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Timing Fungicide Applications for Management of Sclerotinia Stem Rot

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Sclerotinia stem rot, also called white mold, is a widespread problem in potato fields in the Columbia Basin. The disease is favored by high relative humidity, long periods of free moisture on foliage, and fertility practices that promote dense foliage. *Sclerotinia sclerotiorum*, the fungus that causes white mold, has a wide host range of approximately 400 species of broad leaved (dicotyledonous) plants. Among these are potato, bean, tomato, carrot, radish, pea, sunflower, and canola.

Basics of Sclerotinia Stem Rot

Sclerotinia stem rot first appears as small water-soaked lesions usually at the point where branches attach to stems or on branches or stems in contract with the soil. A white cottony growth of fungus mycelium develops on the lesions and the infected tissue becomes soft and watery. Lesions expand and may girdle the stem which causes the foliage to wilt.

During dry conditions, lesions become dry and will turn beige, tan or bleached white in color and papery in appearance. Hard, irregularly shaped resting bodies of the fungus, called sclerotia, form in and on decaying plant tissues. Sclerotia are generally ¼ to ½ inch in diameter, initially white to cream in color but become black with age and are frequently found in hollowed-out centers of infected stems. Sclerotia will eventually fall to the ground and enable the fungus to survive until the next growing season.

Sclerotia are very durable and can survive in soil for at least three years. They require a conditioning period of cool temperatures, provided by winter weather, before germination. During the growing season, sclerotia within 1 to 1.5 inches of the soil surface germinate when the canopy of the growing crop shades the ground and soil moisture remains high for several days.

Sclerotia either germinate directly as mycelium which may infect stems near the soil surface, or they produce fruiting bodies called apothecia (singular is apothecium). Apothecia are cup-shaped on their upper surface, about 0.5 inch in height, fleshy in texture, and pale pink or light tan in color. Millions of ascospores are formed in each apothecium. Ascospores are ejected into the air and are carried by air currents up to several miles in distance. Airborne ascospores are deposited into potato fields before row closure and continue for eight or more weeks. Number of ascospores peak near full bloom of primary flower clusters, which is defined as bloom of more than 90 percent of the flower buds on primary inflorescences over more than 75 percent of the field.

Ascospores of *S. sclerotiorum* are incapable of direct infection of intact green potato tissues, but **they must first colonize flowers** or dying or dead plant tissues and then use them as an energy source to infect green tissues.

Blossoms are crucial for infection and development of Sclerotinia stem rot in potato. Airborne ascospores are deposited on open potato blossoms still attached to the canopy. Infested flowers fall and are trapped on stems, usually leaf axils, or fall on the ground and fungal mycelia then rapidly colonize the blossoms when humidity is high in the plant canopy. Ascospores are also deposited on senescent and dead plant material on the ground, germinate, and produce mycelium. Infection occurs shortly after contaminated blossoms become lodged on stems in the plant canopy, or after stems come in contact with contaminated fallen blossoms or decomposing plant tissues on the ground. Secondary spread to additional stems may occur when green stems lodge or lean onto actively expanding lesions on infected stems. Flowers and other senescing tissues colonized by ascospores are generally the cause of the vast majority of lesions as opposed to infections near the soil line initiated by mycelium from soil-borne sclerotia.

Fungicide Application

Foliar fungicides are needed in areas with severe disease pressure. Effective materials include Endura, Omega, and Topsin M. Foliar fungicides should be targeted at infection from ascospores via contaminated blossoms. Current research has demonstrated that **foliar fungicides should be applied at full bloom of primary flower clusters.** An additional application of a foliar fungicide could be made seven to ten days later to cover secondary and ternary flower clusters in areas with severe disease pressure. Full bloom of primary flower cluster is a narrow application window, but **application at this time has been significantly more effective than application at row closure** in three of three years of research trials in commercial fields in the Columbia Basin. Fungicides applied at row closure are generally washed from stems and partially degraded before effective inoculum (colonized blossoms) is present; whereas, applications at full bloom of primary clusters are made just before infection would otherwise occur from dropping blossoms. Fungicides applied after blossom fall are ineffective because infection has already been initiated. Omega also has activity against **late blight** and Endura has activity against **early blight**.

Full Bloom of Primary Flower Clusters

Time of potato flower blooming depends on cultivar, fertility practices, and weather. **Full bloom of primary flower clusters** is when all flowers on the primary clusters (inflorescences on the main plant stems) are all blooming throughout most of the field. This generally occurs 5 to 10 days after row closure in commercial potato fields of cultivars Shepody and Ranger in the Columbia Basin. This is when the first fungicide application should be made. In cultivars that flower over an extended period such as Russet Burbank, initial fungicide application in the Columbia Basin has been most effective about 7 days after row closure.

Cultural Tactics

Fungicides will be most effective when combined with practices that limit potato vine growth such as avoiding excessive application of fertilizer. Irrigation practices that promote frequent and long periods of leaf wetness within the crop canopy should be avoided. Irrigation should be restricted during rainy weather, and on cool, cloudy days, whenever possible. Cultural practices need to be employed before stem rot begins developing in fields.

An Update on Resistance to Powdery Scab

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Powdery scab is incited by *Spongospora subterranea* (*S. subterranea*). Susceptible potato cultivars demonstrate sponge-like galls on roots and stolons (Fig. 1) and lesions on tubers (Fig. 2). Infected potato tubers and infested soils are means of disseminating the *S. subterranea*, which also can transmit the *Potato mop-top virus* (PMTV).

S. subterranea is an endoparasitic slime mold characterized by: obligate parasitism, the formation of a plasmodium inside the roots and the tubers (Fig.3), biflagellated zoospores (Fig.4), infectious activity at temperatures 10 to 20°C under wet conditions, and the formation of resting spores commonly referred to as "spore balls" (Fig. 5). The spore balls aggregate on the roots as galls, and in masses in the tuber lesions giving the disease its name, powdery scab. The spore balls are the primary source of inoculum and can survive in the soil or on the surface of the tubers for more than 10 years without losing infectivity.

Powdery scab infections in the Columbia Basin occur early in the growing season when soil temperatures are relatively cool and irrigation water supplies the soil moisture needed for infection. Root galls usually appear 3 weeks after infection, which roughly correlates to 1.5 to 2 months past plant emergence. Most of the potato cultivars grown in the Columbia Basin are russet skin and do not commonly suffer from tuber lesions. However, their roots are susceptible to powdery scab and become severely infected. Reports indicated that root infection can lead to yield loss of 2-5 tons/acre. Damage to potato roots can potentially influence the development of large (>8 oz) tubers needed for processing, resulting in the reduction of the useable potato yield.

The management of powdery scab through resistant potato cultivars may be the most reliable and sustainable technique if resistance is high enough and stable. Seven field trials were carried out between 2003 and 2007 to select potato clones and cultivars (potato selections) with resistance to powdery scab development on roots (root galling). The trials were conducted in commercial fields located near Moses Lake, WA, and Parker, ID that have a history of powdery scab. In 2003 potato selections were examined for levels of root galls and Shepody was selected a susceptible standard. Between 2004 and 2007, 57 potato selections were tested for resistance to root galling at least once. Six selections: Summit Russet, PA98NM38-1, PA95B2-4, PA98N5-2, PO94A009-10 and PO94A009-7 were more resistant than Shepody to root galling. These selections performed significantly better than the industry standards R. Burbank, R. Ranger and Umatilla R., and were ranked among the top 30% in 50-100% of the trials (Table 1). These selections have two factors in common: 1) all are derived from an introgression program to incorporate resistance to the Columbia root-knot nematode *Meloidogyne chitwoodi*, from the Mexican wild species *Solanum bulbocastanum*; and 2) all have Summit Russet appearing more than once in the ancestry. Summit Russet is therefore the best explanation of the genetic source of resistance, and its origin of resistance to powdery scab will be investigated in future research.

The identification of these resistant selections is a promising step towards a sustainable management of powdery scab. These selections have demonstrated high and stable resistance and have already been incorporated as parents in future breeding programs and as resistant standards in future screening trials. Currently, we are testing these selections in the greenhouse in an attempt to establish a rapid screening technique for powdery scab, which would hopefully correlate with the results from the field.

Literature cited

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Fig. 1. Powdery scab galls on roots.
Photo credit: Dr. Dennis Johnson, WSU, Pullman, WA

Fig. 2. Powdery scab lesions on Ivory Crisp.

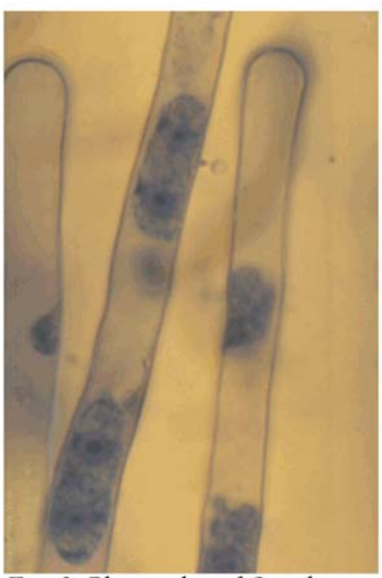

Fig. 3. Plasmodia of *S. subterranea* in potato roots (arrow).

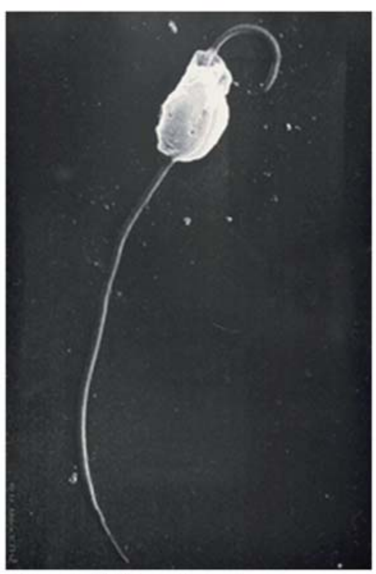

Fig. 4. Biflagellated zoospores of *S. subterranea*.

Fig. 5. An electron microscope image of a spore-ball of *S. subterranea*.

Photo credit for Figs. 3-5: Dr. Ueli Merz, Institute of Plant Sciences, Zurich, Switzerland.

Table 1. Resistance screening outcome in field trials conducted 2004 – 2007 in Washington and Idaho.

Selection	Field trials screening outcome [x]					Frequency of ranking among the best 30% [y]
	2004 ID	2004 WA	2005 WA	2006 WA	2007 WA	
PA95B2-4	R	R	R	R	R	3/5
PA98N5-2	R	R	R	R	R	3/5
PA98NM38-1	R	R	R	R	R	5/5
PO94A009-10	R	R	R	R	R	3/5
PO94A009-7	R	R	R	R	nt	2/4
Summit R.	nt	nt	nt	R	R	2/2
R. Burbank	R	R	S	R	R	0/4
R. Ranger	S	S	S	S	R	0/1
Umatilla R.	S	R	S	S	S	0/1
R. Norkotah	nt	nt	nt	R	R	1/2
Shepody	S	S	S	S	S	-

[x] ID = Parker, Idaho; WA = Moses Lake, Washington, R= resistant; S=susceptible; nt = not tested.

[y] The number of trials that the resistant selection was ranked among the top 30%.

Beet Leafhopper Numbers Still Low

The potato commission-sponsored regional trapping network for beet leafhopper (BLH) has shown that the beet leafhopper is at extremely low levels compared to the past 4 years. As shown in the graphs on our website, www.potatoes.com/research.cfm, the first summer flush of BLH has occurred but was well below 50% of the 4-year average. The second summer flush of BLH is currently underway, and the low level of BLH activity continues to be true throughout the Basin, with no traps showing large numbers that have been typical of some areas during the past four years.

Tuberworm is Still Out There!

The potato commission-supported tuberworm trapping network is up and running again this year. So far it has shown that tuberworm successfully overwintered again. To date we have not trapped any tuberworm moths north of Eltopia, but there are definitely breeding populations close to Pasco and south to Oregon. Remember that tuberworm does very well in hot weather, and it may not take a lot of gravid females in a vine-killed field at the end of the season to cause difficulty in the marketplace. No matter where you are in the Columbia Basin, keep an eye out for tuberworm until your crop is safely harvested. For the latest trap catch data in map format see (updated mostly on Monday and Thursday mornings):

http://www.potatoes.com/research.cfm

Other Pest Management Resources

WA Late Blight Hotline: 1-800-984-7400.

Additional information on late blight can be found at http://classes.plantpath.wsu.edu/dajohn

WA Aphid Hotline: 1-888-673-6273

Additional aphid and insect management information can be found at http://www.potato.prosser.wsu.edu/