Genotypic Differences in Advanced Breeding Lines for Resistances to Black Dot and Powdery Scab

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Introduction

The economics of potato production require that the industry grow their crop more cheaply. From the breeding side new varieties that are improved in resistance to pests and diseases and the physical stresses that assault the crop will contribute to the solution. Powdery scab (***Spongospora subterranea***) has been steadily increasing its geographic coverage, growing from an unusual occurrence to widespread in certain areas. Russet skin varieties are not heavily damaged on the tuber, but may have substantial yield loss due to impairment of root function. Growers report an inability to use Russet Burbank and Umatilla on ground with heavy powdery scab. Total yield is reduced from historic averages and underrepresentation in the large tuber categories lowers incentive payments on contracts to unprofitable levels. Unfortunately, no fungicidal or fumigation treatments that have been tried appear to work. However, there are promising results in germplasm evaluation that indicate that resistance to root colonization may exist in breeding materials and advanced materials with commercial potential. Black dot (*Colletotrichum coccodes*) is also a relative newcomer on the scene. Little is known about it and levels of resistance are unexplored. It appears to be another profit-stealer that makes potato growing more of a challenge. Black dot varies greatly with year and location. It may appear to be an active pathogen that shortens the vegetative period with early dying type symptoms of sudden stem death. Alternatively, it may appear to come in as a saprophyte after the potato foliage has died. Easily confused with Verticillium wilt, it was recognized only within the last decade as a significant factor.

Approach

We have attempted to categorize resistance to black dot (BD) and powdery scab (PS) in field experiments. In the case of PS, plants were hand dug before the onset of senescence. The root systems were rated on a subjective scale for the degree of galling. We also measured the fresh and dry weight of the recovered root system. Fresh weight and percent dry matter of the root are presented here. In the case of BD we have harvested stems from senescing plants, excised stem disks at various intervals up the stem, and plated these out on appropriate medium to detect presence of the fungus. We also employed a technique in 2008 where we harvested the stems and allowed them to air dry. During the drying, BD sclerotia appeared on the epidermis of the stem at varying distances measured on a basal to apical axis. The total distance was measured when the stems were completely dried. We also measured the incidence of detectable BD in the basal end of the tuber. This was accomplished by excising a small piece of tissue with sterile instruments after sterilizing the surface of the tuber with dilute bleach. The excised tissue was plated onto appropriate medium.

Results

A summary of PS root galling results over five year-locations is given for germplasm entries and commercial cultivars in Table 1. The breeding lines PA98NM38-1, PA95B2-4, PA98N5-2, PO94A010-10, and PO94A09-7 were the most resistant breeding lines.

Table 1. Frequency of resistant reactions of breeding lines and cultivars in five field tests.

	Field trials screening out come [y]					
Selection [x]	04-ID	04-WA	05-WA	06-WA	07-WA	Frequency of resistance [z]
PA98NM38-1	R	R	R	R	R	5/5
PO94A009-10	R	R	R	R	S	4/5
PA95B2-4	R	R	R	S	S	3/5
PA98N5-2	R	R	R	S	S	3/5
POR00HG5-1	R	S	R	S	S	2/5
PO94A009-7	R	R	R	S	nt	3/4
PO94A012-2	S	R	R	nt	nt	2/3
Summit Russet	nt	nt	nt	R	R	2/2
Russet Burbank	S	S	S	S	S	
Russet Ranger	S	S	S	S	S	
Umatilla Russet	S	S	S	S	S	
Shepody	S	S	S	S	S	

[x] Selections with greater (P<0.05) resistance to root galling than the standard cultivars Russet Burbank, Russet Ranger, Umatilla Russet and Shepody in two or more trials.

[y] 04, 05, 06, 07 = 2004, 2005, 2006, and 2007; ID = Rexburg, Idaho; WA = Moses Lake, Washington; R= resistant; S= susceptible; nt = not tested.

[z] The number of trials the selection had a greater (P<0.05) resistance to root galling than the standard cultivars Russet Burbank, Russet Ranger, Umatilla Russet and Shepody. Excerpted from Nadav et al. 2008.

Likewise a summary of results over three years is given in Table 2 for disease severity based on culturing out the BD pathogen at different heights along stems.

Table 2. Results over three years of screening for black dot resistance. Disease Severity based on detection of *Colletotrichum coccodes* in stem disks. Shaded breeding lines demonstrate resistance. Excerpted from Nadav et al., 2009

Potato Selection or Variety	2006		2007		2008	
`	R/S	DSI (%) [a]	R/S	DSI (%)	R/S	DSI (%)
A0012-5	R	38	R	32	S	46
A00681-7	R	39	R	41	S	59
A0073-2	R	21	S	85	S	63
A95109-1	R	38	S	94	S	48
PA00N6-1	R	19	S	68	S	71
PA95B2-4	S	54	R	48	R	26
PA98N5-2	S	64	S	83	S	60
PA98NM38-1	R	25	R	46	R	38
PO94A009-7	R	19	S	55	R	19
PA99N82-4	S	42	S	49	S	52
POR00HG5-1	R	29	S	61	R	21
Russet Summit	R	21	R	42	S	75
Russet Norkotah	S	35	S	86	S	57
Shepody	S	88	S	91	S	47

The dramatic coincidence of three clones with the highest levels of resistance to both black dot and powdery scab is the most noteworthy result of these two studies (PA95B2-4, PA98NM38-1, and PA94A009-7).

Survey of components of resistance in Tri-State and Western Regional Trial Entries.

On an annual basis groups of advanced clones are planted in multiple sites for evaluation of yield, disease and pest resistance and post harvest processing and culinary quality. We took advantage of this to measure certain components of resistance in BD plus PS infested fields.

We measured the root and crown fresh weight. The results are shown in Figure 1.

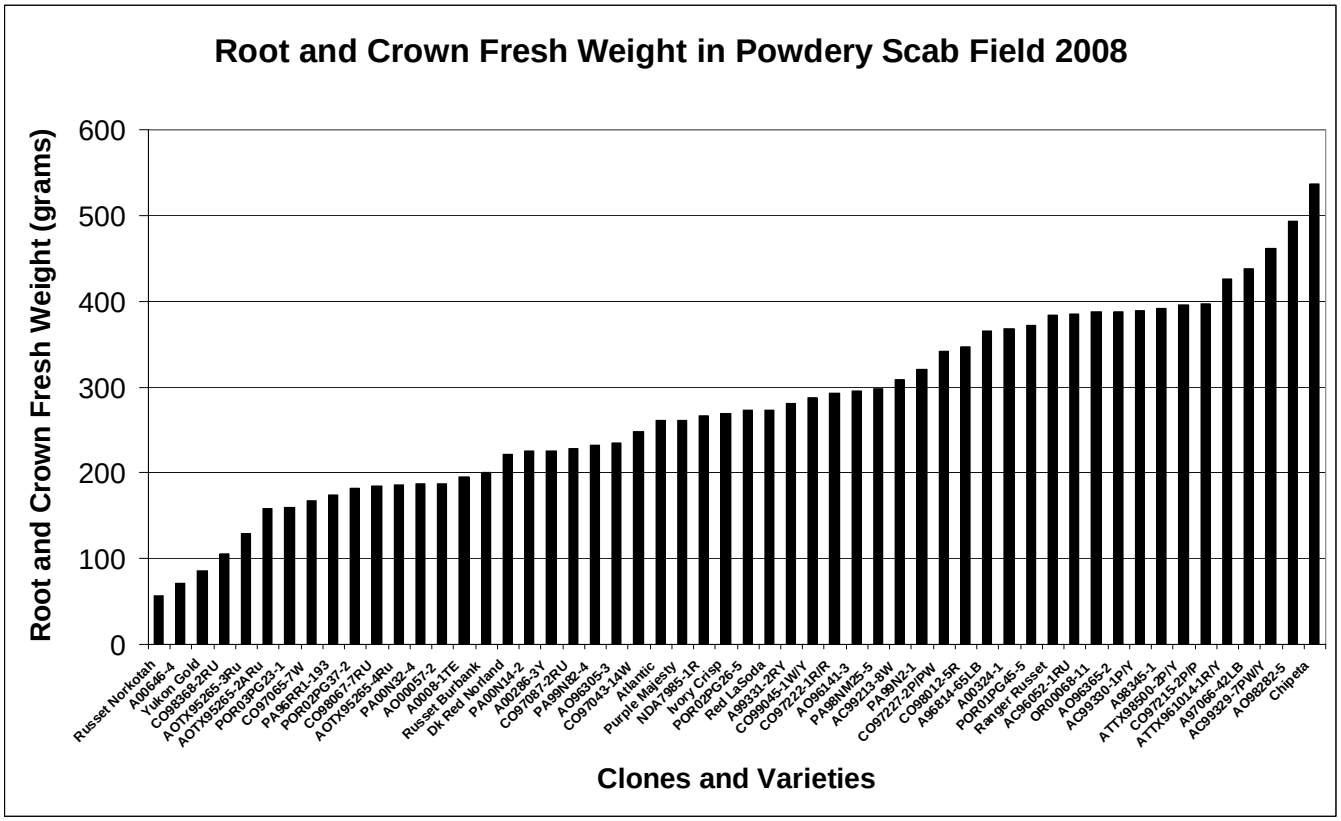


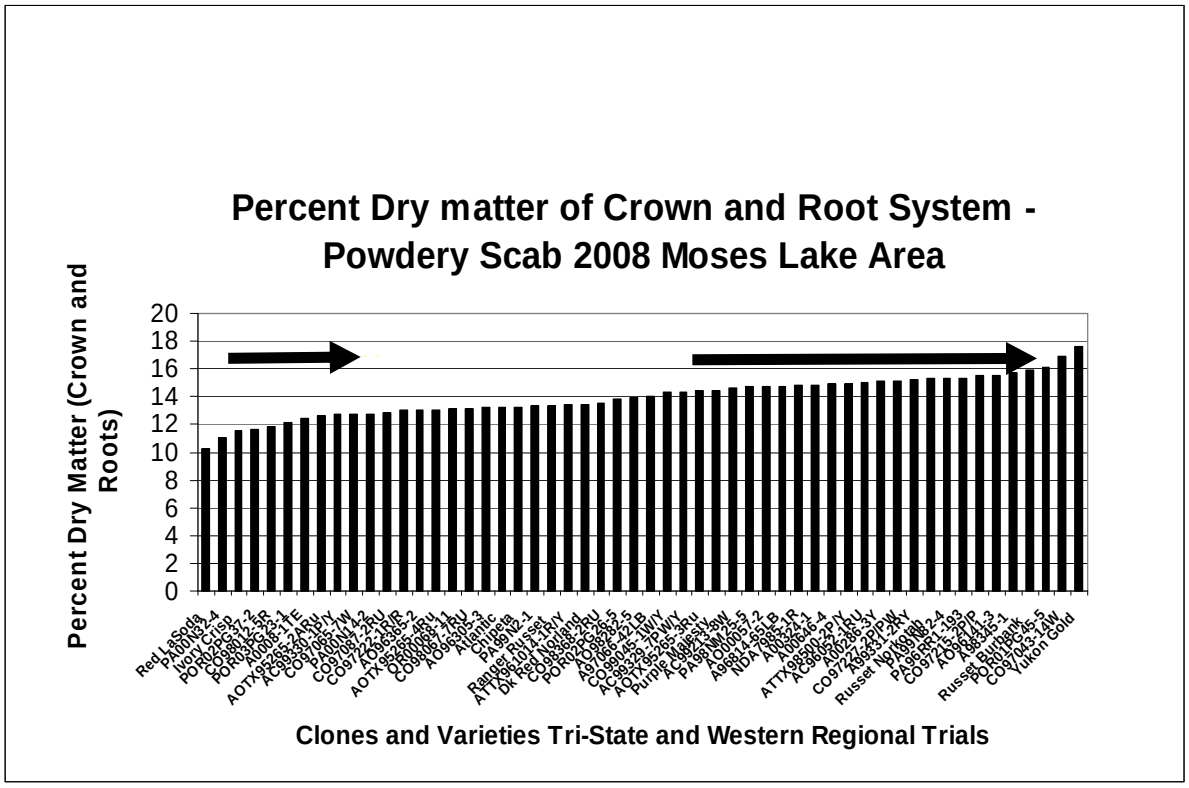
Figure 1. Fresh root and crown weight of Tri-State and Western Regional Trial entries.

Chipeta is renowned for its late maturity and large size and its huge root system comes as no surprise. It is interesting to note however that AO98282-5 and A97066-42LB are also able to maintain a large mass of roots in this infested soil.

The percent dry matter of the root systems was also determined. These results are depicted in Figure 2. This measurement has the intent of emphasizing genotypes that retain moister roots. This is a sign of a healthier root system in the face of the damaging effects of PS.

Black dot invades the stem and remains relatively inactive until the plant enters into senescence. Upon stem death, black dot sclerotia are often seen on the surface of the stem, around the crown of the plant and on the surface of shallow roots. One technique to assess resistance is to harvest senescing stems and allow them to air dry. The extension of the sclerotia up the stem is theoretically a measure of susceptibility. The expansion of BD sclerotia up stems that were harvested and allowed to air dry is shown in Figure 3.

Figure 2. Percent dry matter of Tri-State and Western Reginal Trial Entries.



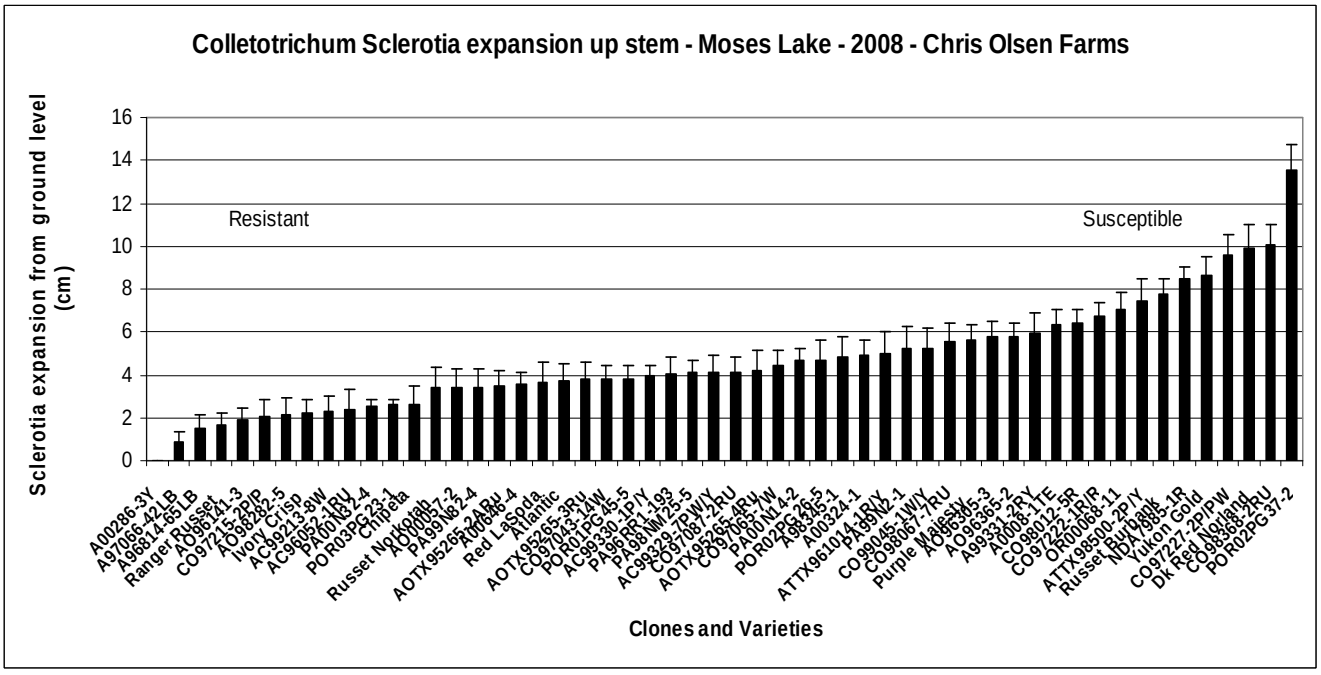


Figure 3. Expansion of sclerotia up the stems of harvested and drying stems. Tri-State and Western Regional Trials.

Interestingly, A97066-42LB and A96814-65LB, clones that have resistance to late blight, show considerable restriction of BD sclerotia expansion up the stems.

The ability of BD to invade tubers is a component of resistance. We tested for the presence of BD at the stolon end. These results are shown in Figure 4.

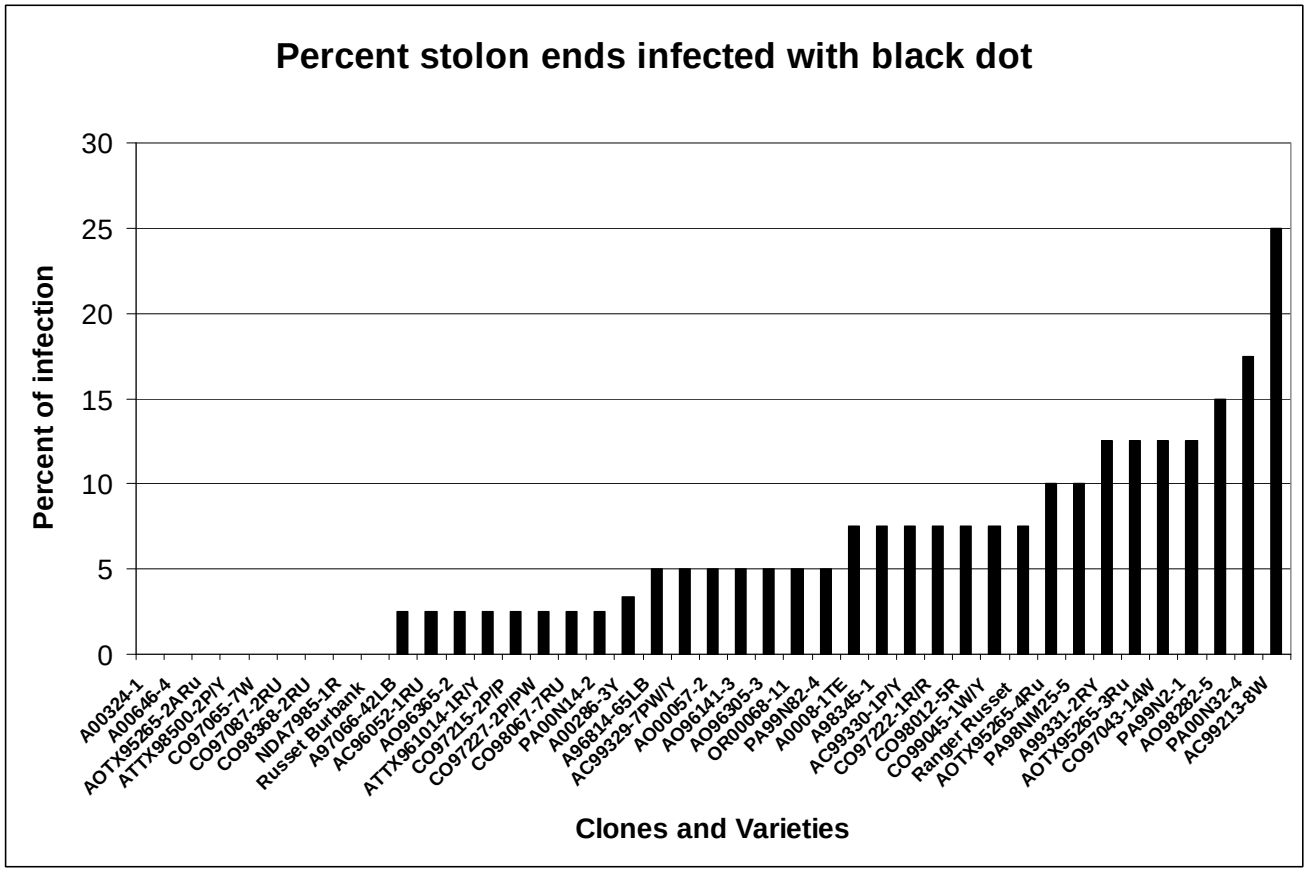


Figure 4. Incidence of infection of the stolon end of tubers by the *Colletotrichum coccodes*.

It is interesting to note that A97066-42LB occurs at the resistant end of the scale with a percent stolon end infection of 2.5.

To make sense of these measurements we included a clone for each trait on a list if its rating occurred in the top third of the range (i.e., indicating greater resistance). All the clones that had two or more attributions were placed in Table 3.

Table 3. Clones that have at least two upper third attributions for traits contributing to resistance to Black Dot and Powdery scab

Clone	Low % tuber inf	Low Sclerotia expansion	High Moist. Roots	High Root Fresh Weight
A00646-4	☺	☺		
AOTX95265-2ARu	☺	☺	☺	
A97066-42LB	☺	☺		☺
AC96052-1Ru	☺	☺		☺
CO97215-2P/P	☺	☺		☺
A00286-3Y	☺	☺		
Ivory Crisp	☺		☺	
PA00N32-4		☺	☺	
AC99330-1P/Y			☺	☺
PA00N14-2	☺		☺	
CO97087-2RU		☺	☺	
AO96365-2	☺	☺		☺
Chipeta		☺		☺
AO98282-5		☺		☺
ATTX961014-1R/Y	☺			☺
ATTX98500-2P/Y	☺			☺

A total of fourteen breeding lines and two varieties appear in this table. If we apply a stricter standard and include clones that have three or more attributions we arrive at Table 4.

Table 4. List of clones with three attributions for components of resistance to black dot and powdery scab. Pedigrees are also given.

Clone	Pistillate Parent	Pollen parent	**Low % tuber infection BD**	**Low sclerotia expansion BD**	**High Moist. Roots**	**High Root Fresh Weight**
AOTX95265-2ARu	**A89216-9**	**A86102-6**	☺	☺	☺	
A97066-42LB	**AWN86514-2**	**A86102-6**	☺	☺		☺
AC96052-1Ru	**A81386-1**	**GemStar**	☺	☺		☺
CO97215-2P/P	**CO94163-1**	**CO94183-1**	☺	☺		☺

Analyzing the ancestry of the four top clones, the parent A86102-6 appears twice and the variety GemStar Russet once. The clone AWN86514-2, which appears once, possesses a high level of resistance to late blight. These clues are helpful in trying to pin down sources of resistance and guidelines for future crossing.

Summary

Surprisingly, our initial testing for resistance to PS and BD resulted in three clones that are resistant to both pathogens at high levels in different environments. A further intriguing connection is that the three originated from a backcrossing program to incorporate resistance to Columbia root-knot nematode originating form the wild species *Solanum bulbocastanum*. However, they also had, in their geneaology, two successive backcrosses to Summit Russet. It appears that the more important clue is the Summit Russet. Our conclusion is that Summit Russet is an important contributor to both BD and PS resistance. Our work with these two diseases will continue with field tests and greenhouse measurements of root development with and without inoculation with BD and PS.

References

1. Nitzan, N, Cummings, TF, Johnson, DA, Miller, JS, Batchelor, DL, Olsen, C, Quick, RA, Brown, CR. 2008. Resistance root galling caused by the powdery scab pathogen *Spongospora subterranea* in Potato. Plant Disease 92:1643-1649.
2. Nitzan, N. Cummings, TF, Batchelor, D, Olsen, C, Brown, CR. 2009. Resistance to stem colonization by black dot pathogen *Colletotrichum coccodes* in potato. Plant Disease (Submitted)