# Effects of Inoculum Source and Fungicides on Black Dot Development

Jason Ingram, Jeremiah Dung, Tom Cummings, Nadav Nitzan and Dennis Johnson,
Department of Plant Pathology, Washington State University, Pullman.

## Introduction

Potato black dot is caused by the fungus *Colletotrichum coccodes* and is appropriately named for the black fungal structures called sclerotia that develop on infected potato stems, roots and tubers. Sclerotia are a survival structure and typically develop on the lower stems and roots of the host plant. Black dot sclerotia can remain infectious in the soil for 8 years and so provide an inoculum source over a period of time that is longer than most crop rotations. However, the numbers of viable sclerotia in soil likely decline after three years without potatoes or other hosts such as nightshades. Sclerotia that develop on the tubers enable the pathogen to be transported to new fields.

## Two Sources of Inoculum

Determining the importance of soil and seed-tuber inoculum sources of the black dot fungus is a logical step in developing management strategies. Studies at the Othello research farm, grower fields and the greenhouse demonstrated that when the black dot fungus is in the soil it “trumps” the effect of inoculum on the seed tuber. In a greenhouse trial repeated over 4 years, Russet Burbank nuclear seed tubers that were clean of black dot fungus were separated into one group that was inoculated with the black dot fungus and another group that was not inoculated. Half of each group was then planted in soil infested with the black dot fungus and the other half planted in soil that was not infested. When the infected and non-infected seed tubers were grown in infested soil, no differences in black dot density on the plants roots were observed (Table 1). These results demonstrated that the effect of soil-born sclerotia masked the effect of the seed tuber-born fungus with regard to severity of root colonization. This finding was again substantiated in a study in the Columbia Basin in 2007 where generation-3 seed tubers from six different certified seed growers were planted in both virgin potato ground and a field that had not grown potatoes for 5 years. For each seed lot, the number of distinct black dot colonies, the total area of the below ground stem covered with black dot and the height to which the pathogen colonized the vines was significantly greater in the field with previous potato crops. For example, *“# of Lower Stem Colonies”* averaged 1.6 per plant in the previous potato field (Othello) while in the virgin (Connell) field *“# of Lower Stem Colonies”* averaged 0.2 colonies per plant (Table 2). This means that a smaller percentage of plants were infected with black dot and that there were fewer initial infection sites per plant in the virgin potato fields.

## Efficacy and Application Timings of Fungicides

A greenhouse study of fungicides and application timing for black dot control was completed in 2007. The fungicides Headline and Quadris were evaluated at labeled rates for black dot. Both fungicides are strobilurins that have similar modes of action and belong to the group 11 resistance management category. These two strobilurins were applied to growing Russet Burbank stems that had been inoculated with the black dot fungus at tuber initiation (67 DAP - days after plant). Fungicide treatments consisted of a single application made at a pre-inoculation timing and at 1, 5 and 10 days post inoculation. A sequential application at 1&10 days after inoculation was also evaluated. Foliar application of the strobilurins prior to inoculation of the plant was the only timing that significantly reduced disease incidence when compared to a non-fungicide control group (Table 3).

Application timing of Quadris (9.0 oz / acre) was evaluated on Ranger Russet at the Othello research farm over a 5-year period to determine the best time to apply fungicides for black dot control. Single fungicide application timings included at planting, full emergence (34 DAP - days after plant), tuber initiation (43 DAP) and at near row closure (60 DAP, initial flower). A window between full emergence (40 DAP) up to initial flower (60 DAP) was identified as the period when fungicide application was most effective for black dot control (Figure 1 & 2). In-furrow applications were not as effective against black dot development in earlier trials.

To evaluate fungicide application by chemigation, Quadris was applied through a center pivot at the 6.2 oz rate to three $30^o$ wedges at 50 DAP and again at 67 DAP. The treated wedges were paired with adjacent $30^o$ wedges that did not receive any fungicide on those dates. The trial was conducted in a commercial Russet Burbank field northeast of Moses Lake in 2007 and all other conditions across the field were the same and in accordance with the growers typical practices for the remainder of the season. On the three assay dates at 79, 102 and 140 DAP, the average black dot colony size on the below ground stem in the treated wedges was significantly reduced when compared to stems from the untreated wedges. Above ground plant stems had less vertical development of black dot within the vines on Quadris treated plants than the non-treated plants on the latter two assay dates. Fewer progeny tubers were infected from the Quadris treated than the non-treated plots, but the difference was not statistically significant (Table 4). The strobilurins in these studies acted fungistatically, halting fungal growth in the plant temporarily and not acting as an eradicant or a curative product.

**Conclusions**

Soil-borne inoculum played a more dominant role than tuber-borne inoculum in causing severe black dot symptoms. Disease management efforts should be directed at reducing inoculum in the soil and reducing the rate of disease development in infected plants. Crop rotations that reduce soil inoculum levels and cultivars resistant to black dot are likely to reduce disease levels in the field. Practices that reduce soil compaction, limit water saturation of soils and improve root development and health should reduce the rate of black dot development and the effects of the disease on plant yield. Strobilurin fungicides such as Quadris when applied just before closure between rows have reduced severity of black dot on potato, but consistent yield benefits have not been realized with fungicides. Chemigation of strobilurins at strategic timings may reduce infections on roots and tubers. Additional research to exploit this window may help develop a fungicide application strategy that reduces black dot and increases potato yields.

Table 1. Sclerotia density on roots of Russet Burbank potatoes grown from infected or non-infected tubers in infested or non-infested soil with *C. coccodes* in the greenhouse in 2003, 2004, 2005 and 2006.

| Inoculum source [a] | | Sclerotial Density on Roots (0–5) [b] | | | |
|---|---|---|---|---|---|
| Soil | Tuber | 2003 | 2004 | 2005 | 2006 |
| + | + | 3.7 a | 3.3 a | 3.5 a | 4.8 a |
| + | - | 3.6 a | 3.3 a | 3.2 ab | 4.8 a |
| - | + | 2.5 b | 3.5 a | 2.6 b | 3.9 b |
| - | - | 1.7 | 0 | 1.4 | 1.5 |

Fischer's protected *t*-tests LSD at $\alpha$=0.05. Different lower case letters within columns represent significant statistical differences among the inoculum source treatments.

[a] Inoculum source: "soil + / tuber +" = presence of *C.coccodes* in the soil and the tuber; "soil + / tuber –" = presence of *C. coccodes* only in the soil; "soil - / tuber +" = presence of *C. coccodes* only in the tuber; "soil - / tuber –" = non-inoculated control plants.

[b] Sclerotial infection on roots was scored visually on a 0 to 5 scale: 0 = no sclerotia, 1 = 1- 10% of the surface area covered with sclerotia, 2 = 11 - 30%, 3 = 31 - 50%, 4 = 51 – 75%, and 5 = 76 – 100%.

Table 2. Level of black dot in seed-tubers and foliage when grown on virgin potato ground at Connell and previous used potato ground at Othello.

| Othello 8/20[1] | Seed % disease[2] | Lower stem severity[3] | #Lower stem colonies[4] | Progeny incidence |
|---|---|---|---|---|
| Seed ID | Cc | Cc | Cc | Cc |
| 1 | 57 | 0.59 | 1.5 | 0.04 |
| 2 | 54 | 0.50 | 1.8 | 0.04 |
| 3 | 25 | 0.42 | 0.9 | 0.01 |
| 4 | 60 | 0.55 | 1.7 | 0.09 |
| 5 | 31 | 0.33 | 1.5 | 0.02 |
| 6 | 0 | 0.58 | 2.1 | 0.02 |
| **Connell 9/5[1]** | **Seed % disease[2]** | **Lower stem severity[3]** | **#Lower stem colonies[4]** | **Progeny incidence** |
| Seed ID | Cc | Cc | Cc | Cc |
| 1 | 57 | 0.00 | 0.0 | 0.02 |
| 2 | 54 | 0.08 | 0.1 | 0.00 |
| 3 | 25 | 0.00 | 0.0 | 0.00 |
| 4 | 60 | 0.42 | 0.3 | 0.00 |
| 5 | 31 | 0.25 | 0.5 | 0.00 |
| 6 | 0 | 0.17 | 0.4 | 0.00 |

[1] Othello- non-virgin field several five year potato rotations; Connell- virgin field never planted to potato.
[2] Percent incidence of seed tubers assayed for black dot (Cc).
[3] Percent of the below ground stem surface covered with Sclerotia
[4] Number of distinct black dot colonies per below ground stem

Table 3. Incidence of infection and colony size of *Colletotrichum coccodes* from the inoculation site when inoculated potato stems were treated with fungicides at various timings.

| | Infection incidence[1] | | Diameter of colony (cm)[2] | |
|---|---|---|---|---|
| Fungicide timing[3] | Trial 1 | Trial 2 | Trial 1 | Trial 2 |
| Inoculated Control | | | | |
| No Fungicide | 1.0 a | 1.0 a | 3.4 a | 4.1 a |
| Pre-inoculation | | | | |
| Headline | 0.0 b | 0.25 b | 0.0 c | 0.6 c |
| Quadris | 0.5 ab | 0.25 b | 0.5 bc | 0.0 c |
| Post-inoculation 1 Day | | | | |
| Headline | 0.75 a | 1.0 a | 1.6 abc | 1.8 bc |
| Quadris | 1.0 a | 1.0 a | 2.0 abc | 3.3 ab |
| Post-inoculation 5 Days | | 1.0 a | | |
| Headline | 1.0 a | 1.0 a | 2.3 abc | 1.8 bc |
| Quadris | 1.0 a | 1.0 a | 3.5 a | 3.3 a b |
| Post-inoculation 10 Days | | | | |
| Headline | 1.0 a | 1.0 a | 2.8 ab | 2.5 ab |
| Quadris | 1.0 a | 1.0 a | 3.5 a | 3.8 a |
| Post-inoculation 1&10 Days | | | | |
| Headline | 1.0 a | 0.75 ab | 1.2 abc | 0.6 c |
| Quadris | 1.0 a | 1.0 a | 3.1 ab | 1.5 bc |

[1] Incidence of infection sites from which *C. coccodes* could be cultured following treatments.
[2] Diameter of colony is the average colony size of *C. coccodes* grown from the infection site after 8 days in culture.
[3] Significance at $P \leq .05$.

Table 4. Black dot disease ratings on below- and above-soil potato stems and infected tuber incidence when Quadris was and was not chemigated in a commercial potato pivot.

| | Black dot disease ratings on stems | | | | | | Tubers |
|---|---|---|---|---|---|---|---|
| | 7/18 | | 8/10 | | 9/17 | | |
| Treated | Below soil Colony (cm)[1] | Above Soil[2] | Below soil Colony(cm)[1] | Above Soil[2] | Below soil Colony (cm)[1] | Above Soil[2] | Progeny Inc. |
| None | 5.5 a | - | 8.8 a | 14.4 a | 19.2 a | 23.7 a | 63% |
| Quadris[3] | 0.3 b | - | 6.7 a | 6.1 b | 9.5 b | 12.7 b | 48% |
| lsd | 5.0 | | 11.6 | 6.6 | 8.4 | 9.4 | 23% |

[1] Below soil stem disease is average measure (cm) of length of black dot colonies.
[2] Above ground stems rating is weighted mean of black dot found on 0.5 cm stem sections sampled at 10, 18, and 26 cm from soil line.
[3] Quadris (6.2 oz/a) @ 0.14 inches/a applied 50 and 67 DAP.

Figure 1. Effects of a single application of Quadris (9oz) to russet potato canopies for reducing black dot on upper crown stems when applied at different times. Trend summary of 3 fields in Othello WA, 2007.

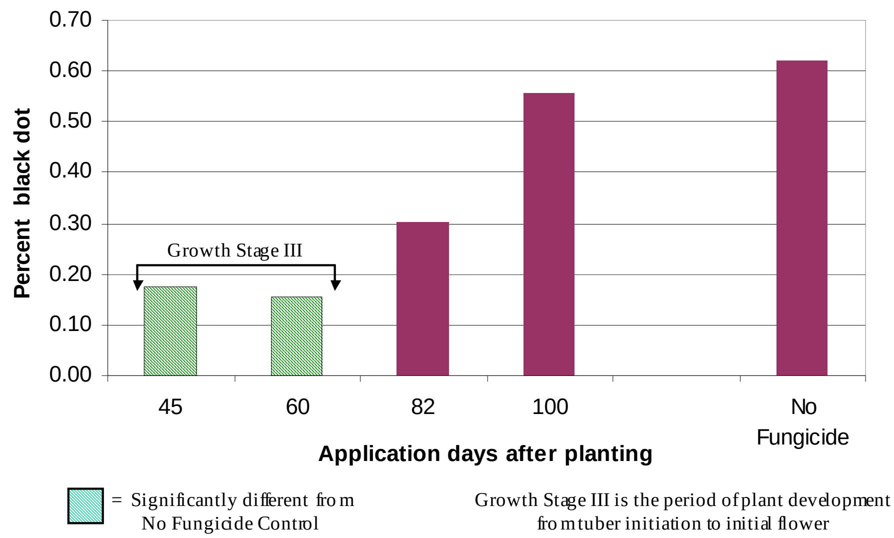


Figure 2. Effects of a single application of Quadris (9oz) to Ranger potato canopy for reducing black dot on daughter tubers when applied at different times. Othello WA, 2007.