Effect of Fungicides Application Timing on Potato Black Dot Development

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INTRODUCTION

Potato black dot, caused by *Colletotrichum coccodes (*Wallr) S. J. Hughes, is a concern in commercial potato production areas worldwide. The disease may develop from either soil-borne, or seed-borne inocula, or a combination of the both. Infection by *C. coccodes* from either inoculum source is latent until mid to late season when first foliage symptoms of early dying may become noticeable. As plants dry out, sclerotia (0.1-0.5 mm in diameter) become visible on roots, stolons, and stems. On drying stems numerous sclerotia may be visible up to 10 inches above ground. Plant debris carrying sclerotia will serve as soil-borne inoculum in coming seasons.

Black dot effect on yield is variable. Yield reduction on susceptible cultivars may reach 30% (Tsror, Plant Dis. 1999). However, results from yield trials indicated that potato tuber yields were not always reduced when plants were infected with *C. coccodes*. Plants in the field may demonstrate high disease severities (stem colonization) and high incidence of infected progeny tubers, and yet without reduction of yield (Scholte et al. 1985; Tsror et al. 1999). It seems that factors such as drought, high temperatures (>70°F), and short day photoperiod, which promote plant stress, increase plants susceptibility to yield reduction. Furthermore, there are indications from greenhouse trials (Nitzan & Johnson, 2005) and from field observations (Dallas Batchelor – personal communication) that the disease causes an increase in the number of progeny tubers while reducing tuber mean weight. Therefore, growers may not always suffer reduction of total yield weight, but rather a reduction of tuber size and quality.

Reduction of quality may also come in the form of reduced specific gravity, which was recorded in field trials by Barkdoll & Davis (Plant disease 1992, 131-135) and in greenhouse trials (Nitzan et al. 2005). The main effect on tuber quality is, however, in the form of skin blemishes developing in high (>90%) relative humidity storage. These blemishes resemble those caused by *H. solani*, causal agent of Silver scurf, and may therefore be confused with the latter. To date no specific fungicide has been developed for the management of potato black dot. In the present study we summarize two field trials conducted in 2003 and 2004 in which the effectiveness of various fungicides to reduce black dot development was tested with a combination of application timing.

MATERIALS & METHODS

General trials were conducted in 2003 and 2004 at the Washington State University research station near Othello, WA, on a Shano silt loam using the cultivar Ranger Russet. Treatments were replicated four times in a completely randomized block design.
In 2003, plots were single row, 30 ft long, 34 inch wide, 10 inch seed spacing, ~2.0 oz cut seed piece. The trial in 2003 was planted on April 17; vine beat October 16; harvested and graded October 17 [(183 days after planting (DAP)].

In 2004, plots were three rows, 15 ft long, 34 inch wide, 10 inch seed spacing, ~2.0 oz cut seed piece. The 2004 trial was planted April 15; vine beat September 30; harvested and graded October 13 (181 DAP).

Fungicide treatment
In 2003, the fungicides Quadris (azoxystrobin) and Maxim MZ were applied separately and jointly (Table 1). The fungicide treatments in 2003 were:
1) in furrow at planting in an 8 inch band at 16 gallon/acre (gpa);
2) before hilling of plots on May 30 (43 DAP) in an 8 inch band on top of the hill at 40 gpa;
3) to foliage, 6-10 inches prior to row closure on June 18 (62 DAP) at 40 gpa (Table 1).

In 2004 the fungicides Quadris (azoxystrobin), Headline (azoxystrobin), Tanos, and Blocker were applied separately (Table 2). The fungicide treatments in 2004 were:
1) in furrow at planting in an 8 inch band at 16 gallon/acre (gpa);
2) before hilling of plots on May 18 (33 DAP) in an 8 inch band on top of the hill at 40 gpa;
3) to foliage, 6-10 inches prior to row closure on June 14 (60 DAP) at 40 gpa (Table 2).

Disease severity on stems
On October 3, 2003 (169 DAP) and on September 28, 2004 (166 DAP) three stems from each plot (12 stems per treatment) were hand pulled and taken to Pullman WA for black dot assay. Stems were washed with water to remove soil deposits and disinfected (1% NaClO for 10 min). Five centimeters (~2.5 inches) of the aboveground and of the belowground parts of the stems were each cut into 6-8 segments, and were placed onto modified potato dextrose agar (PDA) and incubated at 25°C in the dark for 14 days. Disease severity was evaluated separately for aboveground and belowground part of stem as the percent of infected segments.

Disease incidence on progeny tubers
Twenty tubers from each plot were randomly selected at harvest (80 tubers per treatment). Tubers were washed with water to remove soil deposits and disinfected (1% NaClO for 10 min). Stolon-ends were cut and placed onto modified PDA and incubated at 25°C in the dark for 14 days. Incidence of infected progeny tubers was calculated.

RESULTS

Physiological differences were not observed between treatments during the 2003 and 2004 trials, nor where there significant differences between treatments at emergence (33 DAP). In the 2003 trial there was only slight disease pressure for black scurf, silver scurf, and black dot on tuber samples.

In 2003, potato stem segments (5 cm) above and below ground had a significant black dot incidence among treatments ranging from 1 - 46% and from 4 - 63%, on above and belowground stem sections, respectively (Table 3). Stem assays in 2003 showed that application of Quadris at hilling (43 DAP) was the most effective treatment for reducing incidence of black dot in 5 cm stem segments above and below ground. Maxim MZ had no influence on incidence of black dot in stems. Assay of tuber vascular tissue demonstrated infection of black dot in tubers. Yield differences between treatments were not observed.

In 2004, potato stem segments (5 cm) above and below ground had a significant black dot incidence among treatments ranging from 4 - 74% and from 22 - 95%, on above and belowground stem sections, respectively (Table 4). Stem assays showed that applications of Quadris and Headline at row closure (60 DAP) were the most effective treatment for reducing incidence of black dot in 5 cm stem segments above and below ground.

DISCUSSION

The results of the 2003 and 2004 trials demonstrated the effectiveness of strobilurins in reducing potato black dot colonization of stems. The results of the 2003 trial demonstrated that the strobilurin (Quadris) was most effective applied at hilling, followed by in-furrow, and least effective application was at row closure. The results of the 2004 trial, in contrast, indicated that the most effective application was just before row closure (60 dap), the next effective treatment

Table 1: Fungicide treatment and application method in 2003 field trial.

Treatment	Fungicide	**Form**	**Rate**	**Product /AI rate**
Control	Check			
Maxim-MZ 28.3	Maxim-MZ 10.1 DP Chlorothalonil or EBDC*	DP	10.1	28.3 GA/Ha
Maxim-MZ 56.6	Maxim-MZ 10.1 DP Chlorothalonil or EBDC*	DP	10.1	56.6 GA/Ha
Quadris in furrow at planting	Quadris 2.08 SC Chlorothalonil or EBDC	SC	250	1.0 GA/100RowM
Maxim-MZ & Quadris in furrow at planting	Maxim-MZ 10.1 DP Quadris 2.08 SC Chlorothalonil or EBDC*	DP SC	10.1 250	28.3 GA/Ha 1.0 GA/100RowM
Quadris in furrow at planting & hilling	Quadris 2.08 SC Quadris 80 WG Chlorothalonil or EBDC*	SC WG	250 80	1.0 GA/100RowM 112.0 QA/Ha
Quadris with hilling	Quadris 80 WG Chlorothalonil or EBDC*	WG	80	112.0 QA/Ha
Maxim-MZ & Quadris in furrow at planting & hilling	Maxim-MZ 10.1 DP Quadris 2.08 SC Quadris 80 WG Chlorothalonil or EBDC*	DP SC WG	10.1 250 80	28.3 GA/Ha 1.0 GA/100RowM 112.0 QA/Ha
Maxim-MZ & Quadris at hilling & before row closure	Maxim-MZ 10.1 DP Quadris 80 WG Quadris 80 WG Chlorothalonil or EBDC*	DP WG WG	10.1 80 80	28.3 GA/Ha 112.0 QA/Ha 112.0 QA/Ha

Table 2. Fungicide treatment and application method in 2004 field trial.

Treatment	Rate	Form	Date	Notes
Control	-	-	-	-
Quadris in furrow at planting	0.1 lb ai/a	2.08 SC	4/15 (0)	In-furrow
Headline in furrow at planting	0.1 lb ai/a	500 F	4/15 (0)	
Quadris with hilling	0.1 lb ai/a	80 WG	5/18 (33)	
Headline with hilling	0.1 lb ai/a	500 F	5/18 (33)	1-3" height and width
Tanos with hilling	4 oz ai/a	50 WG	5/18 (33)	
Blocker with hilling	10 pts/a		5/18 (33)	
Quadris before row closure	0.1 lb ai/a	80 WG	6/14 (60)	10" before row close/
Headline before row closure	0.1 lb ai/a	500F	6/14 (60)	10-20% flw
Tanos before row closure	4 oz ai/a	50 WG	6/14 (60)	16" height
Blocker before row closure	10 pts/a		6/14 (60)	

Table 3. Disease severity on above and belowground stem sections, and total yield weight of Ranger Russet potato infected with black dot and treated with Quadris and Maxim-MZ applied at different times during 2003 potato operation.

Treatment		Stem colonization (%) [b]		Yield
Fungicide	Application [a]	Aboveground	Belowground	
Control		46 a	63 a	641
Maxim MZ 56.6		34 ab	48 a	612
Maxim MZ 28.3		34 ab	51 a	665
Maxim MZ & Quadris	In furrow	28 abc	59 a	628
Quadris	In furrow	18 bcd	48 a	573
Maxim MZ & Quadris	In furrow and foliar	1.5 d	5.5 b	675
Maxim MZ & Quadris	In furrow and hilling	4 cd	8 b	625
Quadris	Hilling	1.5 d	7.5 b	633
Quadris	In furrow and	1 d	4 b	619

[a] Application: in furrow at planting, foliar at 43 days after planting, hilling at 62 days after planting

[b] Five centimeters (2.5 inches) of above and below ground sections of stem were cut into 6-8 1cm thick segments, and the percentage of infected segments was calculated.

Table 4. Disease severity on above and belowground stem sections, incidence of infected progeny tubers, and total yield weight of Ranger Russet potato infected with black dot and treated with Quadris, Headline, Tanos and Blocker applied at different times during 2004 potato operation.

Treatment		Disease Severity (%) [b]		Incidence of infected progeny tubers (%) [c]	Yield (Ton/a)
Fungicide	Application [a]	Aboveground	Belowground		
Ck	Ck	74 a	89 a	24	52
Tanos	Row close	71 a	81 abc	30	56
Blocker	Row close	54 ab	66 abc	21	57
Quadris	Row close	11 ab	23 c	18	57
Headline	Row close	4 b	22 c	21	57
Tanos	Hill	54 ab	78 abc	17	56
Blocker	Hill	47 ab	62 abc	25	55
Quadris	Hill	32 ab	42 abc	22	53
Headline	Hill	32 ab	28 bc	14	56
Quadris	In-furrow	69 ab	95 a	18	58
Headline	In-furrow	61 ab	86 ab	19	55

[a] Application: in furrow at planting, hilling at 33 days after planting, and to foliage at 60 days after planting before row closure.

[b] Five centimeters (2.5 inches) of above and below ground sections of stem were cut into 6-8 1cm thick segments, and the percentage of infected segments was calculated.

[c] The stolon end of 80 tubers per treatment were cut and put onto agar, and the percentage of infected