Powdery Scab: Management Tactics and the Effect of Root Galls on Potato Yields

Dennis A. Johnson and Thomas F. Cummings
Department of Plant Pathology, Washington State University, Pullman, WA

Powdery scab is a major concern for potato production in the Columbia Basin of central Washington and north-central Oregon. Occurrence of powdery scab in the Columbia Basin before 1981 was light and sporadic, whereas currently the disease occurs at high severities in many fields throughout the region. Infected seed tubers and contaminated soils are means of disseminating the parasitic slime mold that causes powdery scab, *Spongospora subterranea* f. sp. *subterranea*. This parasite also transmits the *Potato mop-top virus* (PMTV) that causes potato mop top.

Potato roots, stolons and tubers are infected early in the growing season when soils are relatively cool in the Columbia Basin. Rain and irrigation water supplies the wet soils needed for infection. Symptoms however, do not develop for three or more weeks after infection. The powdery scab endoparasite synergistically interacts with *Colletotrichum coccodes*, the cause of potato black dot, to produce more severe disease and plant damage. Resting spores of the powdery scab parasite persist in soil for eight or more years.

Symptoms – Symptoms of powdery scab are confined to belowground plant organs. Infected roots and stolons develop wart-like galls. These are white at first and turn brown to black as they mature. Galls vary in size up to that of a pea. Symptoms on young tubers consist of small, gray, elevated areas (pustules) on the tuber surface. Pustules later dry and break open, leaving circular to oval, small, scabby pits. The pits contain a brownish powder that consists of a mass of spores. Pustules on tubers can be entry points for infection by the pink rot, Pythium leak, and late blight pathogens.

PMTV causes raised rings on the tuber surface and necrotic dark brown arcs in the tuber flesh, which resemble corky ring spot symptoms (caused by *Tobacco rattle virus*). The necrotic arcs caused by PMTV in tubers are especially severe in cool weather potato production regions. Symptoms on foliage consist of stunting of stems and shortening of internodes on some or all of the stems of infected plants. Bright yellow blotches, rings, and V-shaped yellow markings can occur on leaflets.

Resistance - Resistance offers a potential of reducing the effects of powdery scab. Tubers of most white cultivars such as Shepody and red cultivars are susceptible to infection and develop numerous pustules, whereas tubers of russet skin cultivars such as Russet Burbank, Ranger Russet, Umatilla Russet and Alturas usually do not develop noticeable tuber lesions. Roots of most cultivars grown in the Columbia Basin are susceptible and can become severely infected when grown on infested ground. However, potato lines resistant to root galling have been identified in test plots in the Columbia Basin. Evaluation began in 2003 by Chuck Brown, Dennis Johnson, Dallas Batchelor and Chris Olsen and has led to the identification of resistance in breeding material used in the Pacific Northwest (2,3). Resistance to root galling is now being incorporated into commercially acceptable cultivars. Cultivars with resistance to root galling have also been developed in Colorado. Cultivars with resistance to root galling include Summit

Russet, Mesa Russet, Rio Grande Russet, Sage Russet, and Owyhee Russet. We will be evaluating Alturas for resistance this summer.

A possible advantage of growing cultivars with resistance to root galling is that fewer resting spores should be returned to the soil at the end of the season and consequently, less inoculum would affect future potato crops. Control of weeds as reproduction hosts would be important during the rotation period. In contrast, growing susceptible cultivars or not managing weed hosts (nightshades) during the rotation period would increase inoculum levels for future potato crops. We are presently quantifying the effects of resistance on subsequent inoculum levels in the Columbia Basin.

Management - Effective control practices are not currently available for reducing powdery scab galls on roots and stolons of potato cultivars once the pathogen has been introduced into a field or soil. The parasite needs to be kept out of fields and areas where it is not currently present. Management of powdery scab consists of planting disease-free seed tubers, avoiding planting on land contaminated with the powdery scab parasite, avoiding applying manure from animals fed infected tubers, controlling weeds in the potato family (nightshade), and avoiding moving contaminated soil on equipment or irrigation water to clean fields. Effective chemical control of powdery scab galls will likely require either a systemic fungicide that moves systemically to new root growth or an application method that distributes an effective material in the root zone of the soil. Neither approach is currently available.

Omega (fluazinam) has activity against the powdery scab organism. In-furrow application has suppressed disease levels in some trials. However, the fungicide needs to be distributed through as much of the planting furrow as possible. Nozzles delivering material before and after the seed piece have been most effect. Cost of the material is high, and the costs relative to expected benefits need to be considered before application. This is especially pertinent with the information reported below that moderate numbers of galls on Umatilla Russet do not reduce plant yields. Hence, the cost of the material is not recovered with an increase in tuber yield.

Cool (50 to 55 F), moist soils favor infection and development of powdery scab. In a previous study in the Columbia Basin (1), fields planted after mid April had significantly fewer infected root systems than those planted earlier. Soil temperatures usually increase in early May, so late planted crops are grown in cool soil for a shorter time, giving the powdery scab organism less time to infect and develop. Soil temperatures above 60 F retard the development of powdery scab.

Effect of root galls on tuber yield - Root galls are not associated with any apparent above ground plant symptoms and previously it was not known if yields were appreciably reduced by the galls. An experiment was conducted in the field in 2010 and 2011 to determine the effect of galls on potato yield. In 2010, Mesa Russet, which is resistant to root galls of powdery scab and Umatilla Russet, which is susceptible, were planted in soil infested and not infested with the powdery scab pathogen. In 2011, Shepody, which is very susceptible to root galls, was included with the other two cultivars. The infested soil was in a commercial field near Warden and the non-infested soil was at the Othello Research Station. Yields of the resistant, susceptible and very susceptible cultivars grown in infested and non-infested soils were compared to determine the effect of galls on yield. Cultivars were arranged in a randomized complete

block design with ten replicates at each location. Plots were six plants rows; roots of three plants were carefully dug to quantify galls and three plants were harvested for yield. A root gall index of 1 to 5 was used to quantify root galling (Table1). Yield ratios and a plot of yield components (total yield, number of tubers, tuber weight) relative to the number of galls were both used to give an indication of the effects of the powdery scab galls on yield. Yield ratios were derived from the following formula for each cultivar: yield of diseased (infested soil)/ mean yield of non-disease (non-infested soil). A yield ratio of 1.00 or higher for a susceptible cultivar would indicate that powdery scab galls had little effect on yield. Linear regression was used to analyze the plotting of the three yield components vs. number of galls.

Results of the experiment in 2010 showed that incidence of root systems with galls and severity of galling was significantly less for Mesa Russet than for Umatilla Russet (Table 2). Yields were higher for Umatilla Russet than for Mesa Russet at both locations (Table 2). Yield ratios for total yield and mean tuber weight were 1.00 or higher for Umatilla (susceptible cultivar), indicating that powdery scab had no effect on these yield components (total yield and mean tuber weight) at the level of galls encountered (about 50 per root system). Yield ratio for tuber number for Umatilla was 0.82; however, yield ratios for total yield and number of tubers did not differ for the two cultivars. Yield ratio for mean tuber weight was less for Mesa than for Umatilla but both values were near or greater than 1.00 (Table 2). These ratios indicate that fewer tubers were formed in the infested field, contributing to a significant increase in tuber weight for Umatilla Russet. This is evident in Figure 1 where mean tuber weight significantly increased as gall index increased for Umatilla Russet ($P = 0.016$). Total yield and tuber number did not change significantly as gall index increased for both cultivars in 2010 (Fig. 1).

In 2011, incidence of root systems with galls and severity of galling was significantly less for Mesa Russet than for Umatilla Russet and Shepody. Shepody had significantly the most galls than the other two cultivars (Table 3). Yields were lower for Umatilla Russet and Shepody than for Mesa Russet at both locations (Table 3). Yield ratios for total yield and mean tuber weight were 1.00 or higher for Umatilla (susceptible) and Shepody (very susceptible), indicating that powdery scab had no effect on the measured yield components (Table 3). Yield ratios for total yield and mean tuber weight did not differ for the three cultivars. Yield ratio for number of tubers was significantly less for Shepody (0.87) than for Umatilla and Mesa (Table 3), indicating that the number of tubers for Shepody significantly decreased as gall index increased in the infested field. Total yield and tuber number did not change significantly as gall index increased for Mesa and Umatilla Russet (Fig. 2). However, total yield decreased as the number of galls increased for Shepody ($P = 0.09$). Mean tuber weight did not change significantly for the three cultivars as gall index increased (Fig. 2).

In conclusion, powdery scab galls did not significantly reduce any of the three yield components for Umatilla Russet both years according to both methods of determining the effect of galls on yield. Number of tubers was reduced for Shepody as indicated by the significantly lower yield ratio in 2011. Total yield was also shown to decrease for Shepody by plotting total yield against increasing gall index. The experiment needs to be repeated in 2012 to obtain a second year of data for Shepody. For future cultivars used in Washington State, resistance to root galling needs to be coupled with desired agronomic traits and yield. Improved cultivars with resistance to root galling will

produce profitable yields and should also reduce disease pressure for future potato crops by reducing inoculum levels in the soil through producing fewer galls in the current crop.

Literature Cited

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2. Nitzan, N., Cummings, T.F., Johnson, D.A., Miller, J.S., Batchelor, D.L., Olsen, C., Quick, R.A., and brown, C.R. 2008. Resistance to root galling caused by the powdery scab pathogen *Spongospora subterranean* in potato. Plant Dis. 92:1643-1649.

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Table 1. Powdery scab index used to quantify number of galls on root systems.

Powdery Scab Index	
Index	No. Galls/root system
0	0
1	1-25
2	25-50
3	50-100
4	100-150
5	151-200

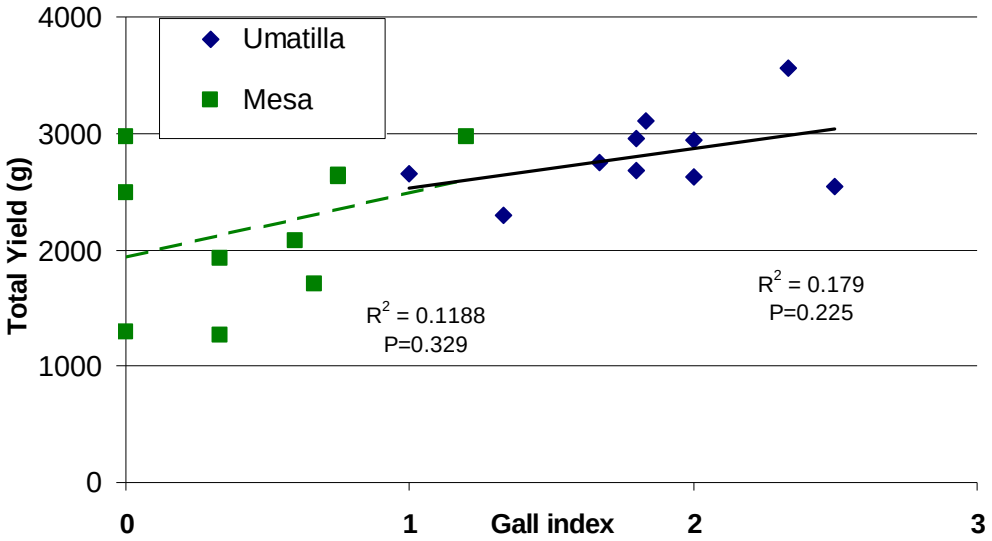
Table 2. Yield and yield ratio of Mesa Russet (resistant to root galling) and Umatilla Russet (susceptible to galling) grown on a sandy loam soil infested with the powdery scab organism near Warden and on a silt loam soil not infested at Othello in 2010.

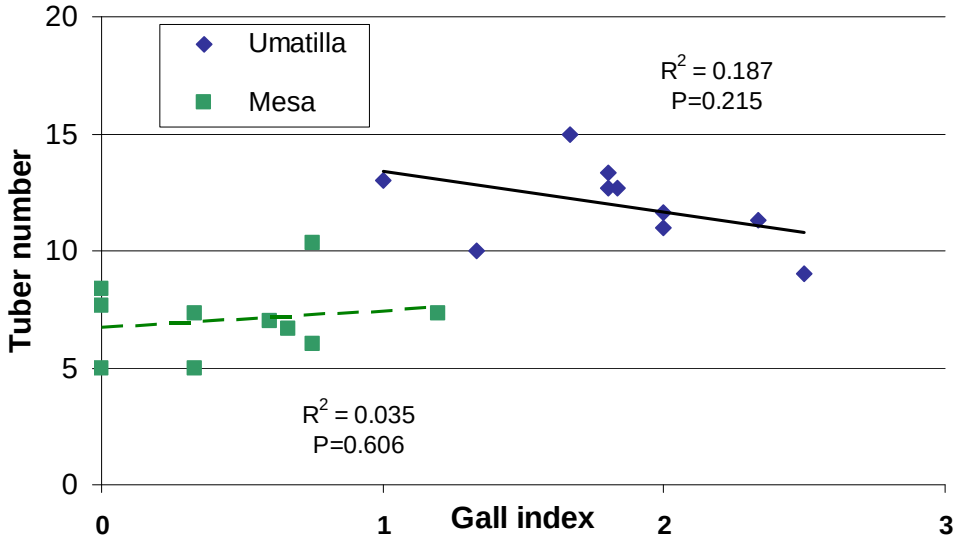
Cultivar	Gall Index	Total Yield (g)	Tuber Number	Mean tuber weight (g)
Infested soil				
Mesa Russet	0.46 a	2194 a	7.1 a	310 a
Umatilla	1.83 b	2810 b	12 b	238 b
Non-infested soil				
Mesa Russet	0	2400 a	7.7 a	321 a
Umatilla	0	2803 b	14.7 b	193 b
Yield Ratio				
Mesa Russet	-	0.91	0.92	0.97 a
Umatilla	-	1.00	0.82	1.23 b

[a]Yield ratio = yield of diseased (infested soil)/ mean yield of non-disease (non-infested soil).

Table 3. Yield and yield ratio of Mesa Russet (resistant to root galling), Umatilla Russet (susceptible) and Shepody (very susceptible) grown on a sandy loam soil infested with the powdery scab organism near Warden and on a silt loam soil not infested at Othello in 2011.

Cultivar	Gall Index	Root Incidence with galls (%)	Total Yield (g)	Tuber Number	Mean tuber weight (g)
Infested soil					
Mesa Russet	0.5 a	53 a	2633 a	9.8 a	271 a
Umatilla	2.2 b	100 b	2331 a	10.0 a	241 a
Shepody	3.5 c	100 b	2245 a	6.1 b	384 b
Non-infested soil					
Mesa Russet	0	0	2100 a	9.3 a	228 ab
Umatilla	0	0	1814 a	9.4 a	194 a
Shepody	0	0	1779 a	7.0 b	267 b
Yield Ratio					
Mesa Russet	-	-	1.25 a	1.05 a	1.19 a
Umatilla	-	-	1.24 a	1.09 a	1.19 a
Shepody	-	-	1.26 a	0.87 b	1.43 a





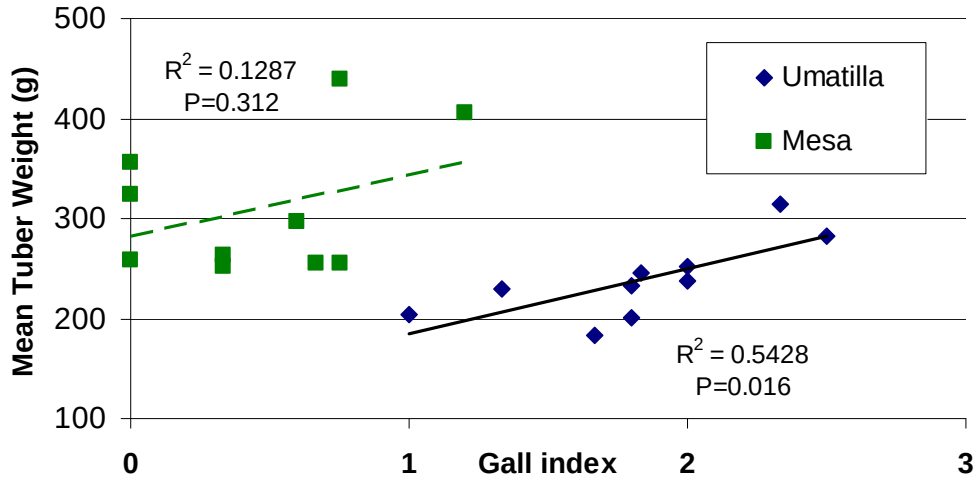


Figure 1. Yield curves for two cultivars on powdery scab infested sandy loam in 2010.

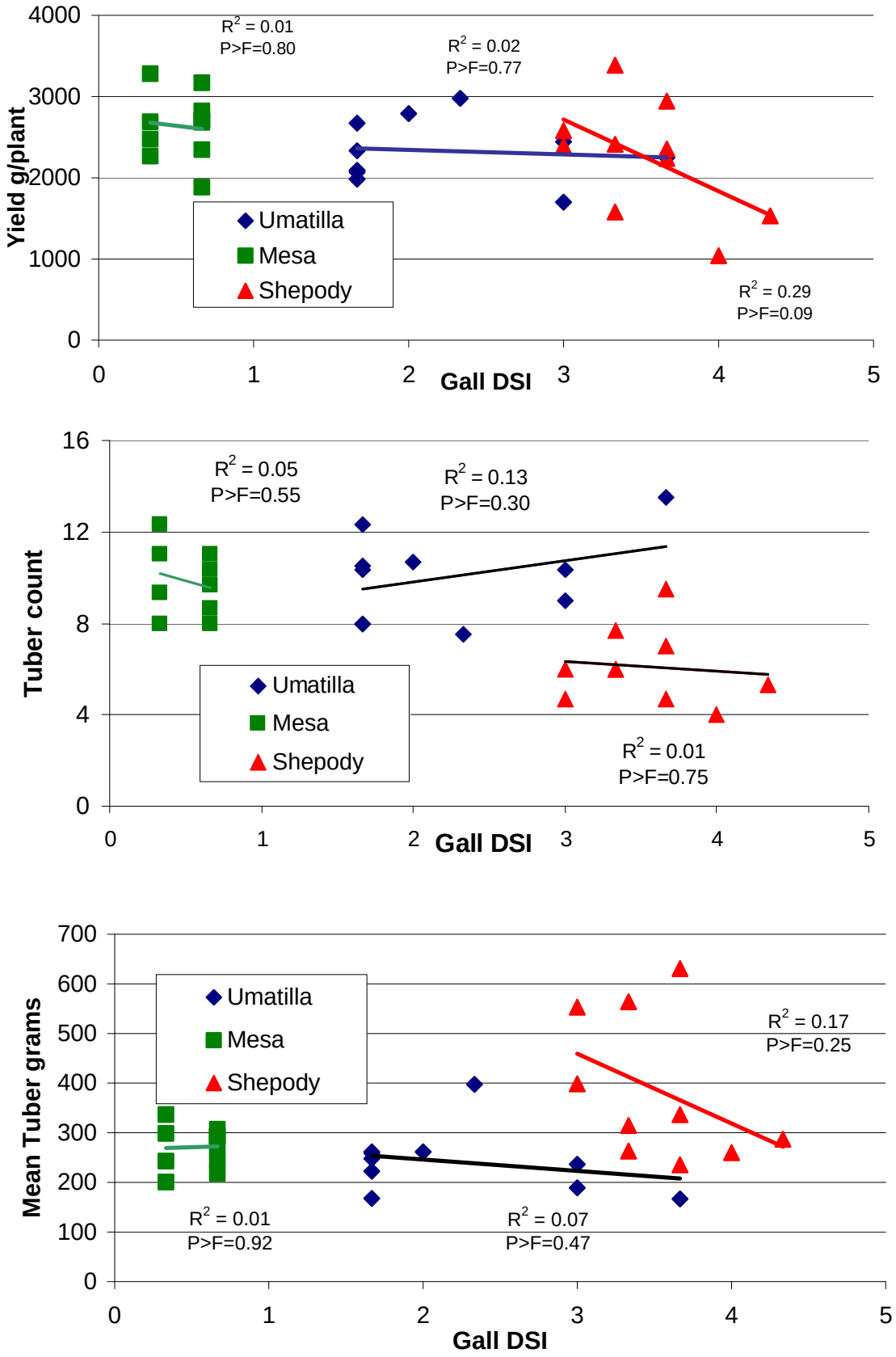


Figure 2. Yield curves for three cultivars on powdery scab infested sandy loam in 2011.