University of Minnesota
2004
Potato Disease Report

Potato Pathology & Genomics
Department of Plant Pathology

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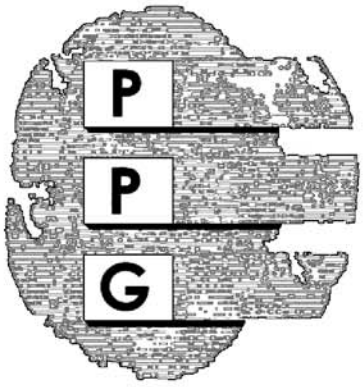

Potato Pathology and
Potato Pathology and Genomics
Genomics

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Section I. Evaluating Potato Germplasm for Disease Resistance

SUMMARY: Disease screening plots were established at two locations in 2004. Entries were screened for resistance to late blight (caused by the fungus *Phytophthora infestans*; UMore Park, Rosemount, MN) and common scab (caused by the Actinomycete *Streptomyces scabies;* Sand Plain Research Farm, Becker, MN). Two methods of evaluating *Verticillium* resistance were also tested at Becker, MN. Germplasm was produced by the University of Minnesota Potato Breeding Program (85 entries tested for late blight, 84 entries tested for common scab), the University of Minnesota Potato Pathology and Genomics Program (114 entries tested for late blight, 105 entries tested for common scab, 45 entries tested for *Verticillium*), or was contributed by researchers throughout the Quad-State Region (20 entries tested for late blight and common scab) and North Central Region (23 entries tested for late blight and common scab). One hundred thirty entries were tested as part of the National Late Blight Trial (Rosemount) and 79 entries were tested as part of the National Scab Trial (Becker). Strengthening our commitment to conduct collaborative research with potato breeders and scientists throughout the Quad-state region, 60 entries submitted by Horia Groza (University of Wisconsin Potato Breeding Program) were evaluated for late blight resistance.

Table 1. Source and number of entries screened at the late blight, common scab, early dying, and *Verticillium* nurseries.

Source	**Late Blight** (UMore Park, Rosemount, MN)	**Common Scab** (Sand Plain Research Farm, Becker, MN)	***Verticillium*** (Sand Plain Research Farm, Becker, MN)[a]
UM Potato Breeding	85	84	
UM Potato Pathology & Genomics	114	105	45
North Central Trial	23	23	
Quad-State Trial	20	20	
National Late Blight and Scab Trial	130	79	
Horia Groza University of Wisconsin	60		

[a]Two method of *Verticillium* inoculation were evaluated at the Sand Plain Research Farm (Becker, MN) including a liquid inoculation for seedlings and a grain inoculation for tuber grown materials.

(A) Late Blight – Rosemount, MN

Late blight, caused by the fungus *Phytophthora infestans*, was responsible for the Irish Potato Famine of the mid-1800's. The disease is characterized by brown to black water-soaked lesions on potato leaves and stems. Under cool, humid conditions, late blight can destroy an entire field within 10-14 days. When sporangia or zoospores are washed into the soil, they can infect potato tubers. Tuber infection is characterized by a dry, brown, granular rot. Secondary pathogens, such as *Erwinia carotovora* (soft rot), *Phytophthora erythroseptica* (pink rot), and *Pythium* spp. (leak) frequently follow. Late blight is currently managed by intensive fungicide applications. This approach is expensive and not environmentally sustainable. Genetic resistance derived from cultivated or wild potato is a promising means to reduce pesticide dependency, risk to the environment, and costs to potato growers.

Resistance to late blight is evaluated at UMore Park (Rosemount, MN) in cooperation with Sr. Associate Dean Phil Larsen (Director), James Rowe (Administrative Professional), Jim Karelis (Sr. Research Plot Technician) and Kimon Karelis (Research Plot Coordinator). The UMore Park is geographically isolated from commercial potato farms allowing intentional inoculation with the late blight pathogen. Because the spores of the pathogen are air-borne, inoculations and late blight screening is restricted to non-production areas. To further protect regional growers, the Late Blight Nursery is planted 4 to 8 weeks later than commercial production fields in Minnesota and Wisconsin.

Disease screening methods are detailed in Appendix A. Complete results for individual entries from the University of Minnesota Potato Breeding Program, University of Minnesota Potato Pathology and Genomics Program, National Late Blight, North Central Region, and Quad State Region for 2002 are listed in Appendix B. Table 2 summarizes our findings.

Among UM Potato Breeding Program materials, three entries (4.0%) were classified as moderately resistant, 27 entries (35.5%) were classified as moderately susceptible, and 46 entries (60.5%) were categorized as susceptible (Table 2).

Materials from the UM Potato Pathology and Genomics Program include 35 heirloom potato cultivars replicated three times each. Appropriate controls from each resistance class were included for comparison [B0767-2 (resistant), Elba (moderately resistant), Kennebec (moderately susceptible), Shepody (susceptible)]. Significantly, the heirloom cultivar 'Inca Gold' was rated as moderately resistant (Appendix B). This cultivar will be further evaluated in 2005 as a source of resistance for incorporation into breeding programs.

Table 2. Number of entries in each late blight resistance class based on infection 25 days after inoculation with the potato late blight pathogen at Rosemount, MN 2004

Sources of entries	No. (percent) of entries 25 DAI
UM Potato Pathology & Genomics	
Resistant	1 (2.8%)
Moderately Resistant	2 (5.6%)
Moderately Susceptible	12 (33.3%)
Susceptible	21 (58.3%)
UM Potato Breeding	
Resistant	0 (0%)
Moderately Resistant	3 (4%)
Moderately Susceptible	27 (35.5%)
Susceptible	46 (60.5%)
National Late Blight Trial	
Resistant	9 (22.5%)
Moderately Resistant	8 (20%)
Moderately Susceptible	16 (40%)
Susceptible	7 (17.5%)
North Central Trial	
Resistant	2 (8.7%)
Moderately Resistant	0 (0%)
Moderately Susceptible	6 (26.1%)
Susceptible	15 (65.2%)
Quad-State Trial	
Resistant	0 (0%)
Moderately Resistant	0 (0%)
Moderately Susceptible	1 (5%)
Susceptible	19 (95%)
University of Wisconsin Potato Breeding	
Resistant	1 (5%)
Moderately Resistant	0 (0%)
Moderately Susceptible	6 (30%)
Susceptible	13 (65%)
All Entries	
Resistant	13 (6.05%)
Moderately Resistant	13 (6.05%)
Moderately Susceptible	68 (31.6%)
Susceptible	121 (56.3%)

(B) *Verticillium* Wilt

Verticillium wilt is caused by the soil borne fungus *V. dahliae* and related species. Symptoms of *Verticillium* wilt include general plant wilting and foliar chlorosis and necrosis. Vascular tissues of the stem turn brown, particularly at the base, and tuber symptoms can include a brown discoloration of the vascular tissue in certain cultivars. *Verticillium* wilt can reduce tuber yields by 45 to 110 cwt/A annually (Davis, 1994). This disease is currently managed by crop rotation and soil fumigation. Crop rotations are typically not long enough to significantly reduce the impact of potato early dying and soil fumigation is expensive and does not always provide adequate control. The use of resistant varieties holds great promise for reducing losses to potato early dying.

In 2004, we compared two methods of inoculation for the evaluation of cultivated potato and wild potato germplasm at the Sand Plain Research Farm, Becker, MN in cooperation with Glenn Titrud (Administrative Director) and Ronald Faber (Sr. Research Plot Technician). Our experiment consisted of two 50x50' plots. The soil at Becker does not naturally contain significant levels of *V. dahliae*. Two methods of inoculation were tested:

1. Grain Inoculum: Beginning with pure cultures of *V. dahliae* isolated from infected potato tissue grown at Grand Rapids, MN in 2003, a liquid inoculum was prepared by washing sporulating Petri plates with a small volume (4ml) of sterile water. The spore suspension was then used to inoculate sterile, autoclaved wheat berries. The berries were incubated for 3 weeks at room temperature. One half cup of infected grain was scattered on top of each potato tuber piece at planting. Although *Verticillium* mycelium was clearly evident throughout the grain, inoculum could not be directly quantitated.

2. Liquid Inoculum: Beginning with pure cultures of *V. dahliae* isolated from infected potato tissue grown at Grand Rapids, MN in 2003, a liquid inoculum was prepared by washing sporulating Petri plates with a small volume (4ml) of sterile water. Inoculum was adjusted to a final concentration of approximately 6 million spores/ml. At planting, 20ml of inoculum was poured on top of each potato tuber piece or on each wild potato seedling.

Tubers and seedlings were planted on May 26. Cultivated tubers included 24 – 4 hill plots of Kennebec, a *Verticillium* susceptible control, and 60 entries submitted by Horia Groza, University of Wisconsin. Wild potato seedlings included 10 seedling plots of 45 populations of *S. bulbocastanum.* In limited experiments in 2002 and 2003, we noted *S. bulbocastanum* as a potential source of *Verticillium* resistance. Uninoculated "observation" rows were included for each *S. bulbocastanum* entry.

Neither inoculation method worked well for cultivated potato and disease symptoms were not observed in any cultivated potato entry, including the susceptible check, Kennebec. Liquid inoculation of seedlings, however, was very effective. By August 6 clear wilt symptoms were evident in inoculated materials while uninoculated materials remained healthy. Consistent with our previous observations that some *S. bulbocastanum* genotypes are resistant, several populations were noted in 2004 as resistant. Further study is need and is planned for 2005. Additionally, resistant genotypes will be crossed with susceptible genotypes to develop populations appropriate for genetic characterization, mapping, and eventual gene isolation.

(C) Common Scab

Common scab is caused by *Streptomyces scabies* and is characterized by lesions that range from being superficial to being 7 mm deep on the tuber surface (Davis and Garner, 1978). *S. scabies* is an actinomycete, which is a class of bacteria resembling fungi in certain ways. The pathogen is soil-borne, infecting potato tubers shortly after tuber initiation. The ability of strains of *S. scabies* to cause disease has been linked to the production of the toxin thaxtomin (King et al., 1991). Common scab incidence can be reduced on resistant varieties through irrigation management. While crop rotation is also recommended for control of this disease, rotations are not long enough to significantly reduce pathogen levels. Additionally, common scab has been observed in fields even when potatoes are grown for the first time. Presently, no chemicals are effective against the common scab pathogen.

Resistance to common scab is evaluated at the Sand Plain Research Farm located in Becker, MN in cooperation with Glenn Titrud (Administrative Director) and Ronald Faber (Sr. Research Plot Technician). Detailed disease screening methods are listed in Appendix A. Severity and coverage ratings for all entries are listed in Appendix B. Table 3 summarizes our findings.

All 'Red Pontiac' plots that were planted next to test plots developed high levels of common scab, indicating disease pressure was fairly uniform throughout the plot. Coverage evaluations did not always correlate well with severity evaluations. Any tuber that received a 0 for severity also was scored with a 0 for coverage. However, scab lesions could range from superficial (severity = 1) to very deep (e.g. severity = 5) and only have 5% or less of the tuber surface covered (coverage = 2). Therefore, several entries that received a severity rating of 3 or 4 had coverage ratings of only 1 or 2. Since tubers can be rejected for sale when common scab lesions are severe, regardless of the degree of coverage, severity is a better measure of resistance in processing-type potatoes. Coverage may be the better assessment for fresh market reds.

Table 3. Number of entries in each common scab resistance class based on Severity and Coverage Ratings at Becker, MN 2004

Sources of entries	Severity Rating (%)	Coverage Rating (%)
UM Potato Pathology & Genomics		
Resistant	7 (6.7%)	7 (6.7%)
Moderately Resistant	11 (10.5%)	24 (22.9%)
Moderately Susceptible	14 (13.3%)	20 (19.0%)
Susceptible	73 (69.5%)	54 (51.4%)
UM Potato Breeding		
Resistant	0 (0%)	0 (0%)
Moderately Resistant	13 (17.1%)	21 (27.6%)
Moderately Susceptible	6 (7.9%)	25 (32.9%)
Susceptible	57 (75.0%)	30 (39.5%)
National Scab Trial		
Resistant	5 (6.3%)	5 (6.3%)
Moderately Resistant	26 (32.9%)	23 (29.1%)
Moderately Susceptible	7 (8.9%)	20 (25.3%)
Susceptible	41 (51.9%)	31 (39.2%)
North Central Trial		
Resistant	0 (0%)	0 (0%)
Moderately Resistant	8 (34.8%)	10 (43.5%)
Moderately Susceptible	4 (17.4%)	3 (13.0%)
Susceptible	11 (47.8%)	10 (43.5%)
Quad-State Trial		
Resistant	1 (5.0%)	1 (5.0%)
Moderately Resistant	4 (20.0%)	4 (20.0%)
Moderately Susceptible	6 (30.0%)	3 (15.0%)
Susceptible	9 (45.0%)	12 (60.0%)
All Entries		
Resistant	13 (4.3%)	13 (4.3%)
Moderately Resistant	62 (20.5%)	82 (27.1%)
Moderately Susceptible	37 (12.2%)	71 (23.4%)
Susceptible	191 (63.0%)	137 (45.2%)

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Hoyos, G. O., Zambino, P. J., and Anderson, N. A. 1991. An assay to quantify vascular colonization of potato by *Verticillium dahliae*. Am. Potato J. 68:727-742.

King, R. R., and Lawrence, C. H., and Clark, M. C. 1991. Correlation of phytotoxin production with pathogenicity of *Streptomyces scabies* isolates from scab infected potato tubers. Am. Potato J. 68:675-680.

Appendix A: Disease Screening Methods

(A) Late Blight

Tubers were planted on June 4. Experimental rows were bordered on both sides by the susceptible cultivar Norchip. Entries were submitted by the University of Minnesota Potato Breeding Program, the University of Minnesota Potato Pathology and Genomics Program, the National Late Blight Trial (conducted by Dr. Kathleen Haynes, USDA/ARS, Beltsville, MD), the North Central Region trials, and the Quad State Trials. Strengthening collaborative research amongst scientists in the Quad State Region, materials were also submitted for evaluation by Horia Groza, University of Wisconsin. Admire 2F insecticide was applied in furrow at a rate of 16 fl. oz./acre to all treatments and border rows. No fungicides were applied to experimental entries or border rows at any time during the season.

All border rows were inoculated with a suspension of *P. infestans* (US-8 strain) zoospores and sporangia at a concentration of 1000 sporangia /ml in the late evening of August 5. Inoculum was applied with a CO_2 sprayer at 20 psi using a single nozzle (6502 tip) wand. Plots were irrigated for 30 minutes prior to inoculation. Sprinkler irrigation was applied the next morning. Thereafter, the plot was irrigated six times per week (Monday am, Tuesday pm, Wednesday am, Thursday pm and Friday am pm) for 1 hour (unless 0.3 inches of rainfall occurred) to prolong natural dew periods. All irrigation was accomplished using a low-volume, overhead mist-type sprinkler system.

Evaluations were initiated 14 days after inoculation and were made every 3 to 5 days until 28 days after inoculation (5 readings total). Each entry was visually scored for disease severity using the CIP scale (Henfling, 1987). The CIP rating system is as follows:

CIP	% Late Blight	
Rating	Mean	Limits
1	0	0
2	2.5	Trace to 5
3	10	5 to <15
4	25	15 to <35
5	50	35 to <65
6	75	65 to <85
7	90	85 to <95
8	97.5	95 to <100
9	100	100

After all disease ratings were made, the CIP ratings were categorized based on readings taken 25 DAI as follows:

Resistance Class	Score
Resistant	<2.5
Moderately Resistant	2.5-4.99
Moderately Susceptible	5-7.49
Susceptible	>7.5

(B) *Verticillium* Wilt

Potato seed pieces and wild potato species seedlings were planted by hand on May 26 at the Sand Plain Research Farm, Becker, MN. Entries were inoculated using ½ cup of grain inoculum (cultivated potato), 20ml of liquid inoculum (cultivated potato and wild potato seedlings), or no inoculum (wild potato seedling observation rows) as described above. Admire 2F insecticide was applied in furrow at a rate of 16 fl. oz./acre. Each entry consisted of four seed pieces (cultivated potato) or 10 seedlings (wild potato species) spaced 12 inches apart. The plot received weekly applications of Quadris (6.2 fl. oz./acre), rotated with Bravo WS (1.5 pt./acre) to control early and late blight. The plot was irrigated (1"/week) during dry periods. All experimental entries were rated for the percentage of foliage exhibiting senescence using the following scale (Hoyos et al., 1991).

1 = 1-12% wilt
2 = 13-25% wilt
3 = 26-50% wilt
4 = 51-75% wilt
5 = 76-90% wilt
6 = 91-100% wilt

Ratings were made on July 21, August 6, and August 17. Observation rows (uninoculated wild potato entries) remained healthy throughout the experiment.

(C) Common Scab

Potato seed pieces were planted on April 29 by hand and Admire 2F insecticide was applied in furrow at a rate of 16 fl. oz./acre. Each entry consisted of 4 seed pieces spaced 12 inches apart, followed by a four-foot space, then two seed pieces of 'Red Pontiac' 12 inches apart, followed by another four-foot space. The 'Red Pontiac' was used as a susceptible check, to measure disease pressure throughout the plot.

For evaluation, all potato hills were lifted from the ground and dropped back on the ground using a one-row potato harvester. Harvest was done on September 14 and evaluations were made on September 17, after a natural rainfall had washed much of the dirt from the tubers. All tubers from the four hills were rated as a group using the following scale:

Rating	Severity	Coverage
0	No scab visible	No scab visible
1	Scab <= 1 mm deep	Trace or 1-2 lesions less than 1 cm^2
2	Scab 2-3 mm deep	1 to 5 % tuber surface covered
3	Scab 3-4 mm deep	>5 to 50% tuber surface covered
4	Scab 4-5 mm deep	Over 50% tuber surface covered
5	Scab over 5 mm deep	---

Entries were considered resistant if the severity and coverage ratings were 0, moderately resistant for severity and coverage ratings of 1-2, moderately susceptible for severity and coverage ratings of 3, and susceptible for severity ratings of 4-5 or a coverage rating of 4.

Appendix B. Field Plot Data

(A) Late Blight: Disease resistance scores for entries in the (1) National Late Blight Trial, (2) North Central Trial, (3) Quad-State Trial, (4) University of Minnesota Potato Breeding Program, and (5) University of Minnesota Potato Pathology and Genomics Program.

1. National Late Blight Trial

Clone	14 DAI	18 DAI	22 DAI	25 DAI	28 DAI
97A-51	1	1.25	1.25	2	2
LBR8	1	1.25	1	1.25	1.5
A 97084-44	1	1	1	1.5	2
LBR9	1	1	1	1.75	2
Awn 86514-2	1	1.25	2	2	2.75
B 0718-3	1	1.5	1.5	2	3.25
A 9520-45	1	1.75	1.75	2.25	2.75
A 96517-2	1	1.25	1.5	2.25	3
EGA 970614	1	1.25	1	2.25	3
Jacqueline Lee	1	1.75	1.5	2.5	3.75
B 0767-2	1	1.25	2	2.75	3.25
MSI 152-A	1	1.25	2	3	4.25
MSJ 461-1	1	1	1.25	3	4.25
B 0692-4	1	1.25	2	3.5	4
MSJ 319-1	1	1.25	2.25	4.25	5
LBR1R2R3R4	1	2	2.25	4.5	7
Alturas	1	2	2.5	4.75	7.25
Ivory Crisp	1	2	3.25	5	6.25
LBR3tbr	1	2	3.25	5.5	7
A 9045-7	1	2	3.5	6	7
LBR5	1	2	3.25	6	8.33
A 9014-2	1	2	3	6.5	8.25
B 1240-1	1	2	3.25	6.5	7.75
Cal White	1.25	2	4.5	6.75	8.25
RN C3	1	2	3.75	7	8.25
RN C8	1	2	4	7	8.25
RN LS1	1	1.75	4	7	8.25
RN LS2	1	1.75	4	7	8.25
RN LS3	1	1.75	3.75	7	8
RN LT	1	1.75	3.75	7	8
RN LW	1	2	4	7	8
RN T112	1.25	2	4.75	7.5	8.25
RN T223	1.25	2	5	7.75	8.5
RN T278	1.5	2	5.5	8	8.75
A 8893-1	1.25	2	3	7.25	8.5

LBR4	1	2	4	7.25	9
Ida Rose	1.25	2	3.75	7.5	8
B 1145-2	1	2.25	6.25	8.25	9
LBR2	1	2	4	8.25	9
Yukon Gold	1.75	2	5.25	8.25	9

2. North Central Trial

Clone	14 DAI	18 DAI	22 DAI	25 DAI	28 DAI
MSI 152-A	1	1	1	2	3
MSJ 317-1	1	1	2	2	4
USDA 02-20312	1	2	5	6	9
A 9014-2 Rus	1	2	4	7	8
AC Stampede Russet	1	2	5	7	8
ND 7882b-7russ	1	2	4	7	9
USDA 02-20066	1	2	5	7	8
W 2128-8	2	3	4	7	8
MSH 095-4	1	2	5	8	9
V1102-1	1	2	6	8	9
Villetta Rose	1	2	4	8	9
W 1443	1	3	5	8	9
W 1773-7	1	2	5	8	9
CV 89023-2 R	1	3	6	9	9
FV12486-2	1	3	5	9	9
MN 96001-2	1	2	8	9	9
MN 96013-1	1	2	5	9	9
MN 99380-1	1	2	5	9	9
MN 99460-21	1	2	5	9	9
MSH 031-5	1	2	5	9	9
USDA 02-20059	1	1	5	9	9
USDA 02-20152	1	2	5	9	9
V 0319-1	1	2	6	9	9

3. Quad-State Trial

Clone	14 DAI	18 DAI	22 DAI	25 DAI	28 DAI
W 2301-1P	1	2	3	5	8
AND 98386-1	1	2	3	6	9
ND 7818-1Y	1	2	2	6	8
W 1836-3rus (Freedom Russet)	1	2	4	6	8
ND 4659-5R	1	2	3	7	9
ND 5255-59	1	2	3	7	9

W 1201 (Megachip)	1	2	5	7	8
W 2133-1	1	2	5	7	8
ND 7443Ab-180	1	3	5	8	9
W 1773-7	2	3	5	8	9
W 2145-11	1	2	5	8	8
W 2249-4rus	1	3	5	8	9
W 2265-25	1	2	4	8	9
W 2309-7	1	2	5	8	9
ATND 98450-1R	2	3	7	9	9
ATND 98459-1RY	1	2	6	9	9
W 2154-1	1	2	5	9	9
W 2233-2	1	2	5	9	9
W 2279-4R	1	2	5	9	9
W 2799-1R	1	2	7	9	9

4. University of Minnesota Potato Breeding Program

Series	Clone	14 DAI	18 DAI	22 DAI	25 DAI	28 DAI
Elite	MN 99352-2	1	1	1	3	6
Advanced	MN 02 415	1	2	2	4	7
Elite	MN 99158-1	1	2	3	4	7
Advanced	MN 02 419	1	1	3	5	6
Advanced	MN 02 450	1	2	2	5	8
Advanced	MN 02 635	1	2	3	5	8
Advanced	MN 02 564	1	2	3	6	8
Advanced	MN 02 510	1	2	5	6	8
Advanced	MN 02 467	2	2	3	6	7
Advanced	MN 02 512	2	2	4	6	8
Advanced	MN 02 455	1	2	4	6	8
Advanced	MN 02 462	1	2	5	6	8
Advanced	MN 02 480	1	3	4	6	8
Advanced	MN 02 538	1	2	4	6	9
Advanced	MN 02 702	1	2	4	6	8
Advanced	MN 02 452	1	2	4	6	8
Advanced	MN 02 586	1	1	4	7	9
Advanced	MN 02 407	1	2	5	7	8
Advanced	MN 02 453	2	2	4	7	8
Advanced	MN 02 469	1	2	5	7	8
Advanced	MN 02 503	1	2	3	7	8
Advanced	MN 02 636	1	2	4	7	9
Advanced	MN 02 495	1	2	8	7	8
Advanced	MN 02 536	1	2	5	7	8
Advanced	MN 02 574	1	2	4	7	9
Advanced	MN 02 422	2	2	5	7	9

Advanced	MN 02 588	1	2	4	7	8
Advanced	MN 02 645	1	2	4	7	9
Advanced	MN 02 533	1	2	4	7	9
Advanced	MN 02 633	1	2	4	7	8
Advanced	MN 02 458	1	2	5	8	9
Advanced	MN 02 644	2	2	5	8	9
Advanced	MN 02 573	2	2	4	8	8
Advanced	MN 02 593	1	2	5	8	9
Advanced	MN 02 703	1	2	5	8	8
Advanced	MN 02 454	1	3	5	8	9
Advanced	MN 02 521	1	3	5	8	9
Advanced	MN 02 497	1	2	5	8	9
Advanced	MN 02 589	1	2	5	8	9
Advanced	MN 02 417	2	2	6	8	9
Advanced	MN 02 587	1	2	3	8	8
Advanced	MN 02 678	1	2	5	8	9
Advanced	MN 02 582	1	2	3	8	9
Advanced	MN 02 696	1	2	5	8	9
Advanced	MN 02 618	1	2	5	8	9
Advanced	MN 02 598	1	2	4	8	9
Advanced	MN 02 514	1	2	4	8	9
Advanced	MN 02 709	2	3	5	8	9
Advanced	MN 02 529	1	2	4	8	9
Elite	MN 17922	1	2	3	8	9
Elite	MN 19470	1	2	5	8	9
Elite	MN 18710	1	2	5	8	9
Elite	MN 96072-4	1	3	6	8	9
Elite	MN 15620	1	2	5	8	8
Elite	MN 98001-4	2	2	5	8	9
Elite	MN 18747	2	3	5	8	9
Elite	MN 99460-21	1	2	5	8	9
Advanced	MN 02 524	1	2	6	9	9
Advanced	MN 02 748	2	2	5	9	9
Advanced	MN 02 689	1	2	5	9	9
Advanced	MN 02 639	1	3	8	9	9
Advanced	MN 02 616	1	2	8	9	9
Advanced	MN 02 619	2	3	6	9	9
Advanced	MN 02 537	1	2	6	9	9
Advanced	MN 02 515	1	2	5	9	9
Advanced	MN 02 496	1	3	6	9	9
Advanced	MN 02 565	1	2	5	9	9
Elite	MN 19298A	1	2	5	9	9
Elite	MN 19298	1	2	5	9	9
Elite	MN 99380-1	1	2	8	9	9
Elite	MN 96001-2	1	2	6	9	9
Elite	MN 99144-1	1	2	8	9	9

Elite	MN 18153	1	2	5	9	9
Elite	MN 96013-1	1	3	5	9	9
Elite	MN 99460-14	1	3	6	9	9
Elite	MN 19350	2	2	4	9	9

5. University of Minnesota Potato Pathology and Genomics Program

Clone	14 DAI	18 DAI	22 DAI	25 DAI	28 DAI
B0767-2	1	1	1.33	1.67	1.67
Elba	1.33	2	2.67	4	6
Inca Gold	1	1.67	2.33	4.33	6.67
Pimpernel	1	1.67	5	5.33	7.33
Reda	1	2	3.33	5.33	7
Ruby Crescent-Ronnigers	1	1.67	4	5.33	8.67
Sieglinde	1	2	4	5.33	7.67
Albys Gold	1	2	4	6	7.33
German Butterball-Hancock	1	2	4	6	8.33
Nooksack	1	2	4	6	8
German Butterball-Ronnigers	1.33	2	4.33	6.33	8
Pink Pearl	1.33	2	3.33	6.67	7.67
Ruby Crescent-Hancock	1.33	2.33	4	6.67	8
All Blue	1	2.33	4	7	8.33
Kennebec	1	2.33	4.67	7.33	8.67
Gold Nugget	1	2.33	5.67	7.67	9
Russian Banana	1.33	2.33	5	7.67	8.67
Butte	1	2	4.67	8	8.67
Carola-Hancock	1	2.67	5.33	8	9
Carola-Ronnigers	1.33	2.33	5.67	8	9
King Edward	1	1.67	4.67	8	9
Princess Laratte	1.67	3	4.67	8	8.33
Shepody	1	2.33	4.67	8	9
Yellow Finn	1	2	6	8	9
Denali	1	2.67	5.67	8.33	9
Saginaw Gold	1.33	3	5.33	8.33	9
Yukon Gold	1	2	6.33	8.33	9
All Red	1.33	2.67	6.33	8.67	9
Huckleberry	1.67	2.67	6.33	8.67	9
Bake King	1.33	2.33	7	9	9
Butterfinger	1	2.33	6	9	9
Caribe	1	2.33	7.67	9	9
Epicure	1	2.33	6.67	9	9
Red Thumb	1.33	2.67	6	9	9
Red Warba	1.67	2.67	6.67	9	9
Rose Gold	1.17	2.67	7.83	9	9

(B) Common Scab: Disease severity and coverage scores for entries in the (1) National Late Blight Trial, (2) North Central Trial, (3) Quad-State Trial, (4) University of Minnesota Potato Breeding Program, and (5) University of Minnesota Potato Pathology and Genomics Program.

1. National Scab Trial

Clone	Severity	Coverage
#1	5	4
#1	5	4
#1	5	4
#2	5	3
#2	5	4
#2	5	4
#3	5	3
#3	5	4
#3	5	4
#4	5	3
#4	5	4
#4	5	4
Alturas	0	0
Alturas	4	3
Alturas	4	4
Atlantic	5	3
Atlantic	4	4
Atlantic	5	4
Atlantic	5	4
B0766-3	1	1
B0766-3	2	1
B0766-3	2	3
Bannock Russet	2	1
Bannock Russet	2	2
Bannock Russet	3	3
CO94035-15Ru	1	1
CO94035-15Ru	2	3
CO94035-15Ru	3	4
CO94165-3P/P	5	4
CO94165-3P/P	5	4
CO94165-3P/P	5	4
CO94183-1R/R	2	2
CO94183-1R/R	4	2
CO94183-1R/R	3	3
Gem Russet	0	0
Gem Russet	3	4
Gem Russet	4	4

GemStar Russet	2	1
GemStar Russet	2	3
GemStar Russet	2	3
Harley Blackwell	3	3
Harley Blackwell	5	3
Harley Blackwell	5	4
MN 96001-2	4	4
MN 96001-2	4	4
MN 96001-2	5	4
MN 96013-1	3	2
MN 96013-1	5	3
MN 96013-1	5	4
MN 99380-1	3	1
MN 99380-1	5	4
MN 99380-1	5	4
MN 99460-21	4	4
MN 99460-21	4	4
MN 99460-21	5	4
R. Burbank	2	1
R. Burbank	2	2
R. Burbank	1	3
Ranger Russet	0	0
Ranger Russet	1	1
Ranger Russet	2	2
Superior	0	0
Superior	1	1
Superior	1	1
VC0967-2R/Y	4	3
VC0967-2R/Y	4	4
VC0967-2R/Y	4	4
VC1002-3 WY	1	1
VC1002-3 WY	1	2
VC1002-3 WY	2	3
Villetta Rose (W2275-3R)	1	2
Villetta Rose (W2275-3R)	2	2
Villetta Rose (W2275-3R)	4	3
W 1201 (Megachip)	2	2
W 1201 (Megachip)	4	3
W 1201 (Megachip)	5	3
W 1836-3rus (Freedom Russet)	0	0
W 1836-3rus (Freedom Russet)	1	1
W 1836-3rus (Freedom Russet)	1	1

2. North Central Trial

Clone	Severity	Coverage
A 9014-2 Rus	1	1
AC Stampede Russet	2	4
CV 89023-2 R	4	4
FV12486-2	5	4
MN 96001-2	2	4
MN 96013-1	5	4
MN 99380-1	5	3
MN 99460-21	5	4
MSH 031-5	5	3
MSH 095-4	4	1
MSI 152-A	4	2
MSJ 317-1	2	4
ND 7882b-7russ	1	1
USDA 02-20059	1	1
USDA 02-20066	3	2
USDA 02-20152	5	4
USDA 02-20312	3	2
V 0319-1	3	4
V1102-1	2	2
Villetta Rose (W2275-3R)	4	3
W 1443	2	2
W 1773-7	4	4
W 2128-8	3	2

3. Quad-State Trial

Clone	Severity	Coverage
AND 98386-1	5	4
ATND 98450-1R	3	4
ATND 98459-1RY	5	4
ND 4659-5R	4	2
ND 5255-59	5	4
ND 7443Ab-180	3	3
ND 7818-1Y	5	4
W 1201 (Megachip)	2	3
W 1773-7	3	4
W 1836-3rus (Freedom Russet)	0	0
W 2133-1	3	1
W 2145-11	2	2

W 2154-1	5	4
W 2233-2	2	4
W 2249-4rus	3	4
W 2265-25	5	4
W 2279-4R	2	4
W 2301-3P	5	3
W 2309-7	3	2
W 2799-1R	5	4

4. University of Minnesota
Potato Breeding Program

Clone	Severity	Coverage
MN 02 407	1	2
MN 02 415	5	3
MN 02 417	5	4
MN 02 419	5	4
MN 02 422	1	1
MN 02 450	5	3
MN 02 452	5	4
MN 02 453	5	3
MN 02 454	2	2
MN 02 455	1	2
MN 02 458	3	2
MN 02 462	4	4
MN 02 467	2	1
MN 02 469	4	2
MN 02 480	1	1
MN 02 495	5	3
MN 02 496	4	4
MN 02 497	4	3
MN 02 503	5	4
MN 02 510	3	3
MN 02 512	5	3
MN 02 514	1	2
MN 02 515	4	3
MN 02 521	4	3
MN 02 524	5	4
MN 02 529	5	4
MN 02 533	5	3
MN 02 536	2	3
MN 02 537	4	2
MN 02 538	1	1
MN 02 564	5	4

MN 02 565	5	4
MN 02 573	5	4
MN 02 574	5	3
MN 02 582	5	3
MN 02 586	5	3
MN 02 587	5	4
MN 02 588	4	4
MN 02 589	5	4
MN 02 593	5	4
MN 02 598	5	3
MN 02 616	4	3
MN 02 618	5	2
MN 02 619	3	3
MN 02 633	4	4
MN 02 635	5	2
MN 02 636	5	4
MN 02 639	5	4
MN 02 644	5	3
MN 02 645	5	4
MN 02 678	5	4
MN 02 689	5	3
MN 02 696	5	3
MN 02 702	5	4
MN 02 703	3	2
MN 02 709	5	4
MN 02 748	5	4
MN 15620	5	4
MN 17922	1	2
MN 18153	1	2
MN 18710	1	1
MN 18747	4	2
MN 19298	4	3
MN 19298A	5	4
MN 19350	5	3
MN 19470	1	1
MN 96001-2	4	4
MN 96013-1	3	2
MN 96072-4	5	3
MN 98001-4	5	4
MN 99144-1	5	4
MN 99158-1	5	3
MN 99352-2	5	4
MN 99380-1	4	3
MN 99460-14	3	2
MN 99460-21	5	4

5. University of Minnesota
Potato Pathology and Genomics
Program

Clone	Severity	Coverage
Albys Gold	4	3
Albys Gold	4	4
Albys Gold	5	4
All Blue	4	4
All Blue	5	4
All Blue	5	4
All Red	4	4
All Red	5	4
All Red	5	4
Augsburg Gold	3	4
Augsburg Gold	4	4
Augsburg Gold	4	4
Bake King	4	4
Bake King	5	4
Bake King	5	4
Butte	1	1
Butte	3	3
Butte	4	3
Butterfinger	1	2
Butterfinger	3	1
Butterfinger	3	2
Candy Cane	4	3
Candy Cane	5	2
Candy Cane	5	4
Caribe	4	3
Caribe	4	4
Caribe	4	4
Carola-Hancock	5	3
Carola-Hancock	5	4
Carola-Hancock	5	4
Carola-Ronnigers	4	3
Carola-Ronnigers	5	3
Carola-Ronnigers	5	4
Denali	4	4
Denali	5	4
Denali	5	4
Epicure	5	4
Epicure	5	4
Epicure	5	4

German Butterball-Hancock	2	2
German Butterball-Hancock	3	1
German Butterball-Hancock	4	2
German Butterball-Ronnigers	0	0
German Butterball-Ronnigers	1	1
German Butterball-Ronnigers	3	1
Gold Nugget	3	4
Gold Nugget	4	4
Gold Nugget	5	4
Hooksack	0	0
Hooksack	0	0
Hooksack	0	0
Huckleberry	2	2
Huckleberry	3	4
Huckleberry	4	3
Inca Gold	0	0
Inca Gold	3	2
Inca Gold	4	2
King Edward	4	2
King Edward	4	3
King Edward	5	4
Pimpernel	5	3
Pimpernel	5	4
Pimpernel	5	4
Pink Pearl	3	4
Pink Pearl	4	3
Pink Pearl	4	3
Princess Laratte	4	3
Princess Laratte	4	3
Princess Laratte	5	2
Red Thumb	4	4
Red Thumb	5	4
Red Thumb	5	4
Red Warba	5	4
Red Warba	5	4
Red Warba	5	4
Reda	5	2
Reda	5	3
Reda	5	4
Rose Gold-Alaska	5	4
Rose Gold-Alaska	5	4
Rose Gold-Alaska	5	4
Rose Gold-Seed Savers	5	4
Rose Gold-Seed Savers	5	4
Rose Gold-Seed Savers	5	4
Ruby Crescent-Hancock	0	0

Ruby Crescent-Hancock	1	2
Ruby Crescent-Hancock	3	3
Ruby Crescent-Ronnigers	1	1
Ruby Crescent-Ronnigers	2	1
Ruby Crescent-Ronnigers	2	3
Russian Banana	0	0
Russian Banana	4	2
Russian Banana	5	2
Saginaw Gold	3	1
Saginaw Gold	4	3
Saginaw Gold	4	4
Sieglinde	2	2
Sieglinde	3	3
Sieglinde	3	4
Yellow Finn	2	1
Yellow Finn	4	4
Yellow Finn	4	4
Yukon Gold	4	4
Yukon Gold	5	4
Yukon Gold	5	4