Developing Integrated Management Strategies for Powdery Scab on Potato Crops

Bo Ming Wu, Fahrettin Goktepe, Brian A. Charlton

Introduction

Powdery scab, caused by *Spongospora subterranea* f. sp. *subterranean* (*Sss*), is an important disease throughout all potato production regions in the world. This disease has become increasingly important over the last decades due to broader use of susceptible cultivars, reduction of the rotation intervals, discontinuation of seed treatments with mercury, and intensive irrigation. Powdery scab causes severe skin blemishes, which drastically reduce tuber quality, particularly for table stock potatoes. Depending on the severity of infestation, powdery scab can cause unattractive tuber appearance and unmarketable yield on fresh packed potatoes, and product loss on processing potatoes due to the requirement of deeper skin removal. Seed potatoes with powdery scab may be completely rejected since the disease can be transmitted via contaminated seed. In addition to adverse effects on potato quality, infection by *Sss* reduces host growth by inhibiting root function. Severely infected potatoes are highly prone to weight loss and shelving in storage, and more vulnerable to secondary infection since the lesions from powdery scabs provide easy access to other microorganisms. *Sss* is also the natural vector of potato mop-top virus, which causes a range of superficial and internal symptoms on tubers. Powdery scab was reported on potatoes from many states in the United States. Severe infections have been observed on potatoes from the Tri-State breeder's seed increasing program in Powell Butte, COARC for many years.

The pathogen survives as sporosori in soil or potato debris. Some sporosori may spontaneously release zoospores, while others may need stimuli to break their dormancy. Zoospores of *Sss* infect root hairs and form multinucleate plasmodium. Sporangial plasmodium cleaves into segments to form zoosporangia. Each zoosporangium normally releases up to eight zoospores for secondary infection. At the end of a growth season, plasmodium turns into sporosori again, which are highly resistant to adverse conditions and able to survive for more than 10 years in soil.

Several obstacles and challenges lead powdery scab disease difficult to control (economically). Rotation is hardly practical and sufficiently effective because the pathogen survives in soil for a prolonged period time without a host. Some alternative hosts other than potato may also allow *Sss* to reproduce and maintain a high level of inoculum in the soil. Seed tuber treatments including heat, formaldehyde, flusulfamide, dichlorophen-sodium, mancozeb, propineb, sulfur, and compounds of copper, mercury or zinc have been shown to reduce transmission of the disease, but they are rarely completely effective for controlling powdery scab and some of them have been discontinued due to safety concerns. Soil applications of sulfur, salts of zinc and

sodium tetraborate have been shown to reduce the disease in the field. Mercury- or copper-containing compounds, mancozeb, maneb, and quintozene; soil fumigation with methyl bromide or metam sodium applied in irrigation water and soil-applied formaldehyde; and fungicides fluazinam (Omega) and flusulfamide have been shown to reduce powdery scab in potatoes as soil applications. Soil application of pesticide chemicals to control powdery scab increases the production costs, and may not always be environmentally friendly. Furthermore, chemical treatments do not completely eliminate the pathogen propagules, particularly where soil infestation levels are high. Potato breeding programs has made continuous efforts to integrate source of genetic resistance into new release cultivars. So far, none of the cultivars have been identified to be completely immune to *Sss*. Biological control agents, *Trichoderma* spp., have been considered to have the potential to reduce powdery scab, presumably via reducing resting spore viability or zoospore activity and infectivity. The efficacy of biological control agents on powdery scab in the field, however, remains undetermined.

Since none of the current measures provides sufficient control of this devastating disease, we conducted this field trial to investigate the possibility of controlling powdery scab disease by an integrating pest management approach combining fungicide, Omega with two biological control agents, Tenet (*Trichoderma* spp.) and Actinovate AG (*Streptomyces lydicus* strain WYEC108), as well as a known resistant breeding line.

Objectives

To evaluate disease management measures, Omega, Actinovate, Tenet, resistant breeding lines, and their combinations for control of powdery scab.

Materials and Methods

A grower's field that was historically infested with *Sss* was chosen in the Lone Pine Valley for the field trial. The field was prepared according to the commercial standards for seed potato production in Central Oregon. A split-plot design was used for the field trial. There were two factors, chemical/biological treatments (main plot factor) and varieties (subplot factor). Thirty main plots were randomly assigned to six treatments: Omega, Tenet, Actinovate, Omega+Tenet, Omega+Actinovate, according to a randomized complete block design with 5 replications. Two subplots in each main plot were then assigned to a highly susceptible smooth skin cultivar Shepody and a moderately resistant non-russet advance breeding line OR05112. Soil samples (each pooled from 5 cores of 1 inch diameter and 6 inch depth) were collected from each plot. Soil samples will be assayed for inoculum level using bait plants (required techniques are still under development). Omega was sprayed at 3.0 pints/ acre with 25 gals water/ acre on June 1 before bed preparation. Each 15 ft × 15 ft main plot was then divided into two 15 ft × 7.5 ft subplots. In each subplot, three rows of Shepody or OR051121 were planted at 9 inch in-row spacing and 36 inches between-row-spacing. Tenet and Actinovate were sprayed at planting onto potato seed tubers and into the furrow

at 3.0 oz/1000 ft row, with 25 gal water /acre. Also at planting, Eptam 7-E was sprayed at 10 oz/acre for controlling weeds. The field was managed according to growers' standards. Six potato plants were randomly sampled to evaluate root galls one month prior to harvest. The following severity scale was used in rating the root galling:

0- Healthy, no gall on the potato;

1- Less than 10% hairy roots infected or fewer than 10 galls;

2- (10~25%) hairy roots infected or 10~25 root galls;

3- (25~ 50%) hairy roots infected or 25~50 root galls;

4- (50% or more) hairy roots infected or no fewer than 50 root galls.

Total tuber yield was determined for the middle 15 ft row at harvest. Then, 25 potato tubers were randomly sampled, visually rated for the severity of powdery scab. The severity scale used for rating powdery scab was:

0- Healthy, no lesions on the potato;

1- Less than 1% area covered by scab lesions or no more than 5 scab lesions;

2- (1~10%) area covered by scab lesions or 6-25 scab lesions;

3- (10~ 25%) area covered by scab lesions;

4- (25~50%) area covered by scab lesions;

5- (50% or more) area covered by scab lesions.

The Procedure Glimmix in SAS (Version 9.2, SAS Institute Inc. Cary, NC, USA) was used to analyze the incidence data of root galling and scab on tubers. The severity data were first transferred into rank data and then analyzed using the Procedure Mixed in SAS.

Results and Discussion

Overall incidence of powdery scab on harvested potato tubers was very low in this trial, although incidence of root galling was higher than powdery scab incidence. Even though the exact reasons were unclear, low pathogen inoculum level in the soil, growth and environmental conditions during the season could be some of the factors leading the low disease pressure. Results of statistical analyses indicated that incidence (data not shown) and severity rank of root galling were significantly lower on OR051121 than those on Shepody (Figure 1 and Table 1). While the incidence and severity of powdery scab were low on tubers of Shepody, no powder scab was observed on tubers of OR05112 (Figure 2). The results confirmed that the breeding line OR051121 was more resistant to powdery scab than Shepody, which is known to be a highly susceptible variety.

Among the individual treatments tested, Omega was the most effective treatment reducing both root galling and powdery scab on tubers. The severity (rank) of root galling was lowest in plots treated with Omega, followed by Actinovate, Tenet and Control (Figure 1). The difference in root galling severity was insignificant between Actinovate and Omega treatments for both tested varieties. Severity of root galling in plots treated with Tenet was not significantly different than nontreated control plots for Shepody but significantly lower for OR051121 (Figure 1 and Table 1). Combination of Actinovate or Tenet with Omega made no significant difference from Omega alone in reducing severity of root galling (Figure 1 and Table 1). The incidence of root galling followed the same trend of severity rank (data not shown). While no powdery scab was detected on OR051121, severity rank of powdery scab on Shepody tubers followed a trend similar to severity of root galling. Plots treated with Omega had the lowest powdery scab severity, followed by Actinovate, Tenet and nontreated control (Figure 2 and Table 2). In this case, however, the difference between Omega and Actinovate was significant while the differences among Tenet, Actinovate and nontreated checks were insignificant (Figure 2 and Table 2).

The total fresh tuber weight of OR051121 in the 15 ft middle row was significantly greater than fresh tuber weight of Shepody (Figure 3). However, there was no significant difference in total fresh weight of tubers among the different treatments tested regardless of the significant difference in root galling and powdery scab. This suggested that the difference between the two potato varieties may not be the results of their difference in resistance to powdery scab. No noticeable impacts on the growth of potato plants were observed during the growing season and at the end, none of the tested treatments significantly affected (positive or negative) the total fresh weight of tubers.

The results from this study were consistent with previous reports. It confirmed that Omega application prior to bed configuration is somehow an effective method for suppression of root galling and powdery scab in potato. The results from this study also suggested that Actinovate may potentially be used as an alternative to fungicide applications. The results from this study justified further evaluation under conditions with higher disease pressures (high pathogen inoculum in the soil and weather conditions conducive for powdery scab). It will be very helpful to test the interaction between variety, application of Omega and treatment with Actinovate under these conditions.

Acknowledgments

We are very thankful to Steve James for his expert input in project design and his help through the whole experiment duration. We also want to thank Ted Fehrenbacher for his help in identifying a field infested with potato scab pathogens for this trial. We are particularly grateful to David Butler for providing his field for this trial and his cooperation.

Table 1. Type 3 tests of fixed effects of treatments on the severity (rank) of root galling caused by *Spongospora subterranea* f. sp. *Subterranean.*

Effect	Num DF	Den DF	F Value	Pr > F
Treatment	5	24	9.28	<.0001
Variety	1	24	198.13	<.0001
Treatment × Variety	5	24	1.47	0.2349

Table 2. Type 3 tests of fixed effects of treatments on the severity (rank) of powdery scab caused by *Spongospora subterranea* f. sp. *Subterranean.*

Effect	Num DF	Den DF	F Value	Pr > F
Treatment	5	24	4.65	0.0041
Variety	1	24	52.81	<.0001
Treatment × Variety	5	24	4.65	0.0041

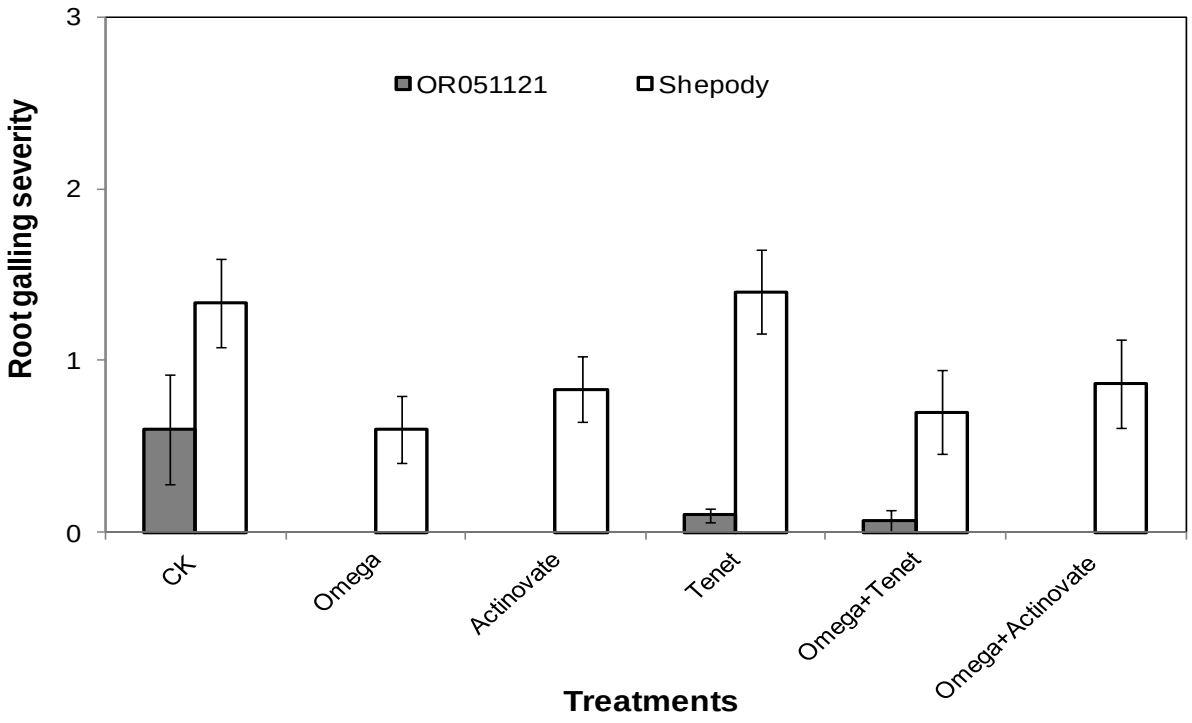

Figure 1. Severity of root galling on Shepody and OR051121 treated with Omega, Tenet, Actinovate and their combinations as compared with nontreated checks (CK). The columns represent means of five replicates and the bars are standard errors of the means.

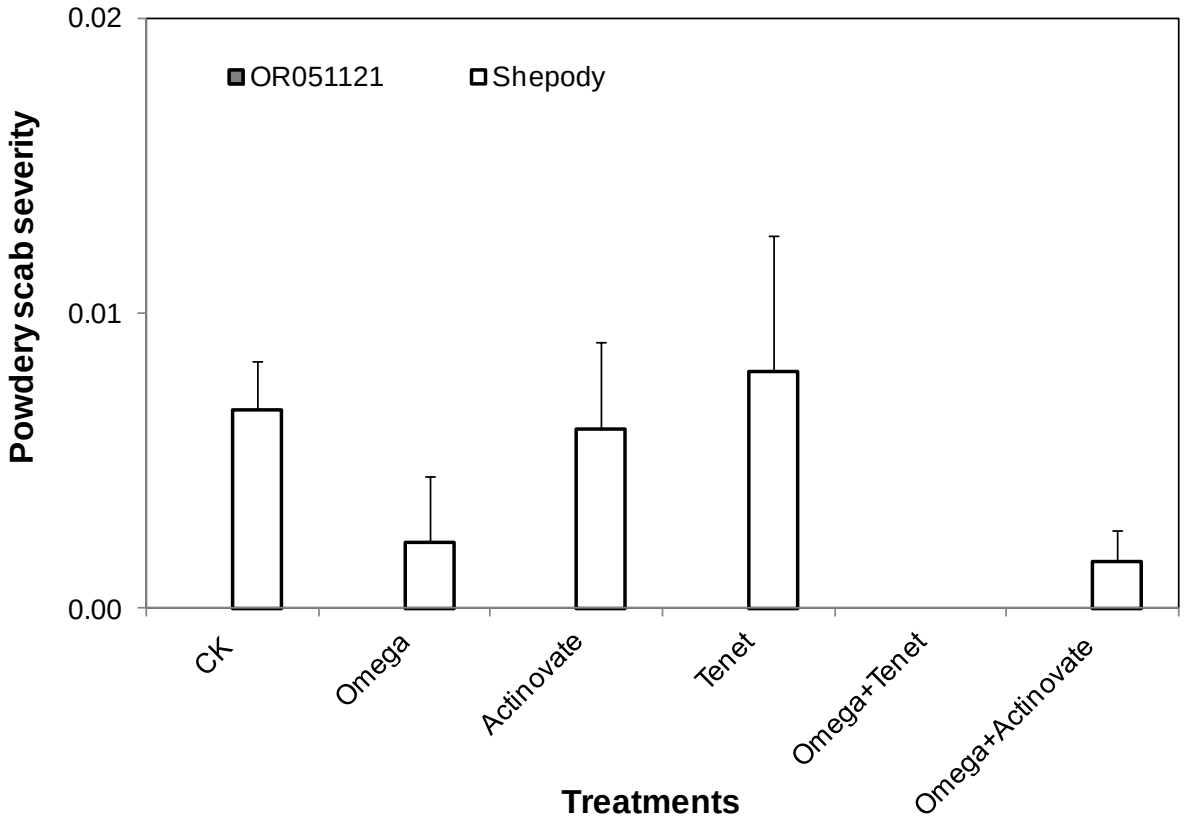

Figure 2. Severity of powdery scab on harvested tubers of Shepody and OR051121 treated with Omega, Tenet, Actinovate and their combinations as compared with nontreated checks (CK). The columns represent means of five replicates and the bars are standard errors of the means.

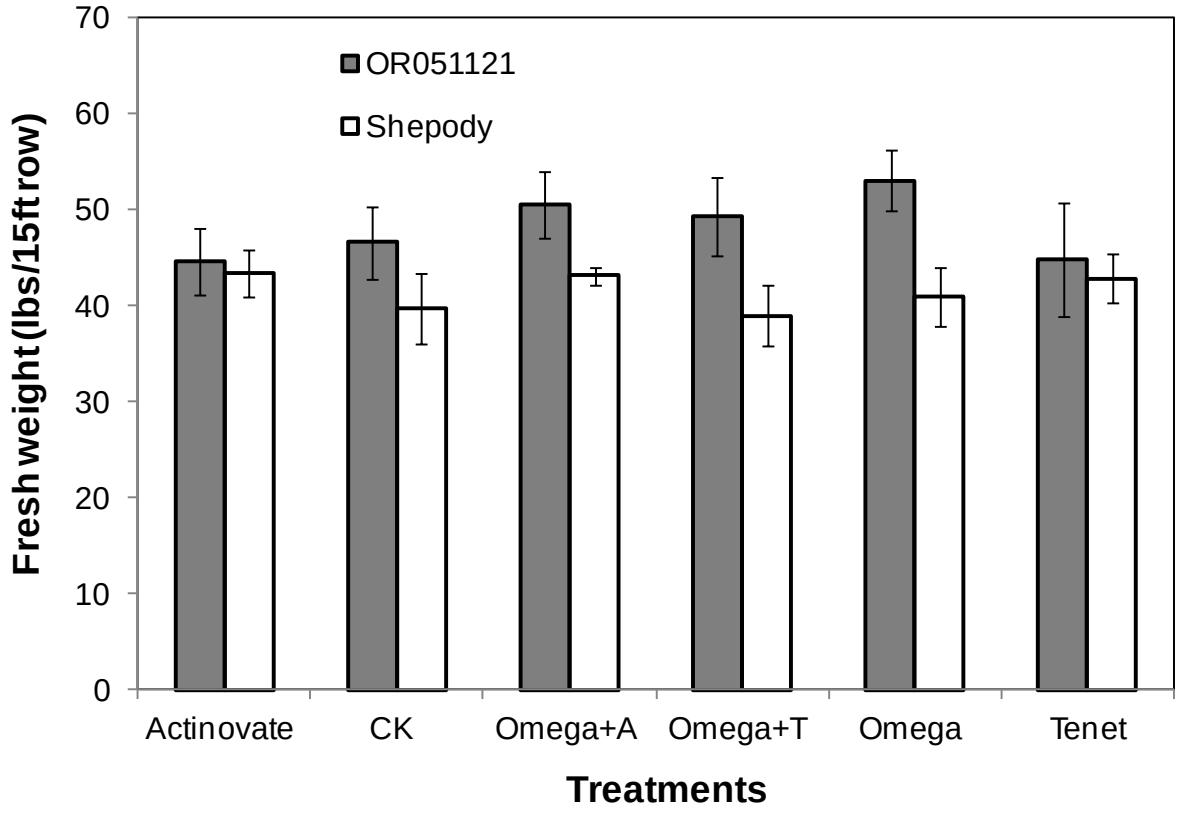

Figure 3. Fresh weight of harvested tubers of Shepody and OR051121 treated with Omega, Tenet, Actinovate and their combinations as compared with nontreated controls (CK).