Controlling Powdery Scab: The Breeding Approach

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Introduction

Powdery scab is a serious disease of potato caused by the fungus *Spongospora subterranea*. *Spongospora subterranea* is a member of the Plasmodiophorales, also known as the parasitic slime molds. The primary diagnostic sign of the disease is cystosori, spongelike aggregates of cysts or resting spores. The motile life stage appears as zoospores with two flagella, which explains the relationship of abundance of soil water to level of damage. The fungus is also the vector for *Potato Mop-Top Virus* (PMTV), which is important because it is rare now in the United States and needs to be monitored and controlled. Areas with widespread occurrence of powdery scab are prime candidates for an outbreak of PMTV.

Life cycle

Powdery scab symptoms are confined to below-ground parts in potato including the roots and the tubers. Initial inoculation is followed by ruptures of the periderm of the tuber and outgrowths which consist of cystosori or spore balls, that appear to be powder-like when disrupted. The powdery scab organism survives in the soil in the form of cystosori. When the cyst germinates it releases a single primary biflagellate zoospore (Figure 1) capable of infecting root, stolon or tuber. A multinucleate plasmodium is then formed (Figure 2), which produces zoosporangia that release multiple secondary zoospores (Merz, 1997). Given good conditions, abundant soil moisture and temperatures at 11-18° C, zoospores from multiple cycles continue the infection process (van de Graaf et al., 2005) (Figure 3). Cystosori can survive up to six years in soil and survive passage through animal digestive tracts.

Damage

There is no known means of control of powdery scab other than avoidance of infected seed and problem fields. The lack of efficacy of fungicides or fumigation means that there are no studies precisely documenting the damage done by the disease. However, growers are convinced that the reduction in yield and, in particular, in size of tubers is real. Russeted varieties appear not to suffer greatly from tuber skin lesions, but they can experience heavy galling of the roots, the disease symptom that is thought to lead to yield reductions. Non-russet skin varieties can suffer lesion formation to the extent that there is unacceptable loss to the grower (Figure 4).

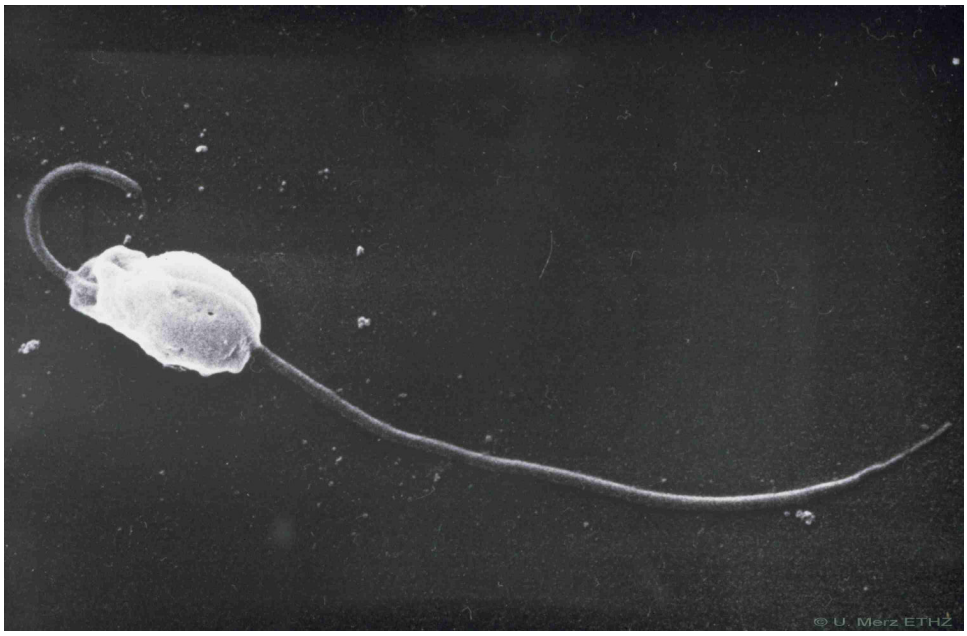


Figure 1. Biflagellate zoospore of *S. subterranea*
(Photo credit: Dr. Ueli Merz, Insitute of Plant Sciences, Zurich, Switzerland)

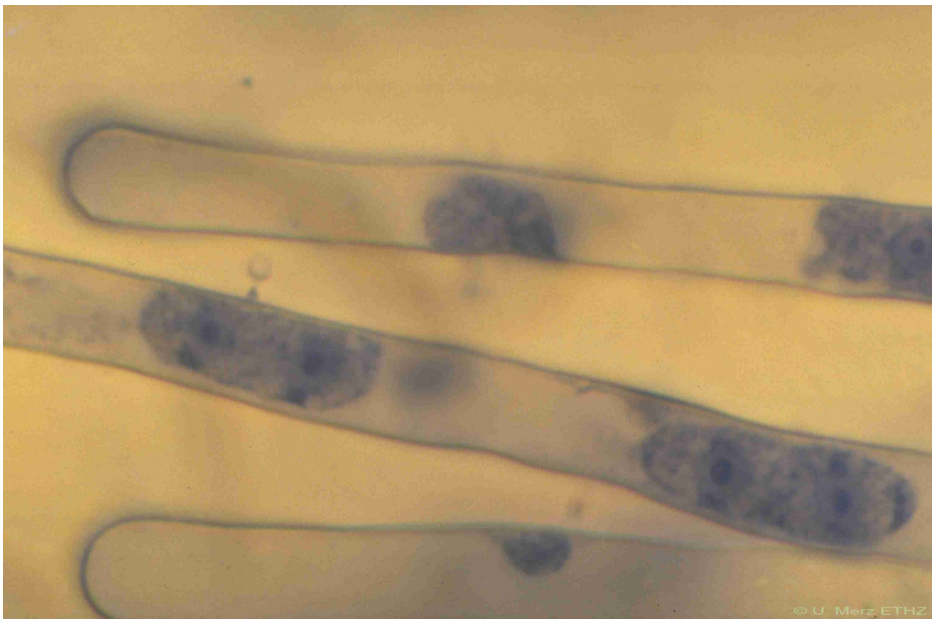


Figure 2. Multi-nucleate plasmodium of *S. subterranea* inside root hairs.
(Photo credit: Dr. Ueli Merz, Insitute of Plant Sciences, Zurich, Switzerland)

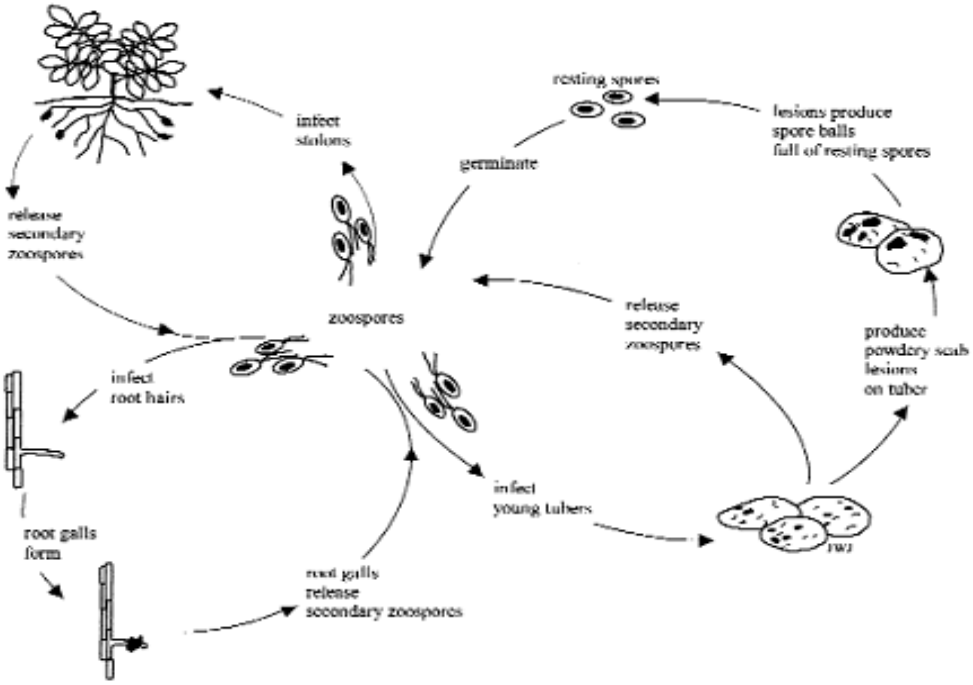


Figure 3. Life and disease cycle of *Spongospora subterranea*

Figure 4. Skin lesions caused by *Spongospora subterranea* on potato tubers.
(Photo credit: Dr. Ueli Merz, Insitute of Plant Sciences, Zurich, Switzerland)

Genetic Resistance

Relatively little is known about resistance of potato to powdery scab. There is some indication of resistance in European varieties, including the cultivars Granola, Nicola, Ditta, and Gladiator (Merz et al., 2004). The Australian variety Tarago is also reported to be resistant. In the Pacific Northwest (PN), most of the acreage is planted to varieties with russeted skin. Russeted skin confers considerable resistance to tuber lesions. Although small lesions may be noted, so far, they are inconspicuous enough to avoid contractual sanctions in potato lots destined for fresh market and processing. Hence the quality problem in the PN occurs among the non-russeted varieties (primarily the processor Shepody and red skinned varieties). Nevertheless a productivity problem is posed by yield reduction caused by powdery scab incited root damage and interactions with other soil-borne pathogens. Certain processing varieties with russeted skin typically suffer yield reductions of 2-5 tons/acre and considerable loss of tuber size, which can affect the contract incentive payments to a high degree. Consequently the focus in our germplasm screening has been on identifying resistance to root galling in the root system.

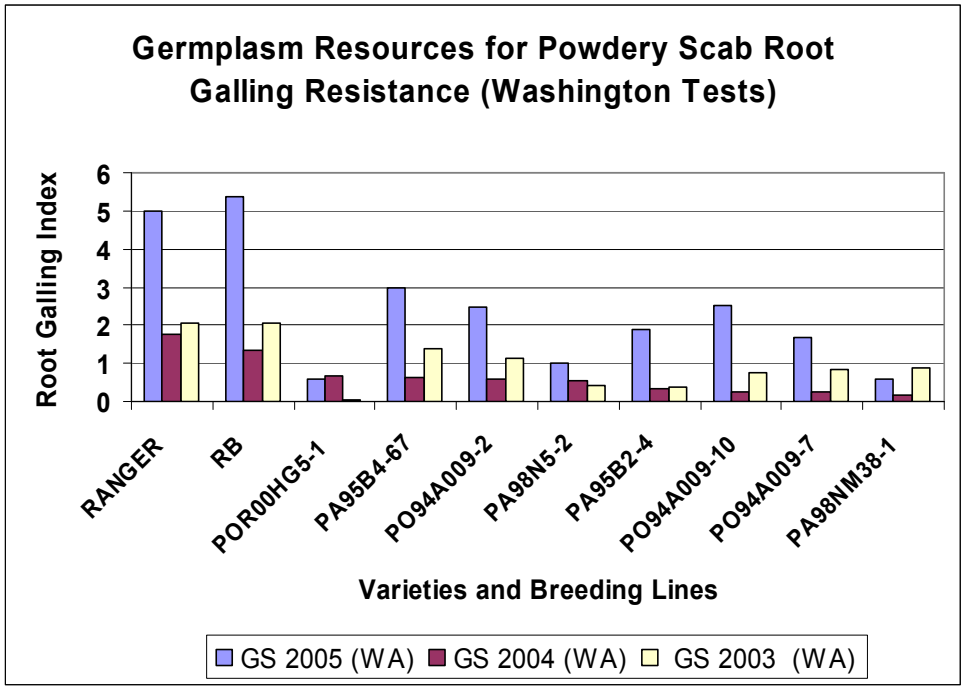
We have screened a number of germplasm lines at two locations during the last three years. In Table 1 a summary of three field tests in Washington State and two in Idaho is presented. The indices of root galling are shown. The indices from Washington are on a different scale than those from Idaho. An interesting observation is that a number of clones have maintained a low level of root galling in all five trials.

All of the shaded entries appear to show stable resistance over the five tests. These entries have two ancestral factors in common: 1) they are all derived from an introgression program to incorporate resistance to Columbia root-knot nematode (*Meloidogyne chitwoodi*) from the Mexican wild species *Solanum bulbocastanum* and 2) they all have two successive backcrosses to the the newly named variety Summit Russet. Summit Russet was tested in 2002 and 2003 in Idaho and was quite resistant to root galling and tuber lesions of powdery scab. These clues will be followed up in future research.

Summarizing the data from Washington and Idaho, we see in Figure 5 that several resistant clones performed consistently in regard to root galling reduction compared to susceptible cultivars. Not all genotypes showed consistent resistance between years and locations, hence the genotypes that were consistently resistant are highly noteworthy and form the nucleus of our present breeding efforts.

Table 1. Root galling scores (GS) on root systems of potato varieties and breeding lines tested in infested fields three years in Washington and two years in Idaho. Entries with shading are considered to be resistant.

Clone or Variety	GS 2005 (WA)	GS 2004 (WA)	GS 2003 (WA)	GS 2003 (ID)	GS 2004 (ID)
PA99N82-4	2.9	2	1.1	4.1	18.3
PA98NM36-16	5.1	2.2	1.3		20.2
Ranger	5.0	1.7	2.1	12.0	24.4
PA99N88-2	2.7	1.5	0.7		12.8
Umatilla	4.8	1.3	2.0		30.3
Russet Burb/	5.3	1.3	2.1	15.0	18.5
PA98NM39-1	3.3	1.2	0.7	12.1	30.8
PA95B1-53	2.5	0.7	0.6	16.8	22.2
PO94A010-3	3.1	0.7	1.4	13.3	14.5
POR00HG5-1	0.6	0.7	0.1	15.4	8.0
PA95B4-67	3.0	0.6	1.4	13.0	27.4
PO94A009-2	2.5	0.6	1.1	5.7	16.9
PA98N5-2	1.0	0.5	0.4	3.9	6.8
PA98NM30-11	4.4	0.5	2.1		12.9
PO94A012-2	3.4	0.4	1.4	8.3	25.8
PA95B2-4	1.9	0.3	0.4	0.8	1.6
PO94A009-10	2.5	0.3	0.7	1.7	4.0
PO94A009-7	1.7	0.3	0.8	2.0	8.4
PA98NM38-1	0.6	0.2	0.9	6.4	4.9



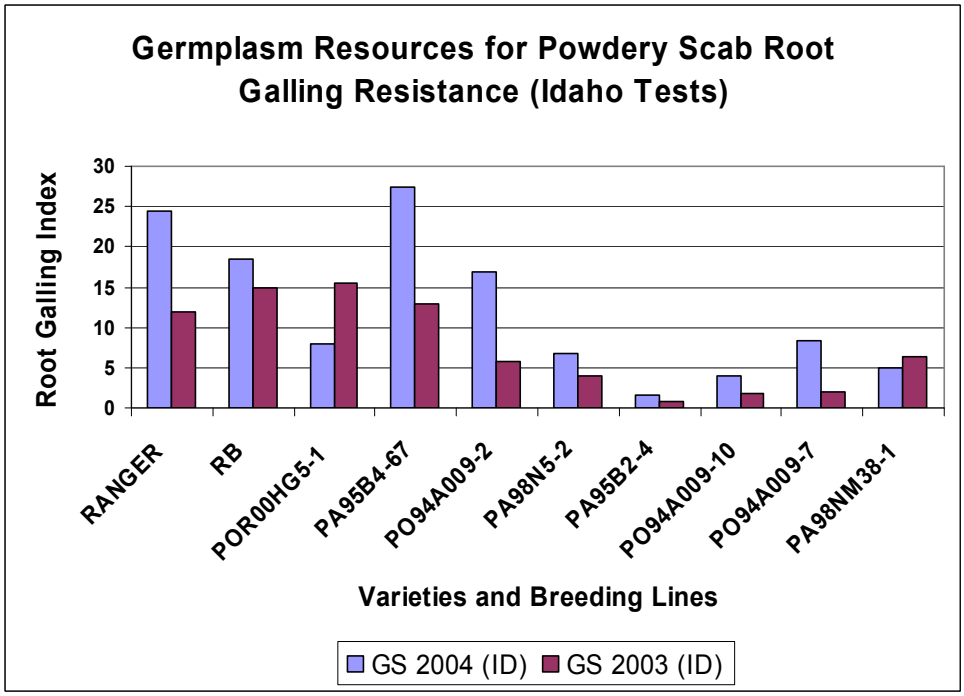


Figure 5. Summary of root galling scores in Washington and Idaho tests. Ranger Russet and Russet Burbank (RB) were consistenly susceptible to root galling while five clones inside the broken line rectangle showed stable resistance.

Conclusions

We have found in five independent field tests, conducted in Washington and Idaho, that some breeding lines show a consistent and repeatable resistance to root galling by the powdery scab organism. The breeding lines that show this resistance have a wild Mexican species and Summit Russet in their ancestry. These clues are leading us to explore descendants of both these parentages in future testing of powdery scab resistance and to use the selected clones already screened as parents in future crosses. The objective is to produce new varieties with substantial and durable resistance to root damage.

References

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