CULTIVAR SUSCEPTIBILITY AND FUNGICIDE CONTOROL OF BLACK DOT ROOT ROT

by

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ABSTRACT

Black Dot (*Colletotrichum coccodes*) is an important potato disease worldwide causing reported yield losses in the 10-30% range. It is involved in the early dying disease complex along with *Verticillium dahliae or V. albo atrum,* and root lesion nematodes. Besides early dying, black dot also causes silvery blemishes on the tuber surface that resemble those of silver scurf which results in reduced value in fresh markets. The purpose of this work was to evaluate North American cultivars for black dot tolerance and to evaluate fungicides for their efficacy in controlling this disease. To evaluate cultivar resistance, thirty-four commercial cultivars were evaluated in inoculated, greenhouse experiments for susceptibility to *C. coccodes*. Plant growth was then evaluated 60 days post inoculation. Inoculated plants were stunted and had reduced dry weight of 0% to 53.6% when compared to un-inoculated controls. Significant reductions in growth were observed for 25 of the 34 cultivars ($P<0.05$). In field studies one treatment, azxoystrobin (Quadris, Syngenta) in-furrow soil treatments applied at planting, followed by a foliar spray of chlorothalonil (Bravo, Sygenta) applied when plants were 25 cm tall, provided optimal control as measured by providing significant ($P<0.05$) reductions in percent early dying (2005) and yield increases (2006). Azoxystrobin infurrow plus chlorothalonil foliar treatment reduced early dying by 46.1% and increased yields by 5.4% compared to untreated plots. In 2005, all in-furrow fungicide treatments and foliar treatments provided statistically similar control of early dying. Yield differences were not statistically significant ($P<0.05$) when compared to the untreated with the exception of azoxystrobin in-furrow plus the same fungicide applied foliar. In 2006, all fungicide treatments significantly ($P<0.05$) increased yields above the untreated. No differences in colony forming units of *C. coccodes* /g stem tissue were noted as resulting from any fungicide treatments in the field in 2005, but in 2006 the azoxystrobin in-furrow plus chlorothalonil foliar treatment resulted in reduced cfu/g stem tissue ($P<0.05$) when compared to the untreated.

INTRODUCTION

Black dot of potato caused by the fungus *Collectotrichum coccodes* (Wallr.) S.J. Hughes has become an important disease worldwide (Lees and Hilton, 2003). Yield losses due to black dot are often under estimated due to symptoms being subtle and easily confused with those of natural senesce and Verticillium wilt (Barkdall and Davis. 1992.; Mohan, et al. 1992; Johnson. 1994, Tsror et al,1999.; Nitzen et al., 2005). Yield losses for this pathogen are typically in the 10-16% range, but losses as high as 30% have been reported (Nitzan et al. 2006; Johnson and Miliczky 1993; Nitzan, et al. 2003; Stevensen et al. 1976; Tsror et al. 2001). Above ground symptoms of black dot include stunting, yellowing, wilting and premature plant death. Below ground, roots and stolons have a dry cortical root rot. When infected plants die, the lower stem has numerous small black sclerotia and acervuli. Symptom expression is not correlated with colony forming units of *C. coccodes* because extensive stem colonization does not occur until the plant begins to senesce (Nitzan et al. 2006). *C. coccodes* infections are relatively common in seed potatoes, which may be an important source of regional spread (Johnson, 1994; Johnson et al 1997). Once introduced into a field the fungus survives as sclerotia associated with infected host tissue and is dispersed by splashed water or airborne conidia (Nitzan et al. 2006, Davis and Johnson, 2001).). Besides the planting of resistant cultivars, cultural control measures for black dot include; avoiding the use of infected seed potatoes, crop rotation, timely irrigation and adequate fertility (Davis and Johnson, 2001). The use of

azoxystrobin (Quadris, Syngenta) applied in-furrow at planting (Nitzan et al. 2005) or azoxystrobin applied in-furrow at planting combined with a foliar treatment of either chlorothalonil (Bravo, Sygenta) or mancozeb (Manzate 200, Du Pont) at row closure (Zitter et al. 2003) has provided control. Preliminary research by Jacobsen, et al. (unpublished) has suggested that effective control could be achieved by an in-furrow application of azoxystrobin followed by a foliar application of either mancozeb or chlorothalonil when plants are 20-25 cm in height. Significant plant resistance has been found among commercial cultivars in several countries including the United Kingdom (Read and Hide, 1995), Israel (Tsror et al. 2001), India (Thirumalachar 1967) and France (Andrivon et al. 1998). To date, other than the research of Nitzan et al. (2005) and Olanya, et al. (2006) who compared the cultivars Russet Burbank and Russet Norkotah, and Atlantic and Superior respectively, no one has reported on the susceptibility of any cultivars commonly grown in North America. Research by Platt and Bollen (1993) shows that initial screening can be done with plantlets derived from tissue culture instead of tuber initiated plants. The objectives of this research were to examine susceptibility to *C. coccodes* of cultivars commonly grown in the Pacific Northwest and to examine the efficacy of different fungicide regimens in controlling black dot in the field.

MATERIALS AND METHODS

Glasshouse Trial 2005, 2006, and 2007

Tissue culture derived plantlets from the Montana Potato Laboratory of thirty-four different cultivars (Table 1.) were evaluated in glasshouse experiments for susceptibility to *C. coccodes*. The inoculum was prepared using an isolate of *C. coccodes* taken from potatoes grown in Montana's Gallatin Valley, and tested for pathogenicity. The isolate was grown on potato dextrose broth on a rotary shaker at 23 C for 14 days. The resulting mycelial mats were ground using a waring blender (Cuisinart, East Winsor, NJ) and cfu (mycelia, conidia and sclerotia) was determined using a hemocytometer. Inoculum was mixed into the soil to achieve the desired ~ 1 x 10^4 cfu/kg of soil. This dosage was chosen because in earlier trials it resulted in 100% infection of the cultivar Russet Norkotah at 50 days post inoculation and is similar to pathogen populations encountered in naturally infested fields. The soil mix used for all experiments was a mixture of Bozeman silt loam **:** washed concrete sand **:** Canadian sphagnum peat, 1:1:1) sieved (2 mm mesh opening). The soil was autoclaved at 121°C and at a pressure of 21 kg/cm^2 for 60 minutes prior to use (pasteurization uses lower temperatures). Five plantlets of each cultivar were planted in uninoculated soil while another 5 were planted in infested soil. Plants were grown under optimum irrigation and fertility using Peters Professional 20-20-20 water soluble fertilizer (Scotts Company, Marysville, OH). Temperatures were

maintained at 22° +/1 C day and 18° +/1C night. Phillips Son Agra 430 HPS bulbs were used to supplement natural light with an additional 80 μmols/m^2/s of radiation and to provide a 16hr photoperiod. Plant height data was taken at 30 days, and again at 60 days when plants were harvested. At harvest, plants were cut at the soil level and fresh weights recorded. Plants were individually placed in paper bags and dried at 84°C for three days. The lower 10 cm of stem was removed and ground with a coffee grinder (Krups, Hong Kong) and dilution plated on Farley's media (Farley, 1972). Plates were incubated at 24°C for 10 days and colony forming units/ g of dried stem determined. This entire experiment was repeated twice, once in 2005 and in 2006. In 2007 the same procedure was repeated a third time with the cultivars Kennebec, Frontier, Cal White, Amisk, Ranger Russet, Altura, Russet Burbank, Russet Norkotah, Atlantic and Dark Red Norland. After 60 days growth, the potatoes were sprayed with diquat desiccant (Reglone, Syngenta) at the rate of 2.3L/ha to promote senescence. A CO_2 sprayer was used for this application at a volume of 38L/ha and pressure of 240kPa using a single Spraying Systems 8002 nozzle. Fourteen days later, plants were cut at soil level and processed as above.

2005 Field Studies

Generation II Russet Norkotah seed potatoes were planted at a commercial seed potato farm in Manhattan, Montana. The inoculum levels in the field were $2.0x10^3$ cfu of *C. coccodes* /gram of dry soil as determined by dilution plating soil samples on Farley's

medium and incubation at 24 C for 10 days. The soil type was a Bozeman silt loam with a pH of 7.9, and the field was last cropped to potatoes 2000. The 2004 crop was barley. The previous fall the field was fertilized at the rate of 230,275,200 kg/ha NPK, and 9 of and Zn in kg/ha. All tillage work was done at that time. The test plots were planted using a mechanical potato planter (Kavernland, Norway) on June 10. Individual plots were two rows 6.1m long with 45 cm between rows. There were 5 replicates for each treatment arranged in a randomized complete block design. Seed pieces were placed 22cm apart. At planting time, two rates of azoxystrobin (Quadris, Syngenta) 425ml/ha, and 850ml/ha were applied in–furrow. A CO_2 sprayer was used for this application at 38L/ha and 240kPa using a single Spraying Systems 8002 nozzle. When plants were 25cm tall, foliar sprays of chlorothalonil at the rate of 2.3L/ha (Bravo, Sygenta), mancozeb at 2.2kg/ha (Manzate 200, Du Pont), or azoxystrobin at 425ml/ha (Quadris, Syngenta), were applied to the potatoes. A CO_2 sprayer was used in all foliar applications at 144L/ha and 240kPa using three Spraying Systems 8002 nozzles. Nozzles were oriented so that one was directly over the row and the other two nozzles oriented to spray the sides of the plants. Before vine kill, each treatment was rated for percent plants showing early dying symptoms and ten 20-25 cm sections of lower stem per replicate were removed, and dried. These stem sections were dilution plated on Farley's media for *C. coccodes*, and on alcohol-streptomycin agar (Nadakavukaren and Horner, 1959) for *Verticillium dahliae* to compare cfu/g of dry stem tissue. Vines were killed with diquat at 2.3L/ha (Reglone, Syngenta) using a tractor mounted sprayer with TeeJet XR003VS nozzles spaced every 50cm held 44cm above the canopy, at the rate of 144L/ha. and

pressure of 240kPa. Thirty days later plots were hand harvested and yield data was collected.

2006 Field Studies

Generation II Burbank seed potatoes were planted at the same farm as 2005; but in a different field with Bozeman silt loam soil and a pH of 7.9. This field was cropped to green dry edible peas in 2005 and was last in potatoes in 2002. Inoculum levels of *C. coccodes* was $2.5x10^3$ cfu *C. coccodes* /gram dry soil as determined by dilution plating on Farley's medium and incubated at 24 C for 10 days.. The field was fertilized in the fall of 2005 at the rate of 205, 275, 200, and 9 of NPK and Zn in kg/ha. All tillage work was done at that time. The field was planted using mechanical potato planter (Kavernland, Norway) May 15 Individual plots 6; 91cm rows by 400m long with 22 cm seed piece spacing and four replications were used in a randomized complete block plot design. Fungicide treatments were the same as 2005 but the azoxystrobin was applied in-furrow with the planter at 38L/ha and 76L/ha using TeeJet XR0015VS nozzles spraying right behind the furrow opener but before the hilling disks. Foliar applications were done using a tractor mounted sprayer at a rate of 144L/ha. and 240kPa using TeeJet XR003VS nozzles spaced every 50cm held 44cm above the canopy. In 2006, only chlorothanil and azoxystrobin foliar applications were made. Harvest was forty days after vine kill with diquat using the same sprayer as above using 2.3L/ha (Reglone, Syngenta) at 144L/ha. and 240kPa. Just before harvest twenty below ground stem sections (the stem between

the seed piece and soil surface) per replicate were collected and dried. Later these samples were plated as in 2005 on selective media, to determine cfu of *C. coccodes and V. dahliae*. The plots were harvested using a 4 row potato windrower (Spudnik, Blackfoot, Idaho), and a two row harvester (Double LL , American Falls, Idaho). Each plot was placed in a single truck. The tare dirt was removed, then each truck was weighed and yield data was collected.

Statistical Analyses.

The cultivar evaluation experiments consisted of 34 individual cultivars t-tests with two treatments (inoculated and uninoculated) and 5 replications. Data from the 2005 and 2006 greenhouse experiments were combined since no experiment x cultivar interaction was detected. The paired t-test was used to compare the difference in growth between plants grown in infested vs pasteurized soil. Both field trials were set up in a randomized block design. In 2005 there were 9 treatments and 5 replications, and in 2006 there were 5 treatments and 4 reps. Both trials were analyzed as a nested design, with each treatment as fixed factors. All data were analyzed statistically using SAS Software (SAS Institute Inc., Cary, NC). The general linear model procedure was used to test at the 5% significance level. Analysis of variance was followed by means separation using Fishers protected least significant difference ($\acute{\alpha}$=0.05).

RESULTS AND DISCUSSION

Glasshouse Trials 2005, 2006, and 2007

The combined data on the 34 cultivars evaluated varied considerably in their growth and dry weight reduction in response to *C. coccodes* infection (Table 1). While not statistically significant ($P < 0.05$), early height and final height data showed growth reduction from 0.0-32.7%, and from 0.0-32.8% respectively. Table 1 presents data the on percent reduction in growth and dry weight of potato cultivars grown in soil infested with *Colletotrichum coccodes* compared to the same cultivar grown in non-infested soil. Kennebec was the most susceptible cultivar tested with *C. coccodes* infection resulting in a 53.6% reduction in dry weight. Cultivars such as, All Blue, Alpha, Altura, Amisk, Bannok, Binjte, Chipta, Denali, Purple Viking, Russet Norkotah, Ranger Russet, Red Lasoda, Red Norland, Red Pontiac, Shepody, Umatilla Russet, Western Russet, White Rose and Yukon Gold were of intermediate susceptibility with dry weight reduction of 28.9-11.2%. The most resistant cultivars were A-9045-7, Atlantic, Cal White, Frontier, Gem Russet, Gem Star, Red Lasoda, Russet, Sangre, and Viking based on dry weight reductions of 0-2.5%. These data are in agreement with respect to the high resistance of the cultivar Atlantic (Olanya et al. (2006) as well as moderate susceptibility of cultivar Alpha reported by Tsror et al. (1999) (2001). It should be noted that this study only examined the growth reduction in the above ground portion of plants after 60 days

growth in the greenhouse. Tuber yield was not studied and therefore may respond differently. In both experiments stem sections taken from the lower 10 cm of stem above the soil line did not have detectable cfu of *C. coccodes.* It should be pointed out that at the time stem sections were taken they were still green. Research by Nitzen et al. (2006) indicates that stem colonization by this pathogen does not take place until senescence. Roots were examined and plated on selective media and all samples contained *C. coccodes* but because it was very difficult to obtain a consistent root section of the same size and location no data are presented.

In the 2007 experiment, we chose a smaller subset of cultivars to repeat the experiment with the intention of desiccating the vines to check for *C. coccodes* in the stem tissue based on the report of Nitzen et al. (2005). The 10 cultivars were chosen because they present a full spectrum of resistance to susceptibility noted in earlier experiments. When senescence was induced by diquat, *C. coccodes* was detected in the 12,000 to 20,000 cfu/g stem tissue range. There were no statistical differences between potato cultivars. This suggests that the differential cultivar susceptibility to stunting caused by *C. coccodes* did not extend to stem colonization of senescent plants. These observations agree with Nitzen et al. (2005 and 2006), that colonization by *C. coccodes* of stems which senesced quickly and dried out differed but differences were not statistically significant ($P< 0.05$). The stems which senesced at a slower rate had more cfu/g stem than those which senesced quickly. The use of tissue culture derived plantlets was useful in distinguishing differences between cultivars in susceptibility to *C. coccodes*. It should be considered that plantlets my not respond exactly as tuber initiated

plants would in the field, but the cultivar differences from one cultivar to another should behave similarly based on research by Platt and Bollen (1993).

Table 1: Percent reduction in growth as measured by dry weight, of potato cultivars grown 60 days in pasteurized soil and soils infested with *Colletotrichum coccodes*[1]
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Cultivar	**Dry Weight**	**Cultivar**	**Dry Weight**
A-88338-1	4.4	Gem Russet	0.0**
A-9045-7	0.0**	Gem Star Russet	0.0**
All Blue	28.9**	German Butterball	8.3
Alpha	11.6	Purple Viking	13.1
Altura	21.6**	Russet Burbank	8.6
Amisk	27.9**	Russet Norkotah	11.4
Atlantic	0.0*	Ranger Russet	22.5*
Bannok	11.3	Red Lasoda	0.7
Binjte	20.2*	Red Norland	14.9**
Cal Red	11.2*	Red Pontiac	18.6
Cal White	2.5	Sangre	4.26
Chipita	10.8	Shepody	26.0*
Dark Red Norland	6.9	Umatilla Russet	16.5
Denali	12.7	Viking	1.9
Frontier	0.0**	Western Russet	18.4*
Kennebec	53.6**	White Rose	23.2**
Gem Chip	5.7	Yukon Gold	18.6**

[1] Percent growth reduction calculated as percent of growth of dry weight of plants grown in pasteurized soil.
* Significant at $P < 0.05$
** Significant at $P < 0.01$

Field Trials 2005 and 2006

For our trials, the in-furrow azoxystrobin treatment alone is inferior to an in-furrow treatment followed by a foliar fungicide (Table 2 and 3). These results match

work of others which showed that a foliar fungicide in combination with in-furrow application of azoxystrobin is better than a single in-furrow application of azoxystrobin (Zitter et al, 2003). Our results differ from that of Zitter et al. (2003) in that we used an earlier application time for the foliar fungicide. The research by Nitzen et al., 2005 showed the benefit of in-furrow azoxystrobin treatment and this study did not include foliar treatments. In 2005, a lower percentage of plants with early dying symptoms was observed in the in-furrow plus foliar fungicide treatments compared to the low rate of azoxystrobin in-furrow only treatment (Table 2). The high rate of azoxystrobin in-furrow treatment was equivalent to the azoxystrobin plus foliar fungicide treatment with respect to the percentage of plants showing early dying symptoms. The stem sections collected had *C. coccodes* infections in the range of 1500-3000 cfu/g of stem tissue but there were no statistical differences detected between treatments. At the time the stem tissue was collected, the stems were still green but foliage showed some natural senesce. The stem tissue also showed *V. dahliae* populations in the range of 40,000 to 80,000 cfu/g with statistically significant differences only for the high rate of azoxystrobin applied in-furrow plus azoxystrobin applied as a foliar spray ($P< 0.05$). Data is not presented here because it is outside the focus of this paper. Despite the reduction in percentage of early dying plants, fungicide treatments did not have a statistically significant effect on yield (Table 2). It is possible that the yield data may not correlate with the visual data due to the variety used, or naturally occurring variations in field inoculum. These results are in agreement with Nitzen et al. (2006) who demonstrated foliar chlorosis and necrosis are not good indicators of either colonization or effects on yield of the cultivar Russet

Norkotah (Nitzen et al. 2005). These workers also suggested that lack of yield difference in two of the reported studies may have been attributable to the presence of *V. dahliae.* In 2006 we decided to change cultivars for field testing based on Nitzen et al. (2005) who concluded that the cultivar Russet Burbank was more responsive to yield improvements by azoxystrobin application than the cultivar Russet Norkotah. Our data in Table 1 does not support the conclusion that the cultivar Russet Norkotah is more resistant than the cultivar Russet Burbank, although both cultivars are of intermediate susceptibility based on growth reduction in the greenhouse tests.(Table 1).

In the 2006 field trial, although some differences in row closure were observed, no visual differences in premature dying were observed. Except for the 425 ml rate of azoxystrobin applied in furrow, all fungicides increased yield with the 425 ml rate of azoxystrobin applied in-furrow plus a foliar chlorothalonil providing best yield improvement (Table 3). The 850 ml rate of azoxystrobin applied in-furrow provided statistically similar results (Table 3). The yield losses with little symptom expression agrees with other published research (Barkdall and Davis 1992; Johnson 1994; Tsror et al. 1999; Nitzen et al. 2005). The yields were much higher in 2006 than 2005 and we feel this is a result of an earlier planting date and longer growing season. In 2006, the stem sections were collected 40 days after vine kill but before harvest. This time we collected underground stem sections, from the seed piece to the soil surface, to hopefully give a more representative example of disease level. Only the 425 ml rate of azoxystrobin applied in-furrow plus a 2.3 liter rate of chlorothalonil applied when plants were 25 cm tall treatment had significantly lower cfu/g stem colonization by *C. coccodes* when

compared to the untreated (Table 3). *Verticillium dahliae* stem infections were either non detectable or at very low levels with no correlation between this pathogen and yields noted.

Based on our greenhouse research we suspect that slight differences in moisture levels or duration of senescence from one plant to another in the field, will cause variations in total stem colonization. We felt that by using underground section of stems, the natural soil moisture would contribute to a more uniform environment where colonization to occur. Therefore the comparison of colony forming units from underground stem sections may be more representative of the actual disease load in the field.

Table 2: The effect of in-furrow (IF)application of azoxystrobin (Quadris, Syngenta) and foliar (F) application of mancozeb (Manzate 200, Du Pont) and chlorothalonil (Bravo, Syngenta) on early dying symptoms and yield of Russet Norkotah potatoes in 2005.

Treatment Product/ha	**Early Dying**	**Yield t/ha**
Untreated	15.6^{A}	17.9^{AB}
Quadris 425ml (IF)	13.2^{AB}	15.6^{AB}
Quadris 425ml (IF)/2.3L Bravo (F)	7.2^{BC}	16.4^{AB}
Quadris 425ml (IF)/2.2kg Mancozeb(F)	4.4^{C}	14.8^{B}
Quadris 425ml(IF)/425ml Quadris	4.4^{C}	18.8^{A}
Quadris 850ml (IF)	2.4^{C}	15.8^{AB}
Quadris 850ml (IF)/2.3L Bravo(F)	6.4^{C}	17.1^{AB}
Quadris 850ml (IF)/2.2kg Mancozeb(F)	4.4^{C}	16.6^{AB}
Quadris 850ml (IF)425ml Quadris(F)	3.6^{C}	15.6^{AB}
$LSD_{(0.05)}$	9.3	3.9

All treatments are on a per hectare basis

Means followed by the same number are not significantly different according to Fischer's protected least significant difference at the 5% level the later data is non-statistical

Table 3: The effect of in-furrow (IF) application of azoxystrobin (Quadris, Syngenta) and foliar(F) applications of azoxystrobin (Quadris, Syngenta) and Chlorothalonil (Bravo, Syngenta) on yield and colony forming units (CFU) of underground stem sections of Russet Burbank potatoes in 2006.[1]

Treatment Product/ha	**CFU/g *C. coccodes***	**Yield t/ha**
Untreated	33,500 B	22.7 D
Quadris 425ml (IF)	22,000 AB	23.0 CD
Quadris 425ml (IF)/2.3L Bravo (F)	14,500 A	24.0 A
Quadris 425ml (IF)/850ml Quadris (F)	27,000 AB	23.4 BC
Quadris 850ml (IF)	20,000 AB	23.8 AB
$LSD_{(0.05)}$	14.300	0.6

[1]Underground stem sections are the sections of stem tissue between the soil surface and the seed piece.
All treatments are on a per hectar basis
Means followed by the same letter are not significantly different according to Fisher's protected least significant difference at the 5% level

CONCLUSIONS

The data presented show that black dot caused considerable stunting in some potato cultivars while causing little or no growth reduction in others. Some of the most resistant lines such as A-88338-1, Gem Russet, Gem star Russet and Frontier are cultivars developed in by the USDA at Aberdeen, ID. At Aberdeen, new varieties are selected against early dying, which was assumed to be resistance to *Verticillium dahliae* (Personal Communication Dr. Rich Novy). This data suggest that the USDA Aberdeen breeding program is also unintentionally selecting for resistance to black dot. We will be conducting inoculated field trials with these and other cultivars in 2007 to determine whether field response is similar to our greenhouse data.

The cultivars used in our 2005 and 2006 field experiments were Russet Burbank and Norkotah, which showed statistically similar susceptibility to stunting in the greenhouse tests. Nitzen et al. (2005) showed that azoxystrobin increased and reduced disease severity differentially on the cultivars Russet Norkotah and Russet Burbank. He felt that the presence of *Verticillium dahliae* could have been responsible for inconsistent results. Our 2005 field results showed *V. dahliae* infection was widespread and differences in cfu/g of stem tissue were identified but the cfu/g of *V.dahliae* stem tissue was not affected by the low rate of azoxystrobin plus either chlorothalonil or mancozeb treatments, and these treatments showed the lowest percentage of early dying plants. Therefore we feel the early dying symptoms were not affected by *V. dahliae* in our plots.

In 2006, the level of *V. dahliae* infection based on cfu/g stem was below the level of detection or very low. Regardless of other factors, our field data support the conclusion of Nitzen et al. (2005), that Russet Burbank is more responsive to yield improvement in *C. coccodes* infested soil than the cultivar Russet Norkotah. The 2006 field experiment was done on a large scale, with the plots being almost 200 times larger. In this plot we did show yield increases from the in-furrow plus foliar fungicide treatments. Field research demonstrated yield loss of 5.4% for Russet Burbank when comparing the best fungicide treatment to the untreated. Based on our differential responses to infection shown in Table 1, it should be considered that response to fungicide treatment with azoxystrobin may depend on the cultivar chosen.

In the 2007 greenhouse experiment, where senescence was induced with diquat, colonization of *C. coccodes* in stems of resistant cultivars was similar to that for susceptible cultivars. This would indicate that cultivars which show resistance to black dot will still contribute to inoculum buildup. Fungicide applications had no effect on inoculum produced in stems in 2005 on the cultivar Russet Norkotah. But at the time we collected green stems which showed very little *C. coccodes* infection. Had we taken underground stem tissue after vine kill, we may have seen a differential response. In 2006 the best fungicide treatments did affect inoculum in below ground stems taken after vine kill of the cultivar Russet Burbank. Therefore even though resistant, these culitvars will contribute to inoculum buildup in the field. Our results suggest that it may be possible to reduce the inoculum level through the use of fungicides.

More research is needed on impact of inoculum production and yield loss of different cultivars in the field. Critical to the seed industry is the need to determine if cultivars differ with respect to tuber born infections. Nitzen et al. (2005) showed that azoxystrobin-treated plants had decreased progeny tuber infection. Our current work has shown that combination of the foliar fungicide in addition to azoxystrobin applied in furrow further reduced inoculum on underground stems than that of the azoxystrobin applied in-furrow alone. Therefore it may be possible reduce the inoculum produced in seed tubers as well as tuber blemishes from this pathogen. The work done in the UK shows that fungicide treatments may reduce tuber blemish symptoms but may not reduce the inoculum present on the seed tubers. In addition, this same research also concluded that disease on the seed tuber increased disease severity in inoculated plots (Read and Hide, 1995). The impact of field fungicide treatments on over all crop quality also needs to be determined. This research could also focus on the impact of black dot on the tuber size profile as well tuber shape and grade. This would be of particular interest to both the seed and fresh markets.

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