PLANT RESISTANCE AS PART OF THE LATE BLIGHT BATTLE

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Breeding potato varieties for late blight resistance began soon after the disastrous epidemics in Europe in the mid nineteenth century. Since that time "The search for and development of resistance to late blight has exercised the minds of pathologists and breeders alike" R. Wastie.

The best way to control late blight is to grow resistant varieties, and throughout most of the world where late blight is endemic, partial resistance plays an important role in managing the disease. However, in North America all major varieties are susceptible to late blight. A few like Atlantic, Kennebec, and Nooksack have what is called race specific resistance. This means that both the vine and tuber are immune to a specific race or combination of races of Phytophthora infestans, the late blight pathogen. Unfortunately, this pathogen is so adaptable that it has eventually been able to overcome race specific resistance. There are at least 11 specific resistance genes, and for each known combination there is a P. infestans race with virulence factors that can overcome them. Many European varieties have specific resistance gene combinations. Yet they still cannot be grown without fungicides because the complex pathogen populations have produced new virulence races. For this reason, the goal of breeding programs is to produce varieties with what is called general resistance. General resistance is controlled by many genes and is not overcome by new races of the pathogen, but because it is multigenic, it is much more difficult to breed for this kind of resistance. No varieties yet developed have complete general resistance. All are attacked to some degree by the pathogen. However, even moderate general resistance can still be quite useful. A degree of general resistance along with immunity to some of the races in a late blight population means that fungicide timing, and rates are less critical and potential yield losses are lower, particularly when blight pressure is not extreme. Some examples of varieties with good field resistance in foliage and tubers are Brodick (UK), Cara (Ireland), and Bzura (Poland).

The two dominant populations of late blight in the northwest are US-8 (an A2 mating type) in the Columbia Basin and Idaho, and US-11 (an A1 mating type) in northwest Washington. Both of these populations are highly aggressive and appear to be made up of races with a complex virulence spectrum that can easily overcome specific resistance.

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They also are insensitive to metalaxyl, the most potent late blight fungicide available until the pathogen developed resistance to it.

Even with these complex, metalaxyl insensitive, and highly aggressive populations of P. infestans, differences in susceptibility of varieties can be very important in managing the disease. Russet Norkotah is the most susceptible of the potato varieties that predominate in the northwest followed by Shepody, which is also quite susceptible, then Russet Burbank and Ranger Russet, which are noticeably less susceptible than the early maturing varieties. There is no margin for error in fungicide timing and coverage with Russet Norkotah. There may be a greater margin with Russet Burbank and Ranger, especially when the climate does not favor blight spread. Tuber susceptibility often follows vine susceptibility, possibly because of the amount of inoculum produced on the vines. However, this is not always true and there does not appear to be a direct association between general resistance in the tuber and in the vine. Many other factors contribute to the amount of tuber infection, and vine management and harvest conditions usually have more impact on tuber infection than small differences in susceptibility. What is needed, ideally, is a variety that has high general resistance in both the vine and tuber. However, partial general resistance, combined with immunity to some of the races in the population, can give the grower a big advantage in fighting late blight.

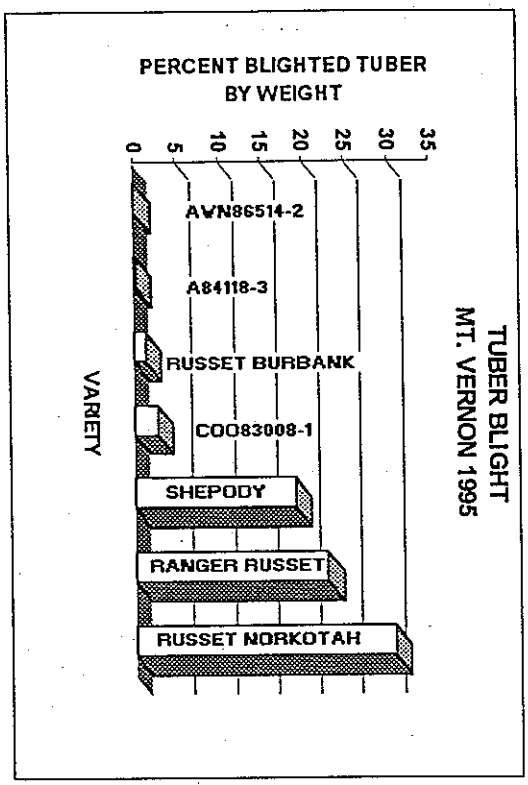
Breeders have found both general resistance and race specific resistance in a number of wild species, particularly those that have evolved along with late blight in Mexico. Species such as Solanum demissium and S. stoloniferum have been widely used in breeding programs to develop late blight resistance. During the last 20 years these efforts slackened. The results of breeding for race specific resistance were discouraging, and general resistance was hard to identify and very difficult to evaluate. Although efforts continued in Europe and at the International Potato Center and in Mexico, the advent of the fungicide metalaxyl made late blight resistance less important. But nature doesn't tolerate the status quo and the late blight pathogen in Europe and eventually in the US changed dramatically over the last 10 years. Almost everywhere strains of the fungus appeared that were resistant to metalaxyl. In addition the A2 mating type has spread around the world and the old populations that tended to have a limited virulence spectrum were replaced by new populations with complex virulence patterns. In North America, it has taken about 2 years for the US-8 strain to replace most of the old strains in the major potato growing areas. This has naturally put renewed emphasis on breeding for resistance.

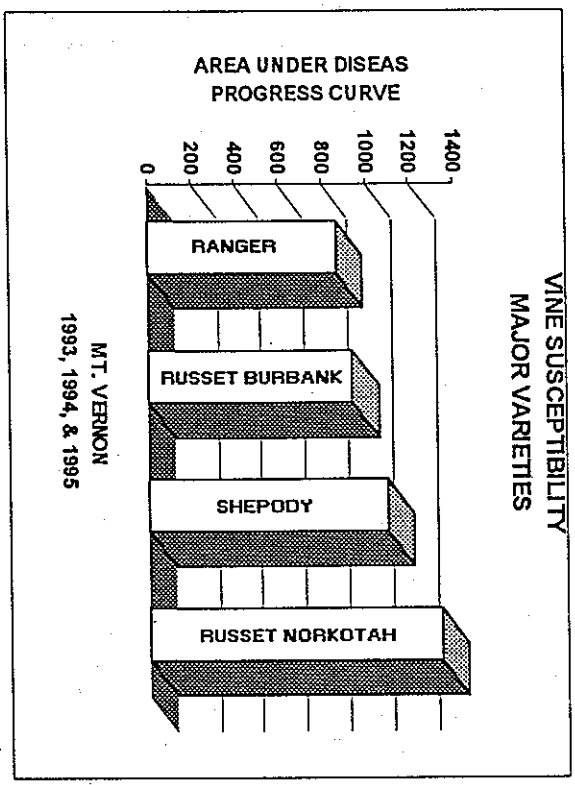
In the past two years the Tri-State breeding program and cooperators in the northwest have tested advanced selections that are close to becoming varieties for late blight resistance. This was done at Mt. Vernon, WA, in 1994 and 1995 by Dr. Inglis, and in 1995 Dr. Powelson tested a large group of breeding parents at Corvallis, including varieties from Europe and Latin America that were reported to have late blight resistance. The 1995 tests at both locations were dramatic in their severity. We are now fairly certain that none of the selections that are close to becoming varieties have high resistance to late blight populations in the northwest. However, two russets, A84118-4 and COO83008-1, have been consistently less susceptible to foliar late blight than Russet Burbank, and both appear to be moderately resistant to tuber blight as well. Both of these are suitable for french fry processing and fresh market.

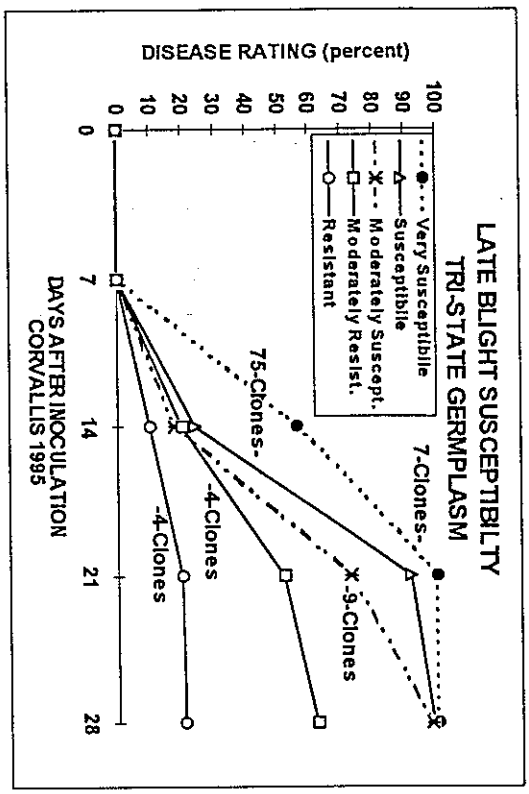
We need to test these along side of Russet Burbank, Ranger, Shepody, and Norkotah to determine if this reduced susceptibility will make any practical difference in an integrated management program.

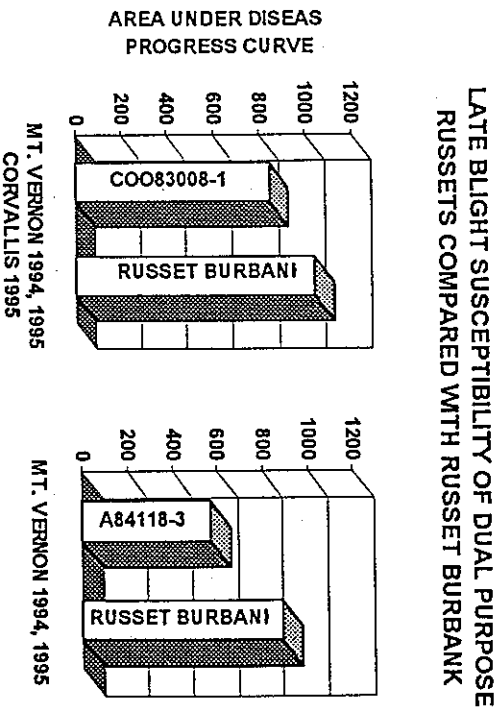
When we consider the potential to develop high general resistance over the long term, the prospects look good. Four breeding selections A90586-11, AWN86514-2, AWN86524-5, and G6582-3 had high resistance at Corvallis. AWN86514-2 was also at Mt. Vernon and looked very good. A90586-11 and AWN86514-2 are hybrids of Ranger Russet with Polish germplasm that represents many decades of developing late blight resistance in Europe. In addition to this material, there are fusion hybrids of cultivated potato with a wild Mexican species, S. bulbocastanum, produced by Dr. Helgeson in Wisconsin, that have shown very good resistance wherever they have been tested including Mt. Vernon, WA, and Toluca, Mexico. Dr. Brown, at Prosser, WA, has produced hybrids with several wild species that also show very high resistance, and both the USDA-ARS Beltsville and Agriculture Canada breeding programs have parent germplasm with good field resistance. It is not a simple matter to move this multigenic resistance into varieties suitable for our markets. Clones with the highest resistance are typically very late maturing and have small tubers. We don't know how well the vine resistance will relate to tuber resistance since general resistance in tubers is even harder to evaluate than in the vines. In spite of these difficulties, it is likely that we can breed varieties that can be grown with minimum fungicide use under moderate to high pressure from aggressive late blight strains. This will take at least 10 years for fresh market type whites and possibly some chippers, but will probably take longer for varieties suitable for fry processing out of storage or for fresh market russets. Gene transformation of existing varieties might also work. This is being tried today in a number of labs. However, this technology is still bound by limitations in conventional field testing on a seasonal basis and the usual problems with seed multiplication. Five to eight years would be a realistic time frame for developing a transgenic variety once a functional gene is identified, and a successful transformation takes place.

For the time being, we will have to adapt our late blight management approach to varieties that are moderately susceptible to highly susceptible. This will require fungicide use and attention to all the details of sanitation, forecasting, timing, application techniques, and so on. Over the long term, if breeding efforts are sustained at the level they are today, there will be varieties with high field resistance for the grower to rely on in the battle with late blight.


PERCENT BLIGHTED TUBER
BY WEIGHT
0
5
10
15
20
25
30
35
AWN86514-2
A84118-3
RUSSET BURBANK
CO083008-1
SHEPODY
RANGER RUSSET
RUSSET NORKOTAH
VARIETY
TUBER BLIGHT
MT. VERNON 1995


AREA UNDER DISEAS
PROGRESS CURVE
0
200
400
600
800
1000
1200
1400
RANGER
RUSSET BURBANK
SHEPODY
RUSSET NORKOTAH
MT. VERNON
1993, 1994, & 1995
VINE SUSCEPTIBILITY
MAJOR VARIETIES


DISEASE RATING (percent)
0
10
20
30
40
50
60
70
80
90
100
Very Susceptible
Susceptible
Moderately Suscept.
Moderately Resist.
Resistant
75-Clones-
7-Clones-
-4-Clones
-9-Clones
-4-Clones
0
7
14
21
28
DAYS AFTER INOCULATION
CORVALLIS 1995
LATE BLIGHT SUSCEPTIBLITY
TRI-STATE GERMPLASM


AREA UNDER DISEAS
PROGRESS CURVE
0
200
400
600
800
1000
1200
CO083008-1
RUSSET BURBANK
MT. VERNON 1994, 1995
CORVALLIS 1995
A84118-3
RUSSET BURBANK
MT. VERNON 1994, 1995
LATE BLIGHT SUSCEPTIBILITY OF DUAL PURPOSE
RUSSETS COMPARED WITH RUSSET BURBANK