.763
Oats/Rye	1.100	28.344	6.664
Oats/Barley	0.875	17.890	4.841
Tukey's HSD (α=0.05)	1.814	14.381	1.814

April 21

Cover crop	Avg no. thrips/ ft^2	Fresh wt	Dry wt
Wheat “Hopewell”	0.900	88.652	13.461
Rye	0.600	95.013	14.708
Barley “Penco”	1.300	70.645	10.292
Oats/Wheat	0.700	82.679	13.433
Oats/Rye	0.600	113.196	16.896
Oats/Barley	0.167	81.212	12.157
Tukey's HSD (α=0.05)	1.283	63.869	8.367

Thrips Data May 5

Cover crop	Avg no. thrips/ ft^2	Fresh wt	Dry wt
Wheat “Hopewell”	2.100	118.334	23.280
Rye	0.400	196.607	33.120
Barley “Penco”	2.400	141.707	23.513
Oats/Wheat	1.000	143.154	28.421
Oats/Rye	0.900	156.187	28.059
Oats/Barley	3.167	101.343	17.588
Tukey's HSD (α=0.05)	2.886	102.091	15.680

b. 3-year Summary

In the first year of the experiment (2002), there were no significant differences in the seasonal total of thrips from different cover crops. *Rhizoctonia* incidence was extremely low, probably due to very dry conditions. Radishes were planted again with the same result- lack of disease. In 2003 flooding destroyed the plots. In 2004, the amount of Rhizoctonia root and hypocotyl rot that developed in the experiment was again relatively low, and there were no statistically significant differences among cover crop treatments in the amount of Rhizoctonia disease that developed. However, the stand count in 'RS95167' (number of radishes per row) was significantly lower (P=0.01) for radishes grown in soil previously cropped to oats/rye than for those in which the preceding crop was barley, oats, or oats/barley. There were strong block effects, probably the result of heavy rain that occurred during the trial and uneven drainage across the field.

In summary, we were unable to demonstrate a consistent effect of cover crops on the succeeding radish crop in incidence of Rhizoctonia root and hypocotyl rot. The experiment was hampered by very dry weather in 2002 and heavy rainfall in 2003 and 2004 that flooded the plots. There was also no effect of cover crop on thrips populations. Farmers may consider planting the cover crop or combination of cover crops that best suits their needs, without consideration of potential effects on Rhizoctonia disease incidence.

Objective 2: Determine the Level of Disease Resistance of Newer Radish Varieties

Fifteen radish cultivars were evaluated for response to Rhizoctonia hypocotyl rot and clubroot in a field trial at the Ohio Agricultural Research and Development Center Muck Crops Research Station in Celeryville, OH. Fertilizer (17-17-17, 500 lb/A) was incorporated into the field on 27 Apr. Plots were disked, leveled, and compacted, and radishes were direct seeded at a rate of 12 seeds/ft on 20 May. Cultivars were arranged in a randomized complete block design with four replications. Plots were 6 ft apart and consisted of three 20 ft rows with 18 in. between rows. Dual II MAGNUM (1.5 pt/A) was applied on 20 May for weed control. Plots were sprinkle irrigated with 0.5 in. water on 20 May. Radishes were harvested from a 10 ft section of the center row of each plot on 14 Jun, and mean clubroot disease severity, percent Rhizoctonia hypocotyl rot, and percent soft rot were determined. Data for percent Rhizoctonia hypocotyl rot was analyzed by adding one to the raw data and using the long transformed values; the remaining data were analyzed without transformation, all by ANOVA using SAS statistical software. Means were separated using Fisher's protected least significant difference test. Average maximum temperatures for 20-31 May and 1-14 Jun were 78.1 and 77.7 °F; minimum averages were 54.2 and 59.0 °F and total rainfall was 2.7 and 5.16 in., respectively.

Disease pressure was low for Rhizoctonia hypocotyl rot and no differences in disease incidence were observed among cultivars. Downy mildew was not observed. Clubroot severity was high and although all cultivars were susceptible, three ('CW93-222 F1', CW93-221 F1" and E61-7149 F1') had significantly lower clubroot severity than the most susceptible cultivars, including the standards 'Cherriette', 'Cabernet', 'Red Silk' and 'Crunchy Royale'. However, the incidence of soft rot was high in 'E61-7149 F1'

and moderate in ‘CW 93-221 F1’. Six cultivars (‘CW93-222 F1’, ‘SSX17-9124’, ‘Cherriette’, ‘N1Z-34-46 F1’, ‘Red Silk’ and ‘Crunchy Royale’) had negligible (< 2.5%) soft rot incidence.

Cultivar	Seed Supplier	Clubroot severity*	% Rhizoctonia	% Soft rot
CW93-222 F1	SeedWay Inc.	44.6 bcd**	4.0 a	2.0 ef
CW93-221 F1	SeedWay Inc.	44.4 bcd	2.0 a	11.0 bc
E61-7149 F1	SeedWay Inc.	41.0 d	1.0 a	30.5 a
SSX17-9124	Meyer Seed Int., Inc.....	60.6 a	1.5 a	0.3 f
SSX17-9123	Meyer Seed Int., Inc.....	54.6 a-d	2.3 a	4.5 def
SSX17-9122	Meyer Seed Int., Inc.....	43.7 cd	5.5 a	13.5 b
Cherriette	Siegers Seed Co.	66.3 a	3.8 a	2.0 ef
Cabernet	Siegers Seed Co.	67.0 a	1.5 a	6.5 cde
N1Z-34-44 F1	Vilmorin Seed Co.	55.6 abc	2.5 a	7.8 cd
N1Z-34-45 F1	Vilmorin Seed Co.	62.0 a	5.8 a	8.3 cd
N1Z-34-46 F1	Vilmorin Seed Co.	64.0 a	2.0 a	1.3 f
Red Silk	Siegers Seed Co.	63.7 a	0.3 a	0.5 f
E61-119 F1	SeedWay Inc.	56.9 abc	2.8 a	10.8 bc
Crunchy Royale	Siegers Seed Co.	57.6 ab	2.8 a	2.3 ef

*Clubroot severity calculated using the number of radishes in each of five categories and the midpoint value from the categories: 1 = 0% disease; 2 = 1-20% disease; 3 = 21-40% disease; 4 = 41-60% disease; and 5 = 61-100% disease. Severity = [Σ(category midpoint*number of radishes in category)]/n, where n = number of total radishes harvested.
**Values are the means of four replicate plots; means followed by the same letter within a column are not significantly different at $p \leq 0.05$.

Objective 3: Evaluate Fungicides for Efficacy in Controlling Downy Mildew and Other Diseases on Radish

The experiment was conducted at the Ohio Agricultural Research and Development Center Muck Crops Agricultural Research Station in Celeryville, OH. Fertilizer (17-17-17, 500 lb/A) was incorporated into the field on 27 Apr. Plots were disked, leveled, and compacted and radishes (cv. Cabernet) were direct seeded at a rate of 12 seeds/ft on 18 Aug. Treatments were arranged in a randomized complete block design with four replications. Each plot consisted of three 20 ft rows with 18 in. between rows. Dual II Magnum (1.5 pt/A) and Sevin (1 qt/A) were applied on 18 Aug and 30 Aug, respectively. Treatments were applied on 31 Aug using a tractor-mounted 3.5 hp Honda motor driven sprayer (46.5 gal/A, 40 psi). Foliar downy mildew was evaluated on 13 Sep using a modified Horsfall-Barratt rating scale. Radishes were harvested from a 10 ft section of the center row of each plot on 20 Sep, and mean clubroot disease severity, percent Rhizoctonia hypocotyl rot, and percent healthy roots were determined. Data for percent healthy plants and plants with Rhizoctonia hypocotyl rot symptoms were analyzed using square root transformed values; downy mildew ratings were converted to midpoint values; and the remaining data were analyzed without transformation, all by ANOVA using SAS statistical software. Means were separated using Fisher’s protected least significant difference test. Average maximum temperatures for 18-31 Aug and 1-20 Sep were 78.3 and 77.9 °F; minimum averages were 60.0 and 55.6 °F and rainfall was 4.5 and 1.2 in., respectively.

Disease pressure was low to moderate for downy mildew, low for Rhizoctonia hypocotyl rot, and high for clubroot. Agri-Fos, Acrobat 50WP alone and tank-mixed with Ridomil Gold EC, and Amistar tanked mixed with Ridomil Gold EC were most effective in reducing downy mildew. Radish plants treated with Amistar or Sonata had

significantly less downy mildew than the untreated control, but more than the most effective treatments. Cabrio, Pristine, and Ridomil Gold EC alone or tank-mixed with Cabrio did not reduce downy mildew severity. None of the treatments reduced clubroot severity and plants treated with Ridomil Gold EC had more clubroot than the untreated control. There were no significant differences between treatments in percentage of radishes with Rhizoctonia hypocotyl rot or healthy radishes.

Treatment and rate/A	% Downy mildew	Clubroot severity[z]	% Rhizoctonia
Amistar 3.5 oz	11.8 bc[y]	26.7 b-e	0.9 a
Acrobat 50WP 6.4 oz +[x] Ridomil Gold EC 2 pt	4.6 d	33.5 abc	2.5 a
Cabrio 10 oz	16.6 ab	26.2 cde	1.5 a
Amistar 3.5 oz + Ridomil Gold EC 2 pt	6.1 cd	26.1 cde	0.9 a
Acrobat 50WP 6.4 oz	6.1 cd	31.8 a-d	1.2 a
Pristine 18 oz	19.0 a	34.7 ab	0.3 a
Ridomil Gold EC 2 pt	13.1 ab	38.7 a	1.2 a
Sonata 2 qt	11.3 bc	23.2 e	2.0 a
Cabrio EG 10 oz + Ridomil Gold EC 2 pt	16.6 ab	32.5 abc	1.2 a
Agri-Fos 1.25 qt/100 gal	3.5 d	23.8 de	1.8 a
Control	19.0 a	29.1 b-e	1.1 a

[z]Clubroot severity calculated using the number of radishes in each of five categories and the midpoint value from the categories: 1 = 0% disease; 2 = 1-20% disease; 3 = 21-40% disease; 4 = 41-60% disease; and 5 = 61-100% disease. Severity = [Σ(category midpoint*number of radishes in category)]/n, where n = number of total radishes harvested.
[y]Values are the means of four replicate plots; means followed by the same letter within a column are not significantly different at $p \leq 0.05$.
[x] Treatments tank mixed together.

Objective 4: Evaluate Fungicides for Management of Rhizoctonia Root Rot.

The experiment was conducted at the Ohio Agricultural Research and Development Center Muck Crops Research Station in Celeryville, OH. Fertilizer (17-17-17, 500 lb/A) was incorporated into the field on 27 Apr. Plots were disked, leveled, compacted and radishes (cv. Cabernet) were direct seeded at a rate of 12 seeds/ft on 24 Aug. Treatments were arranged in a randomized complete block design with four replications. Each plot consisted of three 20 ft rows with 18 in between rows. In-furrow treatments of Amistar (0.13 oz/1000 row ft) were applied at seeding using a Stan Hay vacuum seeder (24.4 gal/A, 35 psi). Dual II Magnum (1.5 pt/A) was applied on 24 Aug for weed control. Overhead irrigation (0.4 in) was applied on 25 Aug. Post emergence treatments of Amistar (3.9 oz/A) were applied on 2 Sep using a tractor mounted 3.5 hp Honda motor-driven sprayer (46.5 gal/A, 40 psi). Radishes were harvested from a 10 ft section of the center row for each treatment on 20 Sep and numbers of healthy radishes, radishes with Rhizoctonia root and hypocotyls rot symptoms, and culls were recorded. Data were analyzed by ANOVA using SAS statistical software and means were separated using Fisher's protected least significant difference test. Average maximum temperatures for 24-31 Aug and 1-20 Sep were 80.8 and 77.9 °F; minimum averages were 62.6 and 55.6 °F and rainfall was 2.0 and 1.2 in, respectively.

Rhizoctonia disease pressure was low. All of the radishes harvested had clubroot symptoms and were considered non-marketable. There were no significant differences among the Amistar treatments in controlling Rhizoctonia root and hypocotyl rot compared to the untreated control.

Amistar treatment	% Rhizoctonia root rot
Untreated	2.4 a[z]
In-furrow	1.8 a
Post emergence	1.9 a
In-furrow and post emergence	2.7 a

[z]Values are the means of four replicate plots; means followed by the same letter within a column are not significantly different at $p \leq 0.05$.