Diagnosis, Characterization and Management of Powdery Scab on Commercial Potatoes in Alberta

A Research Progress Report Submitted to

The Potato Growers of Alberta
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Introduction

Powdery scab (PS), caused by the fungus *Spongospora subterranea* f.sp. *subterranea* (Ss), is a serious disease in many potato-growing areas of the world. PS seems to be increasing in incidence and severity in Western Canada and there have been several outbreaks in AB, SK and MB since 2000. Ss is long-lived in soil (20 yr), and has alternative hosts such as tomato, pepper and nightshade. Disease development is favored by cool, wet soil conditions. PS can reduce plant vigor, tuber number and yield, and lead to the rejection of tubers for seed and other uses. Effective control measures for PS are very limited, but some new techniques appear promising.

A severe limitation in diagnosing and managing PS has been an inability to reliably detect Ss in soil and on seed tubers. The inability to culture Ss is also a hindrance in studying PS. Current methods for detecting Ss include baiting, serology and PCR (polymerase chain reaction). To enable accurate risk assessment, it is first necessary to quantify the level of infection in potato roots and tubers, and to relate this information to the spore concentration in the soil. Available detection methods have not been critically evaluated for their efficiency in detecting the strains of Ss that occur in Alberta. Access to a reliable and cost-effective diagnostic test would enable potato growers to select fields with a low risk of disease development. Characterization of the genetic variability in Ss strains could help potato breeders develop resistant varieties.

Very few strategies for managing PS have been evaluated under Alberta conditions. No single approach has proven to be effective for preventing or controlling PS in other parts of the world where it occurs. The integration of cultural, chemical and biological control practices, e.g. resistant varieties, seed and soil treatments, irrigation management, soil amendments and crop rotation, might create a cost-effective management program for this disease.

Project Objectives

1) To develop methods for reliably detecting Ss on tubers and in soil, and for predicting the potential risk for PS development in fields selected for potato production.
2) To characterize the strains of Ss occurring in central and southern Alberta in order to determine their genetic diversity, virulence on potato cultivars and lines, and ability to act as vectors for Potato Mop Top Virus (PMTV).
3) To investigate methods for reducing PS incidence and severity in seed, processing and table potatoes, including varietal resistance, seed and soil treatments, irrigation management, soil amendments, and rotational crops.
4) To use the information generated in this study to enhance our knowledge of the biology of PS and to improve the techniques for managing this disease, thereby reducing potential yield and quality losses for growers and processors.

Results for 2005-06

1. Disease Surveys

Approximately 25 samples of potato tubers were submitted to the CDC South for PS diagnosis in 2005. These samples were collected by project team members and growers, and were comprised of several varieties of table, processing and seed potatoes from central and southern Alberta. While most had PS, some were infected only with common scab (CS), or had both PS and CS. The two diseases have similar symptoms at the early stages of their development. Samples of PS-infected tubers were sent to the Lethbridge Research Center for molecular diagnosis. Background information on the fields from which the PS samples were taken is being collected

and summarized. These data will be reviewed to see if any common factors are evident that may have promoted the development of PS.

2. Detection, Quantification and Strain Characterization of Spongospora subterranea

Introduction

Dr. Larry Kawchuk and colleagues at the Lethbridge Research Center are developing assay techniques that can be used to determine the host range of Ss, to examine pathogen levels in soil from fields that will be planted with potatoes, and to confirm the presence or absence of Ss in asymptomatic tubers. This assay will be useful in determining the effectiveness of control procedures and assist in determining the strain populations of the PS pathogen in western Canada. Results of the assay can be obtained within 24 h and may therefore help expedite the certification of seed tubers.

Results

The nuclear ribosomal DNA (rDNA) regions of two hypervariable internal transcribed spacers (ITS1 and ITS2) and the 5.8S rRNA gene from 29 Alberta and Saskatchewan field isolates of SS were obtained with primers to the conserved sequences of the small subunit (SSU) rDNA and large subunit (LSU) rDNA with the polymerase chain reaction (PCR). Amplified sequences are being cloned and sequenced to determine the genetic variation amongst the isolates. The assay is sensitive and able to detect a single SS spore ball in 1 g of soil and in tuber lesions with no detectable spore balls.

SSU

1 **ggaaggatca tta**acactga gtcggttcta ccggcagacc ccaaaaccac atgagaacct

ITS1

61 gggtgcgatt gtctgttgaa gggtgacgcc cgctctgggg ctagctcgaa accttatgca

121 aaccgtatta ctgaacttac taaagtggat cgtttaacta aata**caactc ttaacagtgg**

181 **atatcttggt tcccacaacg atgaagaacg cagcgaaatg cgatacgtaa tgcgaattgc** **5.8S**

241 **agaattcagt gaatcatcaa atctttgaac gcaagttgcg ctttcgagat atccttgaaa**

301 **gcatgcctct ttgagtgtcg gtt**tctattc tcccggaaac gccctgtgcg tggaagggga

ITS2

361 ctatgagctc tggtcggtcc atggcttgaa agattatcca acccggtgcg cgtctctggc

421 ttctgattcg tctctaacca ttggcgtgcc cggtcatata gaaccatttt ttgact**ctag**

LSU

481 **atctcaaatg aggtaagact acccgctgaa tttaagcata tcaataagcg**

Figure 1. An Alberta Ss internal transcribed spacer (ITS) and 5.8S rDNA sequence. Conserved sequences of the three rDNA genes, small subunit rDNA (SSU), 5.8S rDNA, and a large subunit (LSU) rDNA are shown in bold text and underlined.

Discussion

Modification of the developed diagnostic assay will allow characterization of the strains of Ss in western Canada. The determined sequences should provide details that assist in examining the

lifecycle of the pathogen and determining effective control of the disease. Similar diagnostics are also being developed to examine the 29 powdery scab isolates for the potato mop top furovirus that causes spraing in tubers and is vectored by Ss.

3. Disease Management: Chemical Control

Introduction

Six fungicides were evaluated for the control of soil-borne powdery scab by Drs. Jill Thomson and Doug Waterer, Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK. A field trial site naturally infested with high levels of common scab (*Streptomyces scabies*) and powdery scab at the university was used for this study. Black scurf (*Rhizoctonia solani*) was also present. This site was used to evaluate the efficacy of six chemicals, applied on the seed, in the furrow at planting, or at hilling for the control of scab (powdery and common) and black scurf. This site featured a Sutherland Series sandy loam soil (pH 8.1, E.C. <1.0 dS, with 3.8% O.M.). The site was in a three-year potato rotation for 20 years, but beginning three years ago, it was switched to continuous potatoes in an effort to further exacerbate scab problems.

Methods

The trial was managed using conventional production practices. Machine cut Norland E2 seed was planted on May 27 using a single row planter. Row length was 6 m, with 1 m between rows and 25 cm between seed-pieces within the row. The treatments were arranged in a randomized block design with four replicates. A 3 m path separated the replicate blocks. Four side-by-side rows were used for each treatment. Root samples were taken from the outer rows and the two center rows were harvested and assessed for yield and disease.

A 30-tuber sample of the seed used to plant this trial was evaluated for disease levels prior to planting. Three percent of the tubers had more than 5% of the surface infected with black scurf. No scab was present on the seed. Rows were hilled twice – once prior to emergence and again at emergence. Irrigation was applied when the soil moisture potential fell below –60 kPa. Weeds were controlled by preplant application of metribuzin plus linuron applied prior to ground crack.

Six fungicides were applied to the seed prior to planting, as an in-furrow treatment and/or at hilling. The seed treatments were applied to cut seed-pieces as per the experimental protocol. The in-furrow products were applied with a hand-held pressurized sprayer, with the nozzle being held between the opener discs of the planter. The spray was directed over the area of the opened furrow where the seed dropped. The in-furrow and hilling treatments were applied in 3 L of water/24 m of row. The Ranman and Blinix treatments made at hilling (June 15) were applied at the same rate as used for the in-furrow treatments applied at planting. The at-hilling treatments were sprayed as a 15 cm wide band over the top of the hill. The rows were hilled immediately after the spray treatment. A heavy thundershower occurred after hilling, which presumably washed the chemical into the soil.

The fungicide treatments were:

1. Allegro 500F applied as a liquid in-furrow (40% fluazinam, Syngenta, 5.25 g product in 3 L water/24 m row)
2. Tuberseal applied as a dust on the seed (16% mancozeb, United Agri Products, 7 g/25 seed pieces)
3. Dithane DG applied as a liquid in-furrow (75% mancozeb, Dow AgroSciences, 4.4 g

product in 3 L /24 m row)
4. Ranman 400SC applied as a liquid in-furrow at planting and prior to hilling (34.5% cyazofamid, ISK Biosciences, 12 g product in 3 L/24 m row at both applications)
5. Blinix applied as a liquid in-furrow (8.5% Rhamnolipid Biosurfactant, Jeneil Biosurfactant Co., 6 mL in 3 L/24 m row)
6. Blinix applied prior to hilling (same rate as treatment 5)
7. Check – no chemicals applied.

Three hills were dug from one row of each treatment/replicate in early September and the incidence of powdery scab galls on the roots was assessed. The roots from each individual stem were rated for galls using the following scoring system, and the average score for all stems from the three hills was recorded. The system was 0= no galls present, 1 = < 5 galls on the whole root system, 2 = 5-30 galls on whole root system, and 3 = >30 galls on whole root system.

Plants were top-killed at the beginning of September with Reglone and the trial was harvested on September 26, using a single row plot harvester. The harvested tubers were suberized at 15^{o}C with high airflow for several weeks after harvest, then cooled and stored at 5^{o}C. Disease assessments were conducted in November 2005.

Samples consisting of 30 randomly selected tubers were assessed for each row harvested. Tubers were washed under running water before being visually evaluated for the level of disease. The levels of all three diseases – common and powdery scab and black scurf - were determined. Common and powdery scab lesions can have a very similar appearance. Common scab lesions tend to be more raised and superficial, with an irregular outline. Powdery scab lesions are more circular, tend to be clustered in one area of the tuber, penetrate through the tuber skin, and have a slight rim of tuber skin around lesions that may contain distinctive spore balls (cystosori). Lesions were examined carefully for the presence of cystosori, using a dissecting microscope, to identify powdery scab.

The following data were collected:
Disease incidence – the number of tubers infected with each disease, expressed as a percentage of the total number of tubers sampled.
Disease severity – the percentage tuber surface infected by each disease was assessed using rating scales provided by the Canadian Food Inspection Agency. Disease severity was then expressed as the average percentage tuber surface infected for the total number of tubers in a sample.
Percentage of tubers with >5% surface area affected – the number of tubers with more than 5% of the tuber surface area infected, expressed as a percentage of the total number of tubers sampled. This is an important measure of disease development as tubers with more than 5% of the surface area infected are considered to be moderately diseased and only 5% of such tubers are allowed in either seed or Grade A table potatoes.
Total yield – total weight of tubers harvested from each row.
Marketable size yield – the weight of tubers of marketable size, falling between 48 and 88 mm in diameter, without taking into account grading-out due to disease infection.

Data were analyzed using the SAS GLM procedure. The values for the two rows in each treatment were averaged, and the averages analyzed. Tuber samples for disease analysis were

missing for four rows. In two of these cases, a single row was used instead of the average, but both rows were missing from one replicate of the Ranman treatment. Analysis of data with missing values is possible with the GLM procedure. Treatment means were compared using the Duncan Multiple Range test at *P*=0.05.

Results and Discussion

The 2005 growing season at Saskatoon was cool and wet during May and June. Precipitation and temperatures were near normal in July and August. Crop establishment was slow, but conditions were excellent during tuber set and bulking. Thirty-seven cm of rainfall was received over the growing season (normal = 20 cm). A total of 13 cm of supplemental irrigation was applied to the plots. Yields were relatively high in all trials conducted in 2005. No significant problems with diseases or insects were observed in the trial.

Visual examination of the plots showed no effect of the various treatments on emergence, plant growth or vitality. Plant counts were not taken. There were no significant ($P \leq 0.05$) treatment effects on total or marketable size yield (Table 1). The coefficient of variance for the yield parameters was reasonably low.

Table 1. Total and marketable yield of tubers harvested from a chemical control trial at Saskatoon, SK in 2005.

Treatment (chemical applied)	Average yield of tubers (kg/6 m row)	
	Total weight of tubers (kg)	Weight of marketable tubers (kg)
Allegro	40.2	27.2
Tuberseal	38.4	27.3
Dithane	36.4	24.3
Ranman	37.1	25.2
Blinix in-furrow	36.0	25.0
Blinix at hilling	40.8	27.6
None (check)	39.7	25.7
Coefficient of variance (%)	*10.8*	*10.0*

The incidence of root galls formed by the powdery scab organism was significantly lower in the Ranman-treated hills than in the control, Allegro-, Tuberseal- and Dithane-treated hills (Table 2). Blinix-treated hills had relatively fewer galls, but the values were not significantly ($P \leq 0.05$) different from any other treatment. There was no difference between the hills receiving the Blinix at either planting or hilling. The relatively high variance in the root gall data likely reflects non-uniform distribution of powdery scab within both the plot area and the potato root system. The relationship between the incidence and severity of root galls and tuber damage by powdery scab is not clear. However, as root galls represent a significant inoculum source for powdery scab, any treatments that limit root gall formation could help moderate future problems with powdery scab.

Table 2. Effect of chemical treatments on the incidence of powdery scab galls on potato roots sampled in September 2005.

Treatment (chemical applied)	Average gall score

Allegro	2.5 a*
Tuberseal	2.3 a
Dithane	2.4 a
Ranman	1.3 b
Blinix in-furrow	2.0 ab
Blinix at hilling	2.1 ab
None (check)	2.6 a
Coefficient of variance (%)	*29.7*

* Values followed by the same letter are not significantly different using Duncan's Multiple Range Test (P≤0.05).

The levels of black scurf on harvested tubers were not affected by the chemical treatments (Table 3). The average incidence of black scurf was not high, with a range of 18 to 36 % of tubers being infected. The severity of black scurf on the harvested tubers was consistently low. No tubers had more than 5% of the surface area infected by *Rhizoctonia*. The coefficient of variance for the black scurf data was high; this reflects the infrequent and sporadic occurrence of *Rhizoctonia* in this trial.

Table 3. Effect of chemical treatments on disease incidence and severity on tubers harvested in September, 2005.

Treatment (chemical applied)	% of tubers infected with			% of tubers with > 5% surface area infected with	
	Black scurf	Common scab	Powdery scab	Common Scab	Powdery scab
Allegro	18.5	90.5 a*	76.9 ab	33.3 ab	25.5 a
Tuberseal	35.9	90.8 a	79.5 ab	32.4 ab	33.6 a
Dithane	28.4	91.3 a	83.1 a	33.9 ab	23.0 a
Ranman	20.0	77.2 b	30.7 c	18.3 b	4.5 b
Blinix in-furrow	26.8	89.6 ab	83.3 a	36.6 ab	31.8 a
Blinix at hilling	22.9	91.6 a	68.4 b	39.1 ab	18.0 ab
None (check)	26.5	93.9 a	77.1 ab	54.5 a	31.0 a
Coefficient of variance (%)	*44.6*	*9.1*	*48.4*	*9.7*	*46.7*

* Values followed by the same letter are not significantly different using Duncan's Multiple Range Test, p=0.05.

The application of Ranman significantly (P≤0.05) reduced the incidence and severity of both powdery and common scab when compared with the levels seen on the untreated check (Table 3). The Ranman treatment appeared particularly effective against powdery scab. The reduction in percentage of tubers with > 5% surface area infected would have reduced losses to grade-out, and thus would have significantly increased the market value of the crop. The coefficients of variance for the common scab ratings were low – this reflects the uniform and high levels of infestation of the site by this pathogen. Although the overall incidence of powdery scab was

almost as high as for common scab, the powdery scab is less uniformly distributed across the plot area – resulting in greater variation in the data. More replication and/or larger sample sizes may be required to clarify treatment effects for powdery scab control at this site.

The application of Blinix at hilling significantly reduced both the incidence and severity of powdery scab (P=0.09). It should be noted that while Ranman was applied at both planting and hilling, the Blinix treatment was applied either at planting or hilling, but not at both stages. Applying Blinix at both planting and hilling may produce more significant scab control. Further evaluation of both Ranman and Blinix is recommended.

Conclusions

Currently registered seed treatment products, such as Tuberseal, were not effective for the control of soil-borne scab. In-furrow applications of fluazinam (Allegro) and mancozeb (Dithane) were also ineffective at the rates used. Application of Ranman (cyazofamid) in-furrow and at-hilling appeared very promising as it provided a reasonable level of control of both common and powdery scab on a moderately scab sensitive variety growing in very heavily infested soil. Blinix (Rhamnolipid Biosurfactant) also appeared to have some potential; it should be tested at higher rates and/or in multiple applications.

4. Disease Management – Cultivar Resistance

Introduction

Tricia McAllister noted high levels of PS in certain potato trials at the Crop Diversification Centre North, Edmonton and took the opportunity to measure disease incidence (DI) and severity (DS) in tubers from three trials, i.e. Pre-Plant Handling of Seed (PPHS), Lutein Production, and the Prairie Main Crop Replicated Trial (PMRT).

Results

The origin of the infection could not be precisely determined, but the most heavily infested lots were observed in the PPHS trial. In the most severely affected areas, the DI was ≥ 20% (5 of 25 tubers) the DS was ≥ 3% of the total surface covered. DI and DS ratings (based on an average of 4 replications) are given below. Russet Burbank had very little tuber infection and Atlantic also appeared to be somewhat resistant to tuber infection. AC Glacier Chip was highly susceptible.

Trial	Variety/Line	Disease Incidence (% tubers infected with powdery scab)	Disease Severity (% tuber surface covered with scabs)
PPHS	Shepody	52.5	10.8
	AC Glacier Chip	42.3	5.9
	Atlantic	25.5	3.0
	Russet Burbank	0.8	0.1
Lutein	Sinora	18.0	2.5
PMRT	CV97085-1	42.0	6.3
	Shepody	34.8	6.3
	CV97112-4	21.0	2.8
	WV3252-1	18.0	2.5

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