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Breeding for Durable Resistance to Late Blight: The Missing Mexican Link

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For the last century and a half, late blight of potato has been the most important potato disease worldwide. In the Northwest it has become a major problem only in the last 6 years. Late blight rose to prominence in 1845 when it appeared and caused the Irish Potato Famine. This first epidemic is thought to have occurred due to migration of the late blight pathogen from the Toluca Valley of Mexico to Ireland and Europe. Recent studies have shown that the late blight that afflicted potatoes all over the world for the next 140 years changed very little. However, starting in the late 1980s, new strains of late blight emigrated from Mexico and the pathogen diversity picture changed abruptly. Several characteristics changed suddenly.

First of all, late blight populations appeared that were insensitive to metalaxyl, the fungicide that had controlled the pathogen effectively and economically for several decades. Metalaxyl insensitivity today is common throughout the world. Secondly, a new type of late blight known as A2 appeared outside of Mexico. A2 late blight is capable of sexual reproduction, which can lead to greater genetic diversity of the pathogen. Before the 1980s, a genetically diverse population of the late blight pathogen existed only in Toluca, while the rest of the world had a clonal (i.e. asexually reproducing) population. A2 is now common throughout the world. Although our new forms of late blight can reproduce sexually, and cases of this have been documented, they probably infrequently do so. The last change relates to the characteristics of the late blight epidemic. Many of the new genotypes of late blight are more aggressive (particularly those that established in the U.S.) and disease thus develops faster. The period between infection and lesion development has shortened. Also, the rate of lesion expansion and the degree of sporulation have increased. In the Northwest, certain isolates have been found to be more heat tolerant. In the hotter growing areas of the Northwest, it was thought that the temperatures during the growing season were too hot to permit late blight to flourish. This barrier no longer exists.

Breeding for late blight resistance started with the use of *Solanum demissum*, a wild potato relative, as a source of resistance (R) genes. R genes were thought to be the solution until the middle of the Twentieth Century when it was found that the late blight organism easily coevolved so-called avirulence genes that break down the plant host's R genes. Since this discovery, the emphasis in breeding programs has been placed on assembling components of a partial resistance. This type of resistance goes by many names, "rate-reducing resistance," "durable resistance," or "horizontal resistance," all of which refer to the fact that the plant develops disease, but very little of it, and that the disease progresses very slowly. This type of resistance appears to be controlled by many genes and is difficult to breed in combination with the many other characters that need to be in a new variety.

Determining if partial resistance is going to endure is best done by performing many field trials in diverse environments. That's where screening in Mexico becomes important. The International Late Blight Research Program (PICTIPAPA) was instituted in Mexico in the early nineties. Since 1995, researchers in the U.S. have been sending advanced clones and early generation breeding materials. USDA/ARS researchers at Prosser, WA, Aberdeen, ID and Madison, WI have sent individual clones derived from breeding populations. Exact duplicates have been retained in the U.S. in order to relate field results in Mexico to breeding clones back home. In particular, this kind of work has helped to determine the chromosomal location of a new resistance gene from a wild species source of resistance, to identify new wild species sources of resistance, and to select clones as parents in the Tri-State Variety Development Program (See *Potato Progress*, Vol. I, No. 10). Resistance in Toluca is a very good indicator of partial resistance that will endure. The most difficult task is to select new breeding materials that are resistant to late blight but are not also very late in maturity. Researchers have used the field resistance data from Toluca to identify moderate late blight resistance combined with a little earlier maturity. In this manner breeders are moving incrementally toward increased resistance and good varietal performance in yield, maturity, tuber size, and fry quality.

The breeding clone A90586-11 (A90) is promising in having substantial late bight resistance. PICTIPAPA has been screening this clone along with a resistant half-sib from the breeding program, AWN86514-2 (AWN). The clones AWN and A90 have been tested for several years by PICTIPAPA. In Figure 1 the development of foliage damage over time is compared to a local susceptible check, Alpha. It is apparent in Toluca that AWN is more resistant than A90. A90 becomes just as damaged as Alpha, but the disease is slower to develop, giving time for the tubers to bulk. Also, less fungicide is needed to protect A90. PICTIPAPA has shown that the resistance in A90 and AWN has not decreased during several years of screening. They appear to have truly durable resistance. In Figure 2 we see comparisons of several Mexican varieties with Alpha. Their resistance is truly astounding and many of these clones have been tested in more than twenty trials over many years. However, none of these is highly successful in Mexico commercially and if brought to the PNW would be unacceptably late in maturity.

The USDA/ARS has provided special funding to continue screening U.S. potato breeding materials under the auspices of PICTIPAPA, to be administered by Chuck Brown in Prosser. As it is likely that future genetic changes in late blight in the U.S. will originate in the Toluca Valley, our breeders will have a chance to breed for the future, preemptively, by screening parental materials in Mexico. Individuals and organizations in the U.S. interested in using PICTIPAPA to test late blight resistance should contact Dr. Héctor Lozoya-Saldaña (picti@prodigy.net.mx) to discuss arrangements.

See Figures on Page 3

Field Day Dates

As the summer season gets underway, it's time to mark your calendars for the upcoming potato field days planned by local scientists and extension staff.

Othello - Seed Lot Field Day, WSU Research Unit, June 28, 8:30 AM
Patterson - Potato Cropping Systems Field Day, July 8, 10:00 AM
Mt. Vernon - Mt. Vernon Field Day, WSU Research Unit, August 20, 4:00 PM

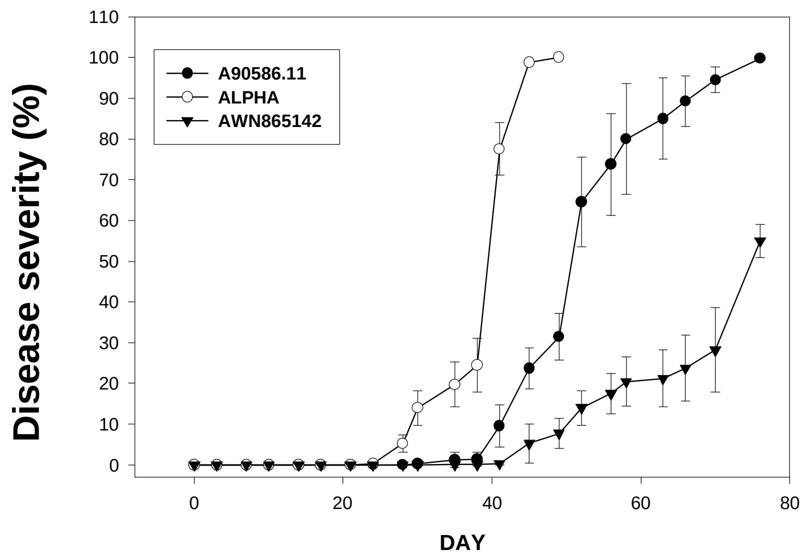

Figure 1. Comparison of A90586-11, AWN86514-2 and the susceptible check, Alpha, in the Toluca Valley in 2000. Disease severity refers to the percentage of the foliage damaged. Data provided by N. Grünwald

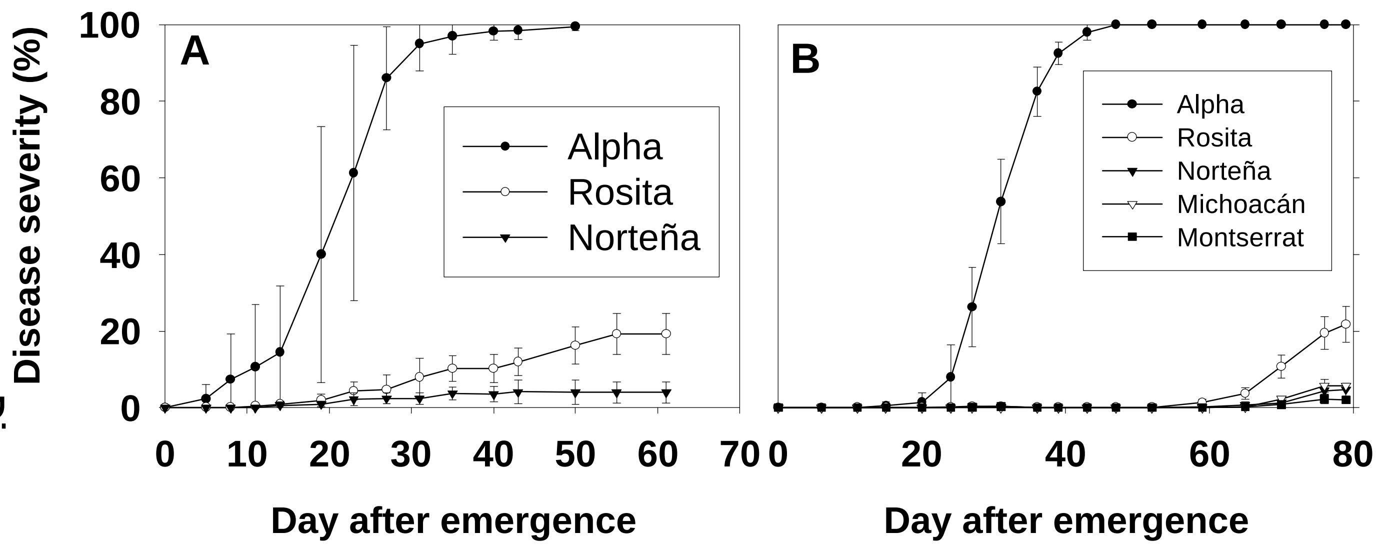

Figure 2. Comparison of Mexican varieties to the susceptible variety Alpha for late blight resistance in the Toluca Valley in 1998 (A) and 1999 (B). Plots were not sprayed with fungicide. Mexican varieties display very high durable resistance, but cannot be used in the United States as cultivars because they are very late maturing and low yielding. Data provided by N. Grünwald.

Mustard Green Manures; On-Farm Research Results, 1999-2001

Andy McGuire, WSU Cooperative Extension, Grant-Adams Area

Dale Gies, a Moses Lake potato producer, has been successfully growing Russet Norkotah potatoes in a two-year rotation with spring wheat for the last six years. Between the wheat and potato crops, he uses a white mustard (*Brassica hirta*) green manure crop. Gies has been cooperating with WSU Cooperative Extension in conducting on-farm research into this unique cropping system. Below are the main results.

Potato yields Over the past two years, in three replicated trials, potato yields in this rotation have averaged 32.5 tons per acre total, and 27.9 tons per acre of #1s (>4 oz.). In the 2001 season, the total yield of 32.9 tons per acre was estimated to contain over 220 lbs of nitrogen. However, it was produced with just 160 lbs of applied nitrogen. This leads us to believe that a significant portion of the nitrogen in the incorporated mustard green manure is being recycled and becoming available to the following potato crop and possibly even the following wheat.

In these same trials, spring applications of metham sodium to fields receiving the mustard green manure did not result in any significant yield or quality benefits. If this metham sodium application is discontinued in this rotation, an estimated net savings of $150 per acre could be realized with no significant effects on potato yield or quality.

Soil quality Water infiltration rates in the fields under this cropping system are two to four times those of neighboring fields with the same soil type, but under conventional management. The soil organic matter levels in fields receiving mustard green manures average 50% higher than in neighboring fields.

Mustard management Mustard for a fall green manure should be planted in August in the upper Columbia Basin. Drilling the seed through standing wheat residues has resulted in the best stands although broadcast seeding after incorporation of crop residues or aerial seeding before wheat harvest have also given satisfactory results.

For mustard planted in August and incorporated in late October, optimum biomass yields can be produced with between 100-120 lbs of total available nitrogen. Incorporating the wheat stubble before planting may tie up soil nitrogen resulting in a higher nitrogen requirement for the mustard crop. In wind erosion prone areas, leaving the wheat straw until incorporation of the green manure can provide added surface residue through the winter and spring. It may also prevent winter leaching of nitrates released from the green manure crop.

We are currently expanding this research to include some longer rotations more common in the production of processing potatoes. For more details on the Gies cropping system, on-farm research results, and mustard green manure management, see the Grant-Adams Extension website at **http://grant-adams.wsu.edu**, or call at 509-754-2011 ext. 413.