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Effects of Green Manure Crop and In-furrow and Seed Treatments on Rhizoctonia Canker and Black Scurf

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A serious Rhizoctonia canker problem on belowground stems and stolons occurred in 2009 where the cultivar Bintje was re-cropped after a cover crop of Sudangrass was incorporated into the soil the previous fall. The potatoes were planted in early April 2009 into cold wet soils followed by a cool wet spring as compared to other years. Emergence of the potatoes was very erratic. The sand ridges in the field were especially bad where the emergence rate was less than 10% at harvest. Upon inspection, Rhizoctonia had caused the new shoots to die back before emerging, the seed sending up numerous shoots that were incised.

Information out of the USDA at Prosser Washington indicated that Sudangrass as a cover crop had a tendency to increase the incidence of Rhizoctonia. Therefore, trials were conducted in 2010 and 2011 to determine if Rhizoctonia could be controlled by chemicals, cultural practices, or a combination of both.

Methods – Commercial fields at least 126 acres in size were used for both the 2010 and 2011 potato-growing seasons. Soil type was sandy loam both seasons and fields were irrigated with center pivot systems. A Lockwood Air Cup planter was used to plant potato seed of the cultivar Bintje with 6 inch in-row spacing, on 34-inch rows. Plots were six rows wide, 85 to 109 feet in length, and separated by 20 foot borders. The center two rows of six were used for data. Seed was planted to a total population of 30,700 plants per acre both seasons. Number of experimental treatments was 8 in 2010 and 12 in 2011. Experimental designs were a split block (cover crop as main plots and seed treatments as subplots, with four blocks (replicates)) in 2010 and a randomized complete block with four replicates in 2011.

The trials were sampled and harvested by hand within 10 foot strips taken out of each plot for each evaluation. Plants per acre, stems per plant, tuber numbers per plant, tubers per stem, yield and size of the tubers, and percent solids were recorded. Disease incidence and severity were evaluated on the stems and stolons. Samples of tubers were harvested and held in storage for two months and evaluated for black scurf on the tubers. Rhizoctonia stem canker was assessed as the percentage of the visual below-ground stem area with cankered tissue. A disease severity index was used to assess black scurf severity on tubers where 1 DSI = 1% severity, 2 DSI = 5%, 3 DSI = 10%, 4 DSI = 20%, 5 DSI = 30%, 6 DSI = 40%, 7 DSI = 50-75%, 8 DSI = 76 -100%.

For the 2010 trial, Martigena mustard and Piper Sudangrass were planted as cover crops in alternating strips in a field north of Pasco, WA in August 2009. The mustard and Sudangrass were chopped and worked into the soil in late October 2009 and allowed to decompose in the field until the field was disked in early March of 2010 in preparation for planting on April 5, 2010. The field was in potatoes in 2005, 2007, and

2009 and sweet corn in 2006 and 2008. The field was directly east of and adjacent to the field that had the problem with Rhizoctonia in 2009.

Plants were dug and evaluated for stem and stolon canker on 1 June and additional tubers were then harvested for yield, solids, and size distribution on June 19 (75 days after planting and at defoliation). Tubers in a second 10 feet of row were dug on July 18, 2010. Tubers were stored at 45 F for two months and then evaluated for black scurf.

The 2011 field was within 2 km of the 2010 field and prior rotation for 2011 was the same as for the 2010 field. Only Martigena mustard was used as a cover crop in 2011. Both in-furrow applications and seed treatments were evaluated for control of Rhizoctonia stem canker and black scurf on the daughter tubers. Martigena mustard was planted in August 2010. The mustard was chopped and incorporated into the soil in late October and disked in early March of 2011 in preparation for planting. Seed was planted April 5, 2011. Potatoes were dug for Rhizoctonia stem lesion evaluation on June 9. Additional tubers were harvested for yield, solids, and size distribution on June 19 (75 days after planting and at defoliation). Ten feet of row was again harvested on July 18 for a subsequent evaluation of black scurf on the tubers. The potatoes were stored at 45 F for 2 months and evaluated for black scurf.

Results – Mean incidence of Rhizoctonia stem canker among treatments ranged from 33 to 79%. Incidence of black scurf on tubers among plots ranged from 1 to 100%, with a mean incidence of 32% for all plots. Conditional severity (severity of infected tubers) of Rhizoctonia was significantly less ($P < 0.05$) on stems after Martigena mustard than after Piper Sudangrass in 2010. Incidence and severity of Rhizoctonia canker and incidence of black scurf on tubers were numerically less on plants grown after a cover crop of Martigena mustard than after Piper Sudangrass (Table 1).

None of the fungicide treatments was significantly better than the mustard check for incidence, severity, and conditional severity of Rhizoctonia canker, and number of stems per plant (Table 2). Incidence and severity of Rhizoctonia canker was numerically less for the 0.08 lb rate of Maxim 4FS (active ingredient: fludioxonil) than the mustard control but not the 0.16 lb rate of Maxim 4FS (Table 2). None of the seed treatments used in 2010 was better than the mustard cover crop for total yield. Potato yield was significantly reduced at the 0.16 lb rate of Maxim 4FS.

The best-performing compound in 2011 was Moncut (active ingredient: flutolanil) in-furrow. It ranked #1 for total and useable yield, #1 for lowest stem incidence, #2 in lowest stem severity, #2 in lowest severity of Rhizoctonia on the tubers and #3 in lowest incidence of Rhizoctonia on the tubers. The treatment was statistically better than the control for disease incidence of both stems and tubers (Table 3). The second best-ranking material overall was Moncut MZ (active ingredients: flutolanil, mancozeb) seed treatment, which was statistically better than the control for incidence and severity of black scurf on tubers (Table 3). The best performer statistically for reduction of Rhizoctonia on the tubers was a combination of Quadris (active ingredient: azoxystrobin) in-furrow and seed treatment of Maxim MZ (active ingredients: azoxystrobin + mancozeb) (Table 3). There were no statistically significant yield responses for any of the combinations of materials used. The poorest performers overall were the control, Quadris in-furrow + Maxim 4FS at 3.2 oz / a applied to seed, and Quadris in-furrow + Maxim 4FS at 0.04 fl oz/ cwt (Table 4).

Yield in specification size by improved uniformity was significantly increased when plots were treated with Quadris applied in-furrow and Maxim seed treatment and Moncut or Moncoat MZ (flutolanil + mancozeb). There was no significant increase in tubers per plant.

The major source of Rhizoctonia inoculum in 2010 was likely from the soil and not the seed, resulting in no significant control of Rhizoctonia by the seed treatments. Both soil- and tuber-borne inoculum were likely factors in 2011. Soil inoculum of Rhizoctonia was increased by growing potatoes every other year. Selected seed and in-furrow treatments were effective in 2011 at reducing Rhizoctonia cankers on stems and black scurf on daughter tubers. Black dot caused by *Colletotrichum coccodes* and Verticillium wilt caused by *Verticillium dahliae* where not major deterrents to the close potato rotation because tubers were harvested with a short season of growth to produce small tubers for a special market.

Establishing a healthy crop stand and managing Rhizoctonia

Major causes of poor crop stands are poor planter performance, herbicide damage, and seed piece diseases (Potato Health Management, Second Edition – APS Press. Order at 1-800-328-7560, www.shopapspress.org). Most frequent damaging diseases of seed pieces and emerging sprouts are black leg, soft rot, Rhizoctonia canker, Fusarium dry rot, Pythium, and late blight.

Selecting high-quality seed tubers, handling seed carefully (reduce bruising), and encouraging quick emergence are three essential components for planting a healthy potato crop. Quick emergence is promoted by warming seed tubers before cutting (50 F) and planting when soil temperature is 50 F or higher. Seed and soil temperatures should ideally be the same at planting. In practicality, a soil temperature of 45 F and increasing in temperature is often satisfactory in the Columbia Basin. Soil should be moist, but not wet (75 to 85% available soil water). A function of selecting high-quality seed is avoiding very susceptible potato cultivars to diseases of seed tubers and young sprouts. For example, Norgold and Kennebec are very susceptible to black leg and should not be planted unless extra risks are assumed and precautions taken.

Rhizoctonia canker, caused by *Rhizoctonia solani* is favored by cool, wet soils after planting. The disease decreases with increasing soil temperature above 63 F. Slow emergence of spouts, induced by cool soil temperatures increases damage on stems, promoting weak and poor crop stands. The pathogen overwinters as sclerotia on tubers, in soil, or as mycelium on plant debris in the soil. When conditions are favorable for the fungus in the spring, sclerotia germinate and invade emerging sprouts and stems. Roots, stolons and tubers are invaded as they develop throughout the growing season. Maximum development of sclerotia on tubers occurs as tubers remain in the soil after death of vines.

Allow crop residue of the previous crop to decompose before planting. Rhizoctonia will be more severe after alfalfa, clover, sugar beet, and Sudangrass. Disease intensity will likely be less with a prior cover crop of white mustard, *Sinapis alba* Martigena. *Rhizoctonia solani* is a pathogen of numerous crops and weedy hosts. Its selective pathogenicity depends on the strain present.

Black scurf refers to the name of the disease on tubers and the black scurfy spots and patches of the Rhizoctonia fungus on the tubers. The black scurfy spots and patches on diseased tubers, also referred to the "dirt that won't wash off" are sclerotia of the Rhizoctonia fungus. The sclerotia are compact masses of mycelium and survival structures of the fungus. Avoid using seed tubers with black scurf.

Inoculum of Rhizoctonia arises from sclerotia (black scurf) on the surface of seed tubers and from the soil. Close rotations of potato crops and rotations with other specific crops mentioned above increase inoculum in the soil. In general, seed treatment fungicides are most effective on tuber-borne inoculum and in-furrow fungicides are most effective on soil-borne inoculum (Atkinson et al 2011). Often initial inoculum originates from both sources. Effective seed treatments or in-furrow fungicides against Rhizoctonia include azoxystrobin (Quadris), fludioxonil (Maxim), (flutolanil (Moncoat, Moncut), thiophanate-methyl (Tops, Topsin M), mancozeb (Dithane M4, Manzate 200), and penthioprad (Vertisan).

Literature cited

Atkinson, D., Thornton, M.K., and Miller, J.S. 2011. Development of Rhizoctonia solani on stems, stolons and tubers of potato II. Efficacy of chemical applications. Am J. Pot Res 88:96-103.

Table 1. Intensity of Rhizoctonia canker on stems and black scurf on tubers of Bintje potato grown after a cover crop of Martigena mustard or Piper Sudangrass north of Pasco, WA in 2010.

	All treatments included				Non-fungicide control only			
	Belowground stem			Tuber	Belowground stem			Tuber
	Incidence	Severity	Cond. severity	Incidence	Incidence	Severity	Cond. severity	Incidence
Mustard	33.0	5.4	13.2*	14.0	36.0	5.0	10.8*	10.2
Sudangrass	46.0	10.0	20.4	19.4	58.0	15.0	25.3	17.3
p-value	0.11	0.07	0.03	0.06	0.19	0.07	0.03	0.11

- = Significantly less than after Sudangrass at $P < 0.05$

Severity = severity of all stems (stems with zero infection were included)
Conditional severity = severity of stems that were infected (the non-infected were not included)

Table 2. Intensity of Rhizoctonia canker on below ground stems of Bintje potato grown after a cover crop of Martigena mustard or Piper Sudangrass and treated with various seed and in-furrow treatments north of Pasco, WA in 2010.

Treatment	Incidence	Severity	Conditional severity	# stems/ plant
Sudan check	58 a	15.0 a	25.3 a	3.6 ab
Sudangrass Maxim 4FS .08 Dynasty	47 ab	10.5 ab	22.4 ab	4.3 a
Sudan Maxim 4FS .08	39 ab	8.0 ab	20.1 ab	4.2 a
Mustard Maxim 4FS .08 Dynasty	40 ab	6.7 ab	15.4 bc	3.6 ab
Mustard Maxim 4FS .16	38 ab	7.8 ab	14.9 ab	4.1 ab
Sudan Maxim 4FS .16	40 ab	6.7 ab	13.9 ab	3.2 b
Mustard Maxim 4FS .08	18 b	2.2 b	12.0 b	4.3 a
Mustard check	36 ab	5.0 ab	10.8 b	4.3 a

Maxim 4FS applied either at 0.08 or 0.16 fl oz/100cwt seed
Dynasty (azoxystrobin) applied to seed at 0.20 fl oz/a
Red highlight = top 3 performers in category

Table 3. Intensity of Rhizoctonia and yield of Bintje potato grown after a green manure crop of Martigena mustard and treated with seed piece or in-furrow fungicide treatments in 2011.

		Rhizoctonia canker on stems		Black scurf on tubers	
Treatment	Rate	Incidence	Conditional severity	Incidence	Severity
Mustard check	-	78	16.5	25.1	8.8
Quadris in-furrow Maxim 4FS applied to seed	9.2 oz/a 3.2 fl oz/a	77	21.6	48.7	20.6
Quadris in-furrow Maxim 4FS Dynasty	6.2 oz/a 0.04 fl oz/cwt 0.20 fl oz/cwt	73	15.9	12.9	6.1
Maxim MZ	0.5 lbs/cwt	71	16.0	15.8	6.3
Quadris in-furrow Maxim 4FS	9.2 oz/a 0.04 fl oz/cwt	70	16.3	73.4^	32.9
Maxim 4FS	0.08 fl oz/cwt	67	15.3	71.4^	31.5
Quadris in-furrow Maxim 4FS	9.2 oz/a 0.04 fl oz/cwt	65	22.1	5.5*	2.5*
Quadris in-furrow Maxim MZ	9.2 oz/a 0.5 lbs/cwt	62	16.5	21.8	9.5
Quadris in-furrow Maxim 4FS Moncut 70 DF foliar	9.2 oz/a 0.04 fl oz/cwt 1.1 lb/a	55	13.5	64.6	28.8
Maxim 4FS Dynasty	0.04 fl oz/cwt 0.38 fl oz/cwt	47	18.7	57.3	27.9
Moncoat MZ seed treatment	1.0 lb/a	35	8.0	2.0*	0.04*
Moncut 70 DF in-furrow	1.1 lbs/a	33*	12.3	6.7*	2.3

Maxim 4FS treatments also were treated with mancozeb dust bark.
Dynasty (azoxystrobin) applied to seed (fl oz /cwt seed)
* = significantly greater than mustard control at $P = 0.05$
^ = significantly less than mustard control at $P = 0.05$
Red highlight = top 3 performers in category

Table 4. Emergence and yield of Bintje potato grown after a green manure crop of Martigena mustard and treated with seed piece or in-furrow fungicide treatments in 2011.

Treatment	Rate	% Emergence	Plants/acre	Stems/seed	Tubers/ plant	T/acre	T/ acre 26-41 mm
Mustard check		86	34751	3.3	11.7	7.67	5.80
Quadris in-furrow Maxim 4FS applied to seed	9.2 oz/a 3.2 fl oz/a	73	27801^	3.8	13.4	7.77	5.78
Quadris in-furrow Maxim 4FS Dynasty	6.2 oz/a 0.04 fl oz/cwt 0.20 fl oz/cwt	83	28573	4.1	13.6	7.88	6.60
Maxim MZ	0.5 lbs /cwt	84	32435	3.9	14.1	7.72	5.41
Quadris in-furrow Maxim 4FS	9.2 oz/a 0.04 fl oz/cwt	95	32435	3.9	12.2	6.56	5.23
Maxim 4FS	0.08 fl oz/cwt	79	30118	3.8	13.0	8.35	6.47
Quadris in-furrow Maxim 4FS	9.2 oz/a 0.04 fl oz/cwt	90	34751	3.5	14.2	9.30	7.39
Quadris in-furrow Maxim MZ	9.2 oz/a 0.5 lbs/cwt	84	33207	4.4	11.5	7.73	6.71
Quadris in-furrow Maxim 4FS Moncut 70 DF foliar	9.2 oz/ a 0.04 fl oz/cwt 1.1 lb/a	85	31662	3.9	13.6	8.74	6.90
Maxim 4FS Dynasty	0.04 fl oz/cwt 0.38 fl oz/cwt	75	33979	3.7	12.8	8.46	6.71
Moncoat MZ Seed treatment	1.0 lb/a	85	36296	3.8	14.6	8.61	6.76
Moncut 70DF in-furrow	1.1 lb/a	96	38613	3.6	16.2	9.58	7.61

Maxim 4FS treatments were treated with mancozeb dust bark.
Dynasty (azoxystrobin) applied to seed (fl oz /cwt seed)
% Emergence at 48 days after planting
^ = significantly less than mustard control at *P* =0.05
Red highlight = highest 3 numerical values per category