BREEDING FOR RESISTANCE TO NEMATODE-CAUSED PROBLEMS OF POTATOES

by
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Introduction:

Nematode-caused problems in the highly productive warm growing area of the Columbia Basin require the investment of $300-400 per acre in the application of chemical fumigants to achieve control. Columbia root-knot nematode (*Meloidogyne chitwoodi*) is a widespread pest that ruins the quality of potato through the penetration of juveniles into the tuber flesh. Dark necrotic spots results that are unacceptable for either the fresh market or processing. The disease corky ringspot results from the transmission of tobacco rattle virus (TRV) by the stubby root nematode (*Paratrichodorus allius*). The chemical fumigants serve to reduce the nematode populations so that damage falls below a threshold that is economically acceptable. Fumigation does not, however, eradicate the nematode from the field. The wide host range for the nematodes and of TRV in rotation crops and weeds ensures that the normal agricultural practices of the Columbia Basin will restore high nematode populations and maintain a TRV reservoir. Increasing the resistance of the potato to these pests is a very worthwhile option. The following paper describes the work that has been going on in this regard.

Discovering Resistance to Columbia Root-knot nematode

One of the first breakthroughs in solving the root-knot problem consisted of discovering resistance in the Mexican wild species *Solanum bulbocastanum* (Brown et al., 1989). This tuber bearing relative of potato is very difficult to cross with the cultivated potato. With the assistance of researchers at the University of Wisconsin somatic hybrids were produced by combining single cells derived from leaf tissue of potato and *S. bulbocastanum* (Austin et al., 1993). We found that resistance was expressed in the resulting somatic hybrids (F_1) and we proceeded to backcross in a repetitive fashion to incorporate the genetic factors controlling resistance (See fig. 1)(Brown et al., 1994, 1995)

During the course of introgressing this genetic source of root-knot resistance were able also develop a species-specific map of the *S. bulbocastanum* genome using a type of molecular marker called the Restriction Fragment Length Polymorphism (RFLP). The RFLP's were derived originally from a map of the tomato genome.

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This helped us to localize genetic control of root knot resistance to chromosome 11 of the wild species, and, in addition, allowed us to find molecular markers that helped us in our screening to identify resistant genotypes (Brown et al., 1996). In figure 2 we see a map of chromosome 11, and the position of the nematode resistance in the upper arm (nema). The introduction of exotic genes into the gene pool of cultivated potato has been done many times. In the past the progress has been slow as the wild donor contributes many undesirable traits along with the desired one. Late maturity, long stolons, small and numerous tubers, bitter glycoalkaloids are traits that usually persist in backcross programs derived from introduction of wild species. We are hoping that new techniques that permit us to analytically determine the proportion of wild genes that remain in our breeding clones will help us to accelerate the breeding process.

Using the molecular markers that were located very close to nematode resistance we were able to find remarkably close coincidence of resistance to the markers in the BC_3 and BC_4 generations (Fig. 3). Screening for nematode resistance in pots or in the field is time consuming and costly. Often, lack of uniform results can delay the selection process for a year until tests can be repeated. The use of markers can allow for a definitive determination of resistance so that resources can be devoted to determining the level of performance in yield, tuber type, frying characteristics and many other traits that will determine if a clone has any promise as a commercially acceptable entity.

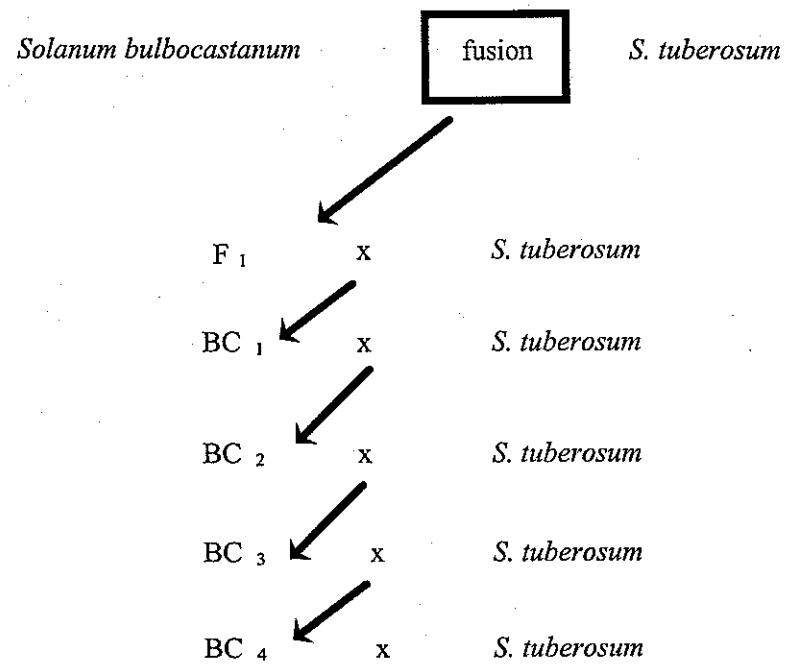

Figure 1. Backcrossing the wild species source of resistance to Columbia root knot nematode into the cultivated potato gene pool.

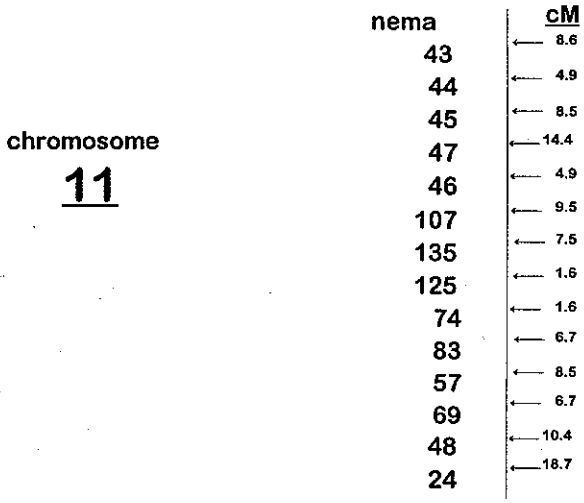

Figure 2. Genetic markers assigned to chromosome 11 of *Solanum bulbocastanum*. Resistance to Columbia root-knot nematode (nema) was localized at the upper end of the chromosome.

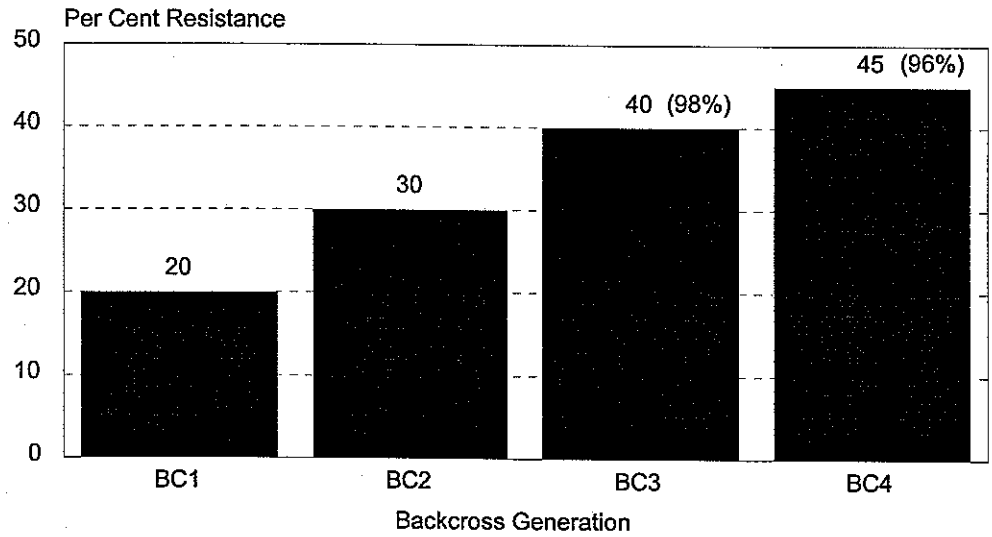

Figure 3. Percent resistance in different backcross generations and coincidence (in parenthesis) of molecular markers with resistance. Use of molecular markers can save time and money over actual screening of individual potato plants.

We have found that the advanced materials continue to behave as expected. Each one of the advanced backcross clones that were tested in the field has shown significantly reduced infestation by M. chitwoodi. This is graphically displayed in figure 4. Clones are listed in order of ascending damage. A group of thirteen are listed and indicated by arrows. The performance of "Russet Burbank" in this trial is indicated by an additional arrow.

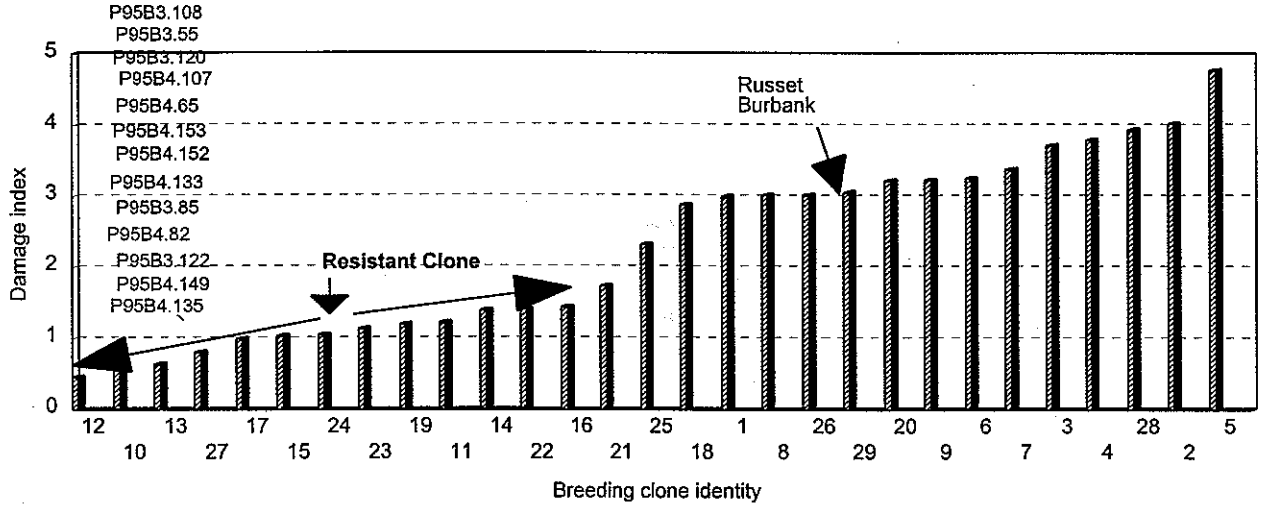

Figure 4. Performance of BC_4 clones classified as resistant compared to the rest of the tested clones including Russet Burbank. These clones harbor a portion of chromosome 11 from *Solanum bulbocastanum.*

Resistance to Corky Ringspot

Sources of resistance to corky ringspot were identified first among selected clones present in the USDA/ARS breeding program at Aberdeen, ID. After a number of seasons of screening in the Columbia Basin three important conclusions emerged. First, resistance per se is to the virus and not to the nematode. All potato genotypes tested in pots are good hosts for stubby root nematode. Second, there is apparently a virus strain difference between sites in Oregon and Washington. Third, we could identify certain parental materials that had resistance to both strains of TRV.

In our first screenings of new seedling progeny we found that about 8 percent of the progeny showed zero incidence of corky ringspot, while as much as twenty five percent of all the progeny showed 5 percent or less incidence per genotype among scored tubers. Figure 5 shows the results within a particular progeny arising from the cross of a resistant parent with a susceptible one. This particular cross displayed a frequency of resistance well above the mean mentioned above. Fully 11 percent of the progeny had no corky ringspot while 5 percent or less incidence of symptoms in the tubers was exhibited by 38 percent of the seedlings.

Clones that have performed very well in field exposures to tobacco rattle virus were tested for fry color and the results are shown in figure 6. A large number of new seedlings have fry colors that are lighter than the standard varieties that now supply the huge processing industry of the Pacific Northwest with its raw product. This shows that resistance to corky ringspot, yield, tuber shape, size, and processing quality are being combined and this set of traits provides very promising clones for the future. Seed of these clones is under multiplication in Aberdeen, Idaho, for eventual submission to the Tri-State Yield Trials.

Crosses have already been made to combine resistance to Columbia root-knot nematode and corky ringspot. A number of clones are being evaluated for both pests at this time. Additional seedlings were selected in the first year of field evaluation last year. New crosses have been grown as tuber families and are available for planting and selection at harvest this year (1999).

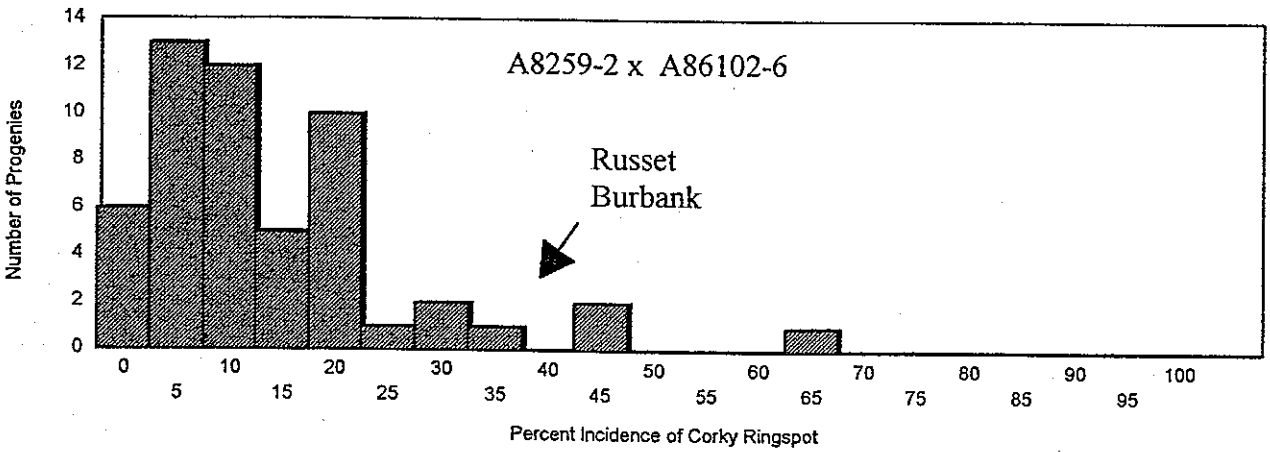

Figure 5. Performance of progeny from the cross of the corky ringspot resistant parent A8259-2 with the susceptible A86102-6. The resistant clone 273-43 was selected from this cross.

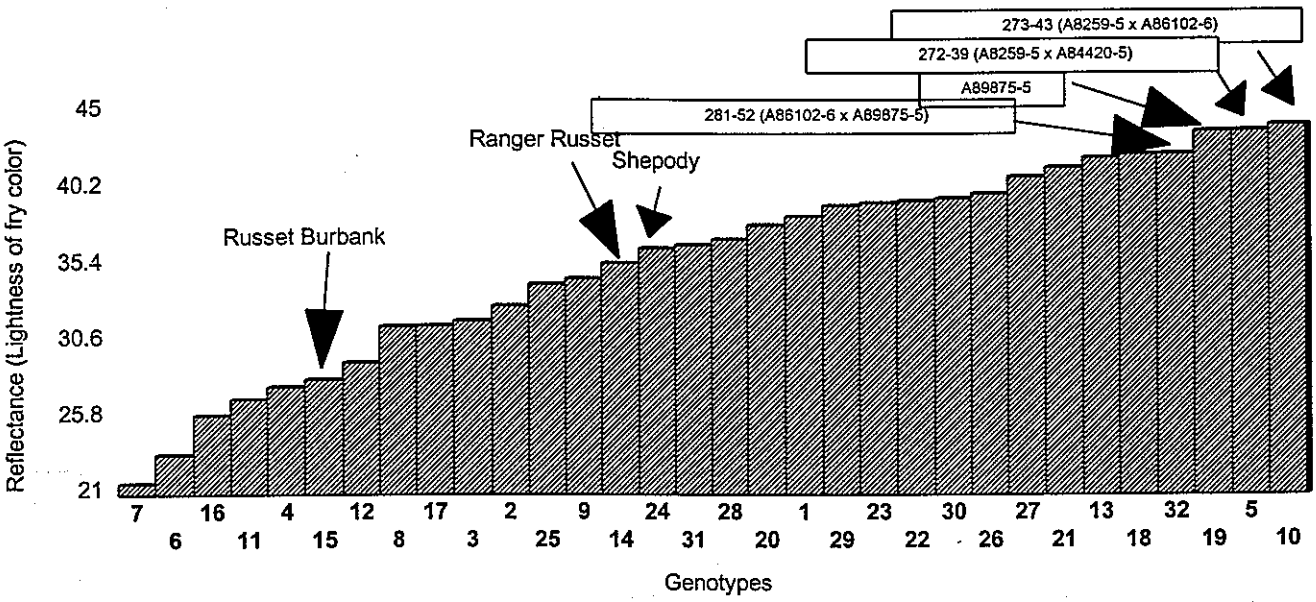

Figure 6. Fry tests of advanced corky ringspot resistant clones. A large group of corky ringspot resistant clones fried lighter (higher reflectance) than all the standard varieties that are the mainstays of the processing industry.

Concluding Remarks

Nematode caused problems of potato in the Columbia Basin are essentially soil borne problems that are addressed with treatments to the soil. At present, soil fumigation is an effective and economically feasible remedy. It is not clear however how much longer we will have some of our fumigants. Fortunately, there are alternatives to chemical fumigation. Certain crop species are nematicidal when their green foliage is disked into the soil and allowed to decompose (green manure). In addition, soil amendments, composed of residues of plant products, have been found with excellent nematicidal properties. These non-chemical reduce nematode populations, but will not work unless there is some host resistance present as well. In particular, *M. chitwoodi* is able to build back up from very low levels during the long warm growing season of the Columbia Basin. Consequently, it is clear that the development of host resistance is essential to positioning non-chemical options in the realm of feasibility. Nematode damage increases with the time that the crop is under cultivation. It damages most, therefore, the late maturity potato varieties. In addition, the severity of the damage increases with storage also. The target of our breeding program must be, therefore, to provide a replacement for Russet Burbank, a late maturing variety which is stored for up to ten months, and which supplies the processing plants during the full length of their annual operation. We now have all the tools we need at hand to accomplish this goal with a team effort.

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