Identifying Potato Germplasm Resistant or Tolremic to Black Dot and Powdery Scab

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Introduction

Black dot is a fungus (*Colletorichum coccodes*) that invades the vascular system of the potato plant and causes death later in the growing season. It is a component of early dying affecting plant growth later in the season. Is it a saprophyte feeding on dead tissue that was killed by other organisms or is it triggered during the foliage senescence process to become an active pathogen and shorten the viability of the foliage, curtailing the yield? Powdery scab (*Spongospora subterranea*) is also a fungus with unusual properties. It spends part of it life cycle in the potato root system and most obviously damages the plant by causing galling on the roots and scabby lesions on the tubers. However, its yield-robbing facility really lies in the dysfunction of the roots that it causes. This is difficult to assess visually, but the size and the functionality of the root system are sharply reduced in susceptible varieties. These two pathogens have several facts in common: 1) they are easily transmitted and spread as viable infections of seed tubers, 2) they are maintained for years in the soil ready to become active the next time potato is planted in the field, 3) they are relatively new to many areas, but have become widespread and predominant in cropping zones, and 4) they frequently occur together in the field.

During 2009 we planted a large number of varieties and breeding lines in three separate trials in a grower's field with a history of both organisms. We made two harvests of the trials, the first while the foliage was still green to evaluate powdery scab and black dot damage on the on the roots and presence of the black dot fungus in the stems, and the second harvest was to obtain measurements of yield components. Previous years' studies had made one thing obvious - identifying specific traits that predicted resistance that were consistent year after year did not occur. The expression of both diseases varied greatly with year. Even our "reliable" susceptible trial entries did not behave that way year after year.

The traits that we measured are presented in Table 1

Table 1. Traits measured in the three trials.

• Total Yield	• Over 14 oz.
• Marketable yield	• Root fresh weight
• Cull weight	• Root dry weight
• Under 4 0z.	• Percent root dry matter
• 4 to 6 oz.	• Powdery scab rating fresh root
• 6 to 9 oz	• Black dot rating fresh root
• 8 to 10 oz.	• Cultured black dot
• 10 to 12 oz.	• Sclerotia expansion dry stem
• 12 to 14 oz.	

The nature of the three trials is depicted in Figure 1. The PV Trial consisted of varieties offered for commercialization by the Plant Variety Management Institute. The GN trial consisted of clones in the Tri-State and Western Regional trials. The RR set consisted of clones with a history of demonstrated resistance. The PV, GN, and RR sets were most available for rapid commercialization in the order PV>GN>RR (Figure 1). Sclerotia appear as discrete black bodies often on the epidermis of the stem about the size of pencil tip (Figure 2). As stems dry out slerotia appear in sequence up the stem in relation to the prevalence of fungus in the stem. We measure from the ground level to the furthest appearance of sclerotia on the stem (Figure 3)

Results

One of the more consistent linkages we found was the relationship between yield of tubers over 14 ounces and the expansion of black dot sclerotia up the stem of green harvested stems that were allowed to air dry.

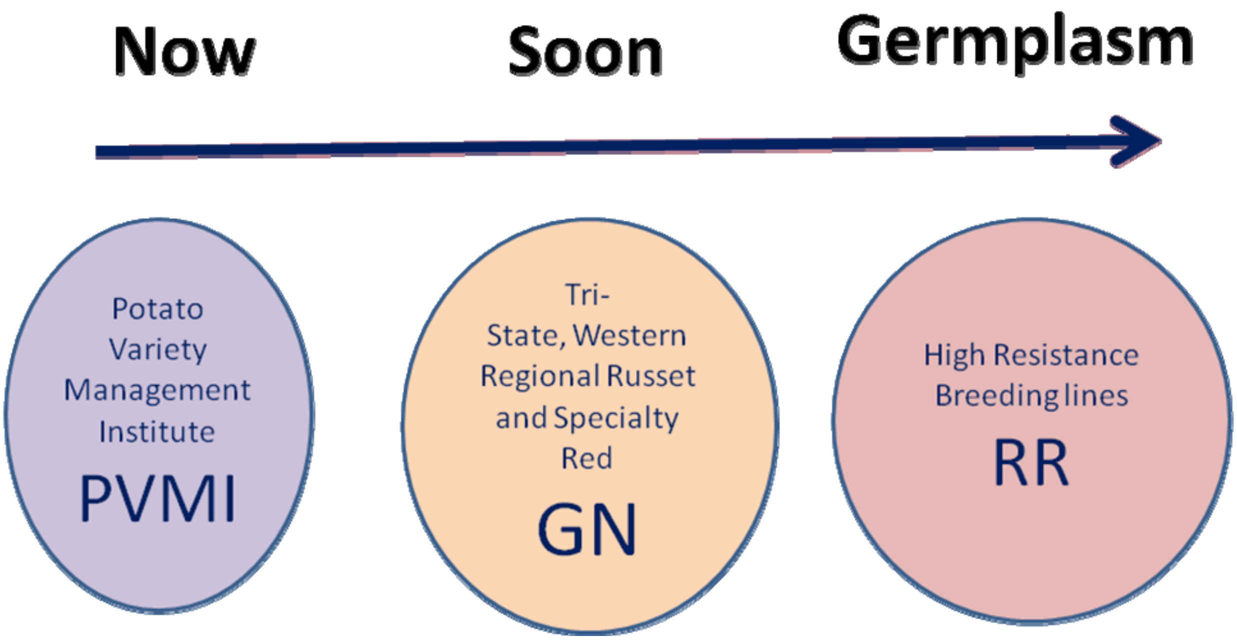


Figure 1. Germplasm under evaluation in field trials in 2009

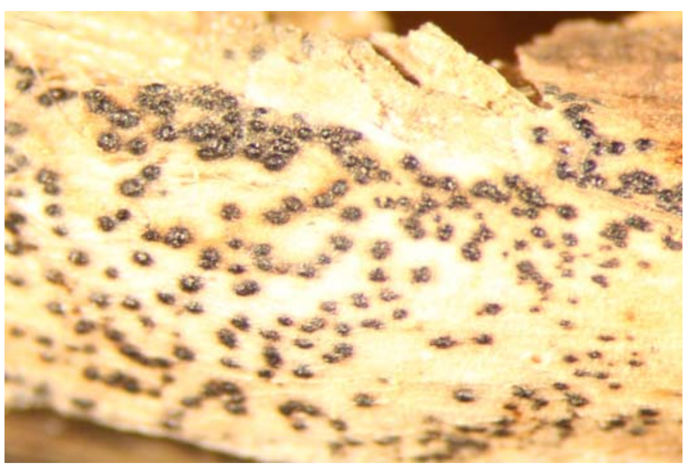


Figure 2. Sclerotia expansion up drying stems in the GN trials

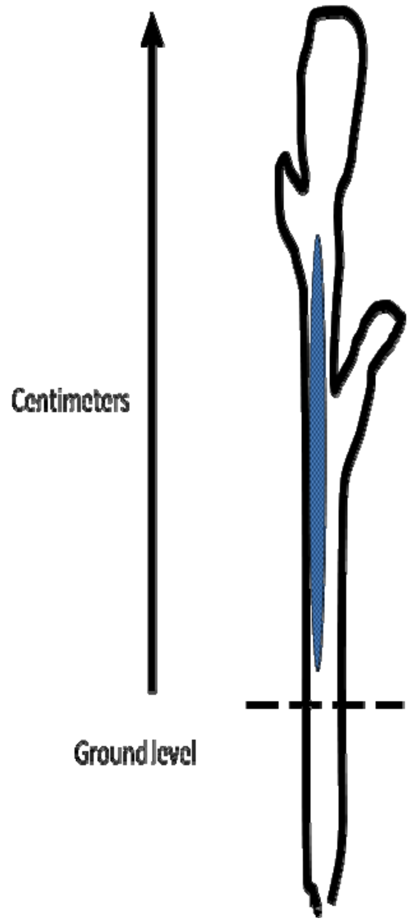


Figure 3. Method of measuring black dot sclerotia expansion on dried stems.

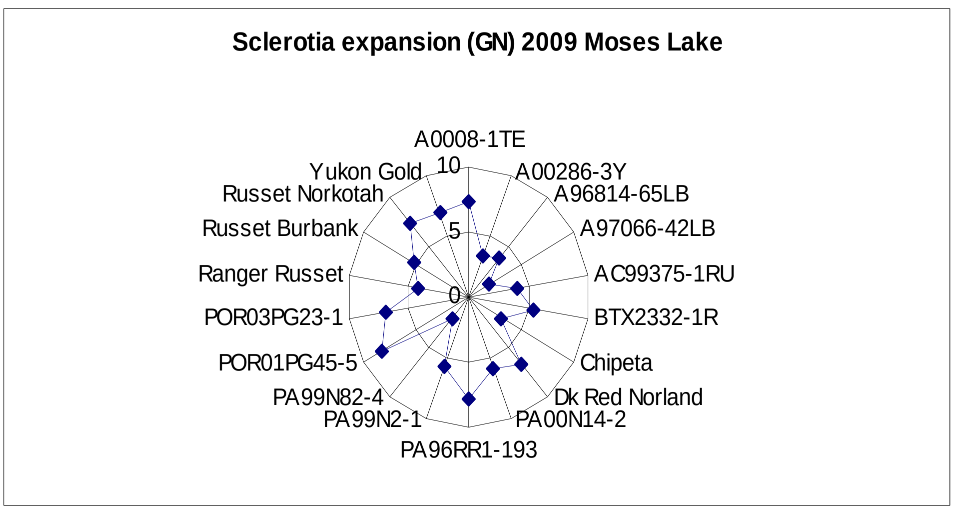


Figure 4. Sclerotia expansion in GN trial.

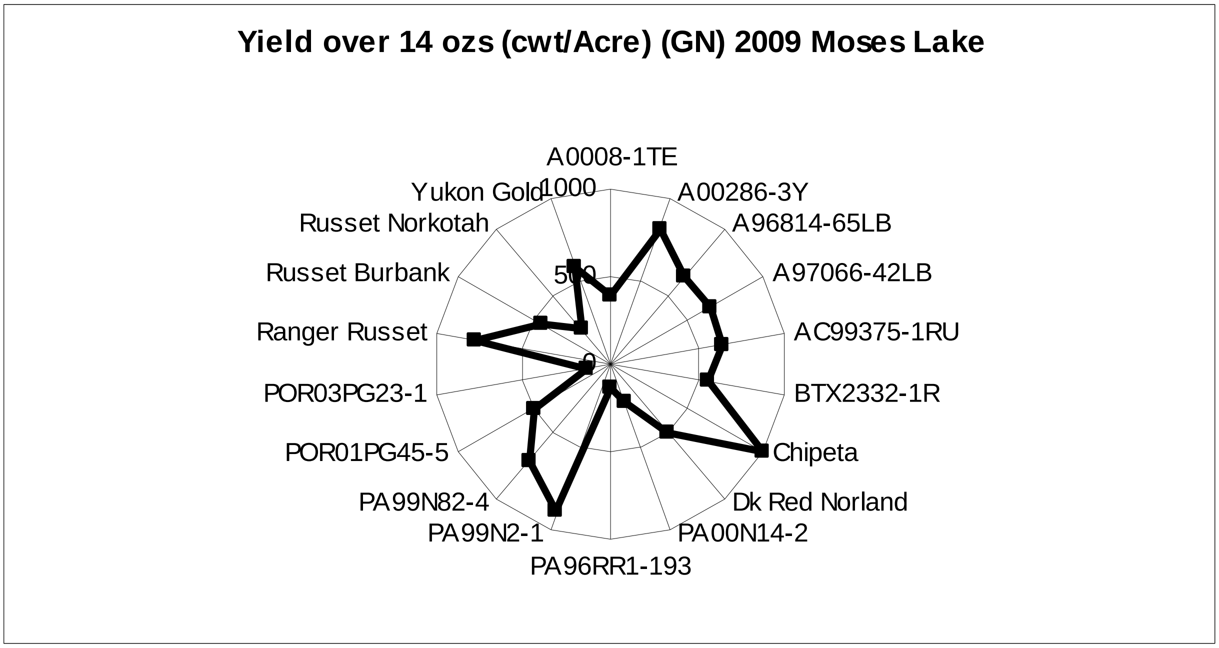


Figure 5. Yield over 14 ounces in GN trial.

The sclerotia expansion indicated strong differences between genotypes (Figure 4). The yield over 14 ounces, indicating the ability of the genotype to produce large size tubers in the face of the pathogen challenge, is almost a mirror image of sclerotia expansion (Figure 5). This relationship is also described by the regression of yield over 14 ounces against sclerotia expansion. A significant negative correlation was found (Figure 6).

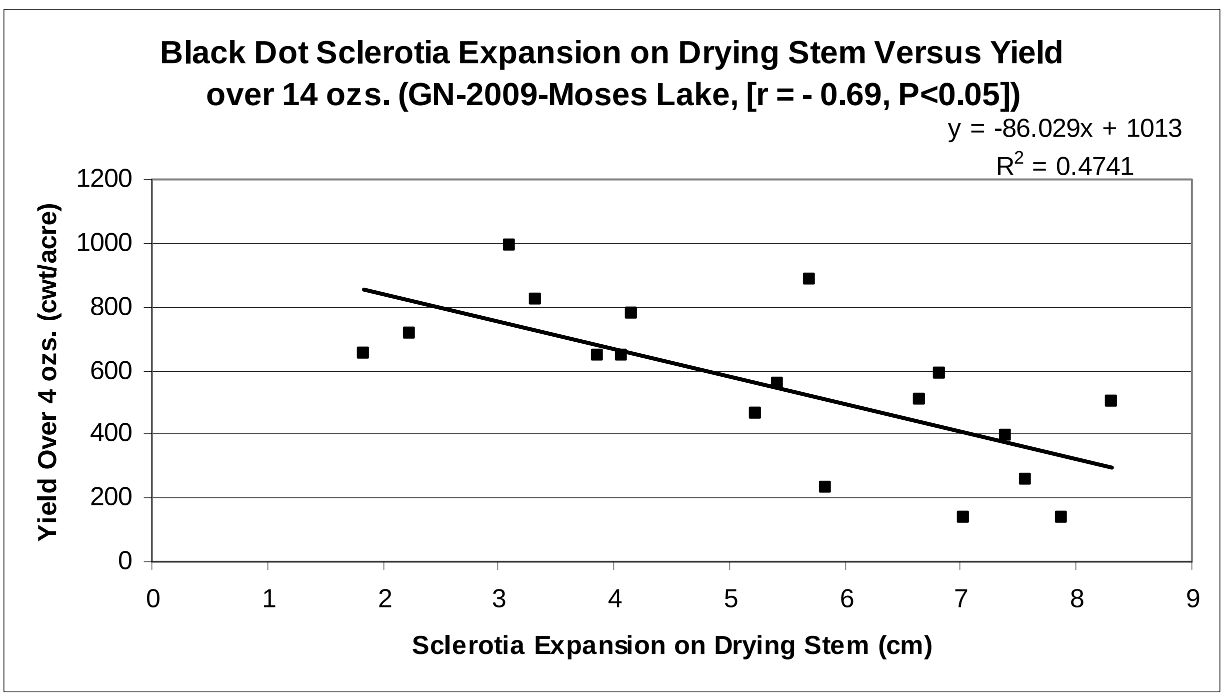


Figure 6. Negative correlation between sclerotia expansion and yield over 14 oz (r = -0.65, P, 0.05).

The most powerful message that emerges from this relationship is that it is possible to predict ability of clones to resist damage from black dot and powdery scab with direct measures of progress of black dot appearance on the stem. However, this is an indirect method. The most direct method is to measure yield directly under severe challenge by the pathogens.

BiPlot Analysis:

Plant breeders are often forced to consider numerous traits simultaneously and to make simple decisions based on complex performance. Biplot analysis is a technique which adds to the decision making power. This is a type of multivariate analysis that identifies which traits are explaining the majority of variation and then presents the breeding clones performance on a two-dimensional display. This method of summarizing results is useful because among other things it identifies a new genotype with unique combinations of characteristics, or, alternatively, identifies new genotypes with performances similar to already established cultivars. We applied this analysis to the GN, PV, and RR trials. The analyses are presented as Figures 7 through 9 on the following pages.

The biplot analyses assist in the identification of clones which perform well on resistance traits or have a high yield of large size tubers, or both. It is apparent that a few clones have high yield profiles while not having resistance to black dot as determined by the disease severity index or by sclerotia expansion.

These clones are tolremic, i.e. they are able to perform well despite the fact that they are diseased. Examples of these are A00286-3Y and Premier Russet. Clones which are apparently resistant to invasion by black dot are Sage Russet, Yukon Gem, and Alturas. It is noteworthy that this is the first determination that Sage Russet may be a promising new candidate for the processing industry with considerable resistance to both black dot and powdery scab. This is based on only the first year of data. Subsequent tests will provide data with greater credibility.

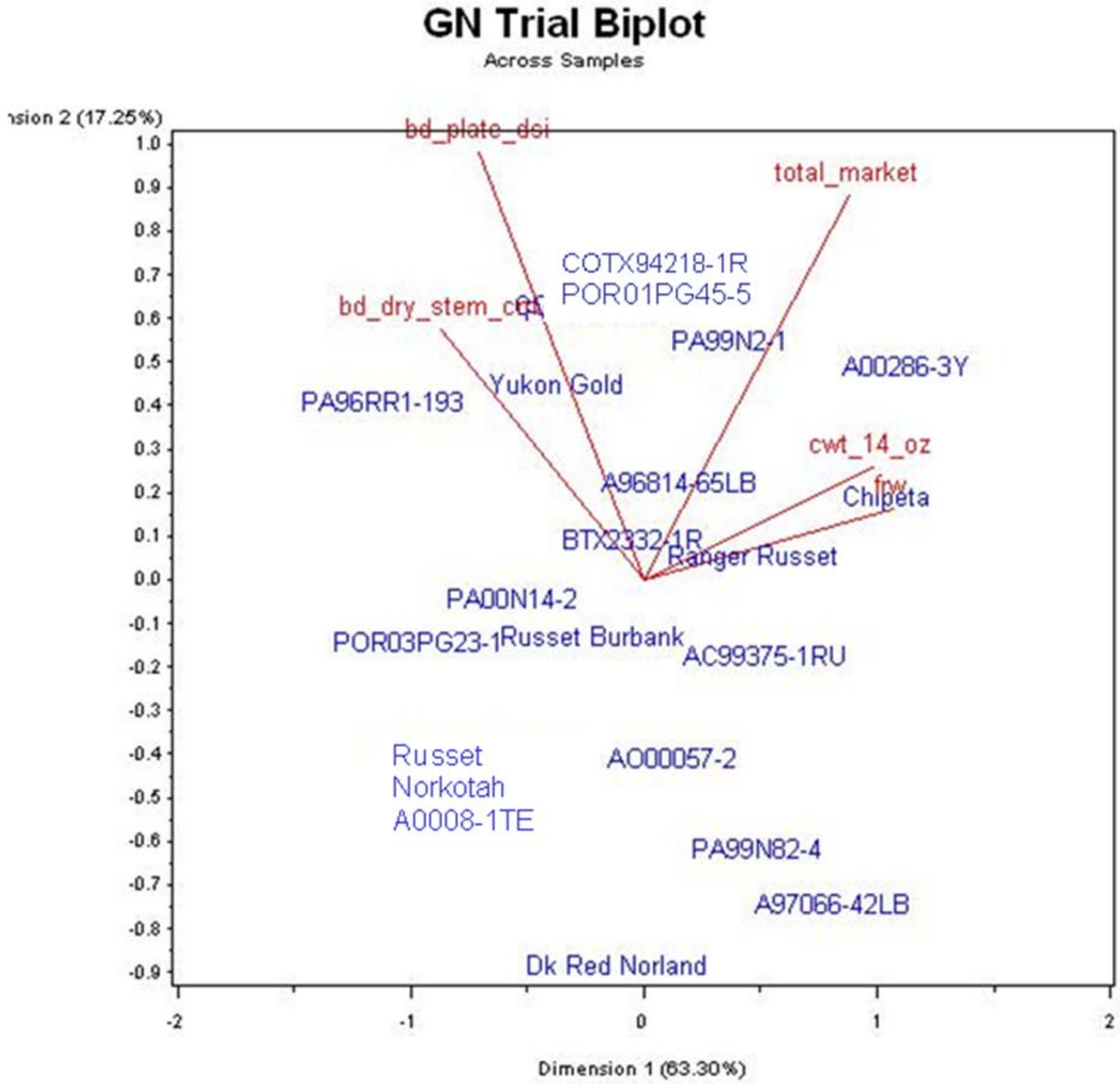


Figure 7. The Biplot analysis of the GN trial. The five lines represent the directionality of five traits: bd_dry_stem = sclerotia expansion up dried stems, bd_plate_dsi = detection of black dot fungus at increasing heights in the stem by plating out on medium, total_market = total yield excluding culls, cwt_14_oz = yield of non-cull tubers over 14 ozs, and frw = fresh weight of roots. Traits whose lines are at acute angles to each other are correlated, at right angles are independent and at obtuse angles are negatively correlated. The traits were picked out by the program as those which explain most of the variation in the data.

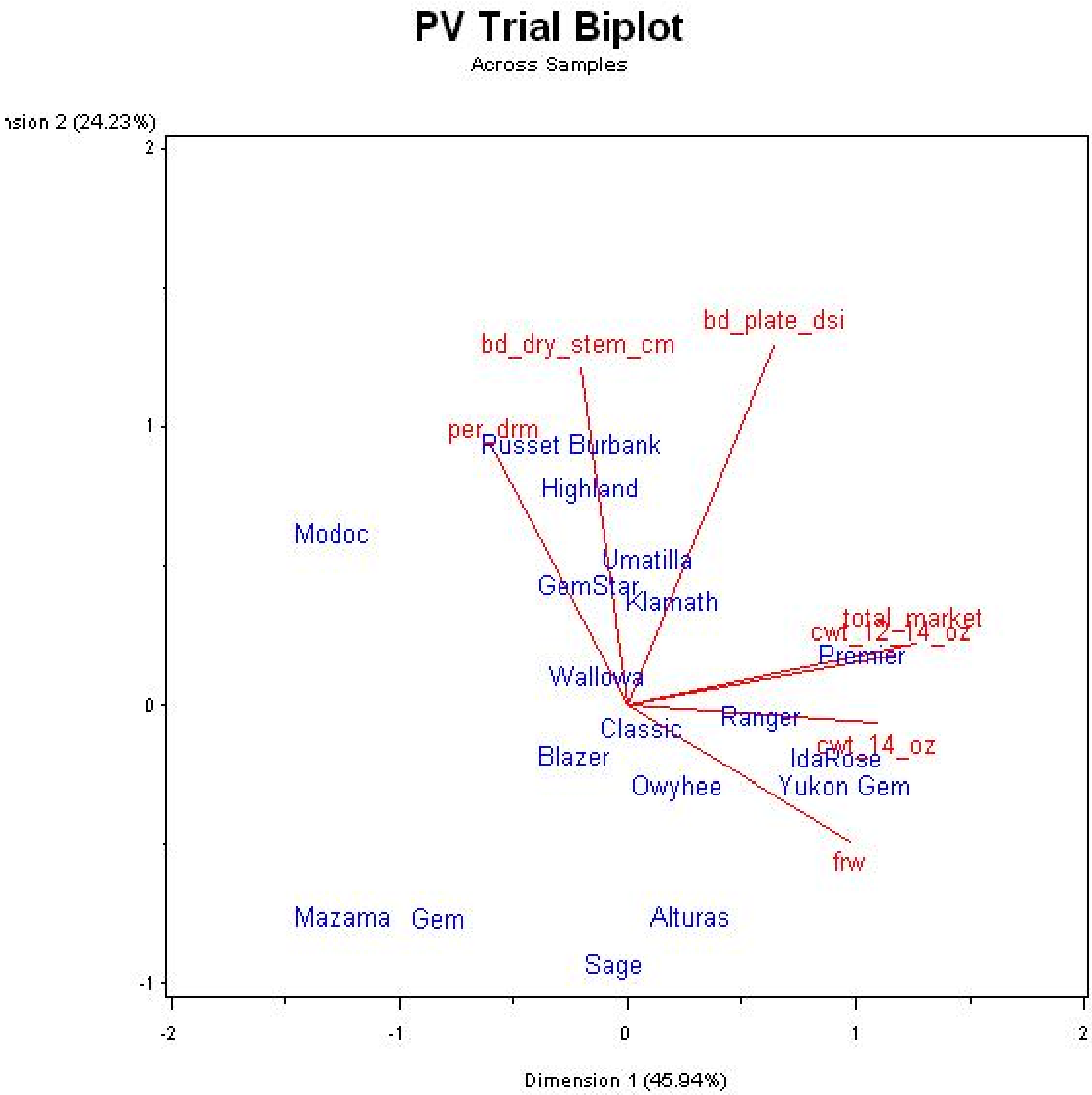


Figure 8. The Biplot analysis of the PV trial. The seven lines represent the directionality of seven traits: per_drm = percent root dry matter, bd_dry_stem = sclerotia expansion up dried stems, bd_plate_dsi = detection of black dot fungus at increasing heights in the stem by plating out on medium, total_market = total yield excluding culls, cwt_12-14_oz = yield of 12-14 ozs size tubers, cwt_14_oz = yield of non-cull tubers over 14 ozs, and frw = fresh weight of roots. Traits whose lines are at acute angles to each other are correlated, at right angles are independent and at obtuse angles are negatively correlated. The traits were picked out by the program as those which explain most of the variation in the data.

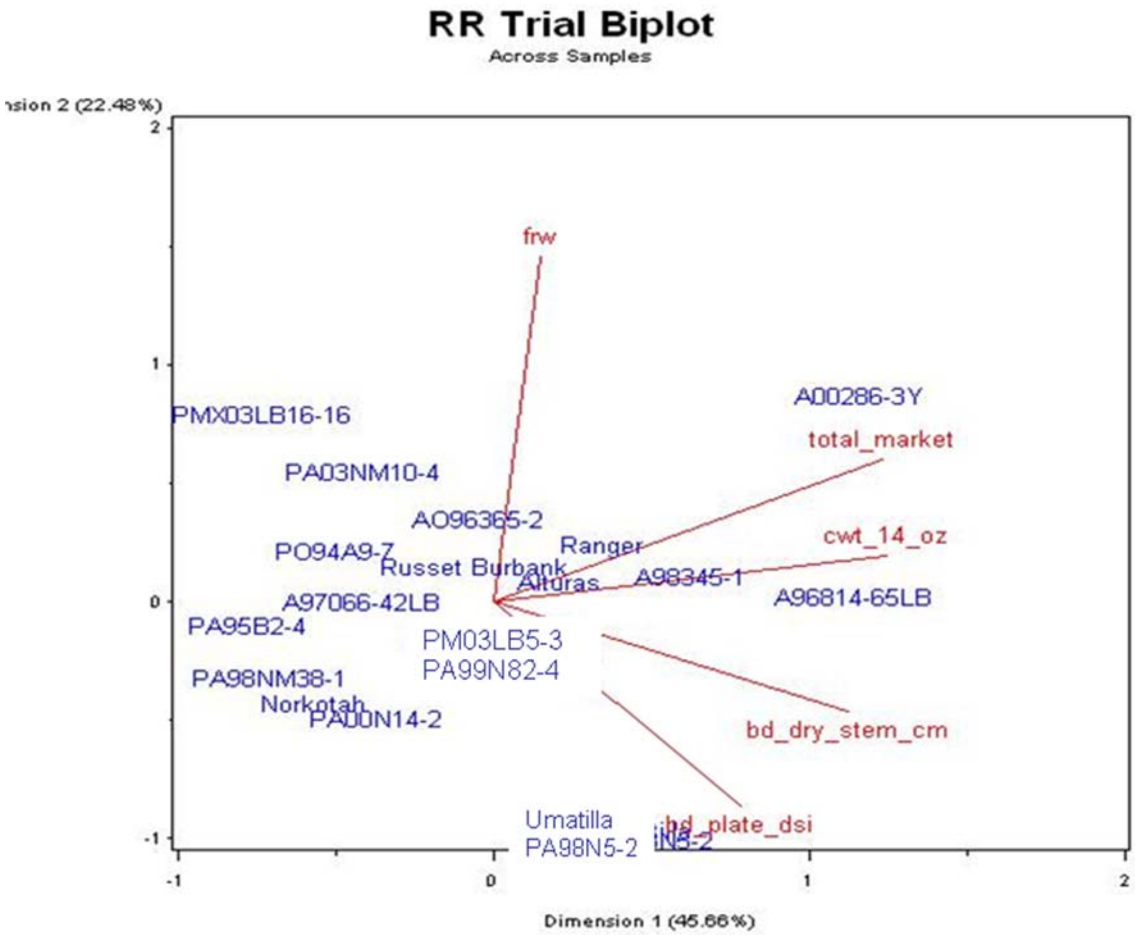
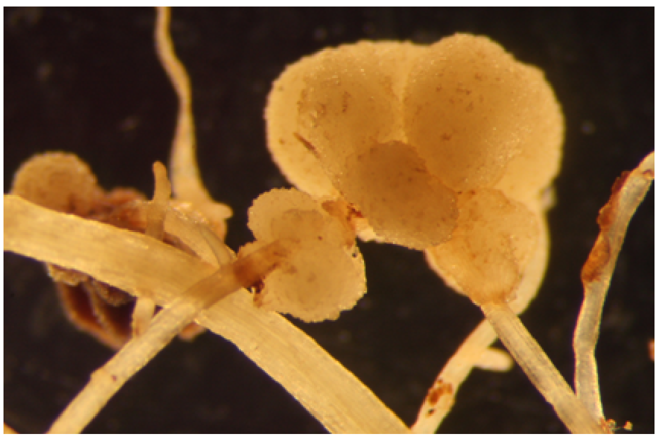


Figure 9. The Biplot analysis of the RR trial. The five lines represent the directionality of five traits: per_drm = percent root dry matter, bd_dry_stem = sclerotia expansion up dried stems, bd_plate_dsi = detection of black dot fungus at increasing heights in the stem by plating out on medium, total_market = total yield excluding culls, cwt_14_oz = yield of non-cull tubers over 14 ozs, and frw = fresh weight of roots. Traits whose lines are at acute angles to each other are correlated, at right angles are independent and at obtuse angles are negatively correlated. The traits were picked out by the Biplot program as those which explain most of the variation in the data.

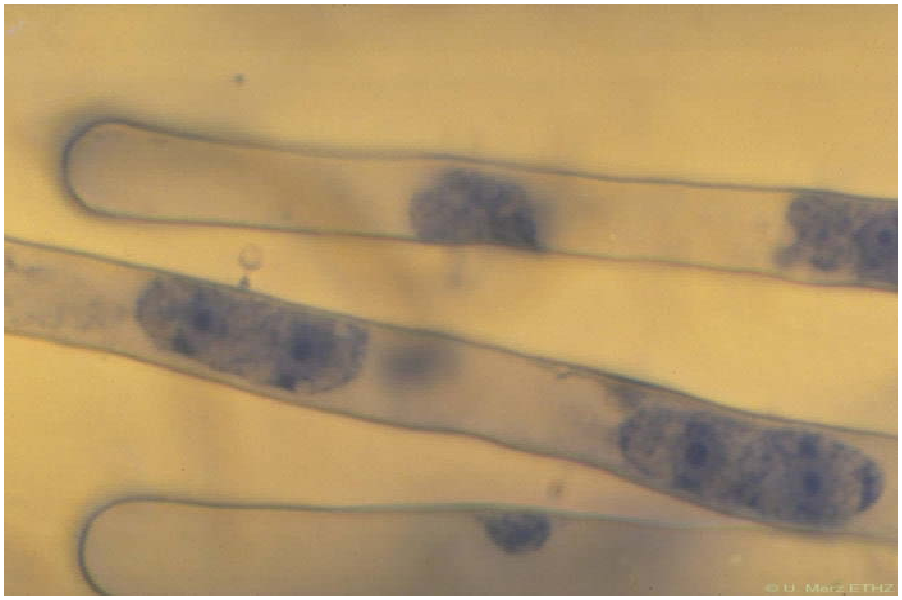
Summary

In the future we will always take detailed yield data on clones that we are evaluating for resistance. All other traits that we measure will be compared to these. Also it has been shown that tolremia is a real phenomenon when it comes to resistance to black dot and powdery scab. Measurements of the amount of disease organism present in the plant will, therefore, mislead us in those cases. Tolremic clones can yield despite being diseased. So far tolremia appears to be accompanied by large root mass. This may be a key to coping with these diseases, i.e., we must find root systems that resist or outgrow the damage caused by the diseases.

Appendices



Appendix 1. Root galls caused by powdery scab organism. Galls remain in the soil after the roots decompose and serve as a source of future inoculums.



Appendix 2. Powdery scab takes the form of plasmodia that inhabit the interior of the roots. This stage of the pathogen may be the most damaging to the roots, per se, although little information is available on the topic .

Appendix 3. Powdery scab lesions on tubers. Worldwide this is the most recognizable form of powdery scab disease. However, russeted skin tubers rarely show this type of lesion in a noticeable way. Powdery scab is therefore primarily a root damaging disease in processing russeted skin varieties destined for processing in the Pacific Northwest. An exception to this is Shepody which suffers from large and deep lesions on the tuber (it is not russeted, either). Powdery scab is often present on seed tubers which provides for ever-present inoculums. Powdery scab infection on seed may be barely noticeable.