The Late Blight Strain Situation in the Pacific Northwest

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INTRODUCTION

Potato late blight, caused by *Phytophthora infestans*, is a serious concern for potato growers in the Columbia Basin of Washington and Oregon. Up until 1990, all isolates or strains of *Phytophthora infestans* found in the Columbia Basin had the A1 mating type and were sensitive to metalaxyl, the active ingredient in Ridomil (Bentley and Johnson, 1992). In the last three years, however, new strains of the pathogen have appeared which are resistant to metalaxyl and have the A2 mating type. These new isolates appear to be replacing the old A1 metalaxyl sensitive isolates (Table 1). This replacement has also been observed in other potato growing regions of the world (Speilman et al., 1991).

This shift from the "old" population of A1 metalaxyl sensitive isolates to the "new" population of A2 metalaxyl resistant isolates raises the question as to whether the new population is more aggressive than the old population. Aggressiveness in this sense can be defined as the degree to which an isolate causes disease on potato foliage or tubers. Another concern arising from the presence of the A2 mating type is the potential for sexual reproduction. Sexual reproduction leads to the formation of oospores that may provide another source of overwintering for the fungus. Additionally, sexual reproduction may lead to greater variability for traits such as aggressiveness in the population.

The purpose of this study was to first, analyze the population *Phytophthora infestans* from the Columbia Basin, and second, to quantify the aggressiveness of selected isolates to see if the new population is more aggressive than the old population.

MATERIALS AND METHODS

Isolates from 1992 through 1995 were characterized for their mating type, metalaxyl sensitivity, and allozyme genotype. The allozyme genotype has been tightly correlated with mating type and metalaxyl sensitivity (Table 2). Allozyme genotyping was developed for the purpose of quickly identifying the mating type and metalaxyl sensitivity of isolates from the field (Goodwin et al., 1995).

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Selected isolates were compared on detached potato leaflets in the laboratory to determine which isolates were more aggressive. Tests were performed in glass petri dishes in incubators to keep the leaflets at 18° C (64.4° F) and 100% relative humidity. A total of 30 different isolates were analyzed. Aggressiveness was measured by the following variables:

1. Rate of lesion growth (area under the lesion expansion curve, or AULEC).
2. The time from inoculation until lesions first appear (incubation period).
3. The time from inoculation until sporulation occurs (latent period).
4. The amount of sporulation (sporulation capacity).
5. Final lesion size.

A highly aggressive isolate would have a high AULEC, low incubation and latent periods, and a high sporulation capacity and lesion size. The most aggressive isolates were then tested on entire plants in the greenhouse with disease progression measured instead of lesion spread.

Since not all isolates to be tested for aggressiveness could be tested together, a standard isolate was chosen. The standard isolate run in every test was A1 metalaxyl sensitive with the US-6 genotype. Scores for each variable in each test were then compared with the standard to obtain standardized scores. The standardized scores were averaged to compare the different populations to each other.

RESULTS AND DISCUSSION

Characterizing the population of *P. infestans* from the Columbia Basin showed that three different phenotypic populations were present. These were A1 metalaxyl sensitive, A1 metalaxyl resistant, and A2 metalaxyl resistant. All A1 metalaxyl sensitive isolates had the US-1 genotype. Three of the A1 metalaxyl resistant isolates were US-11. The rest were either US-6 or unknown genotypes. The A2 metalaxyl resistant isolates had either the US-7 or US-8 genotypes. To this point no A2 metalaxyl sensitive isolates have been found. In 1994, isolates were evenly distributed between the three phenotypic populations (Table 1). In 1995, however, almost all isolates were A2 metalaxyl resistant with the US-8 genotype.

For the aggressiveness tests, the AULEC was the most useful measure of aggressiveness. Isolates rarely showed any significant differences for incubation period and latent period. Great variation existed for both sporulation capacity and lesion size, making it difficult to draw any definite conclusions from these variables. A total of 12 different trials were performed.

Some trials showed no significant differences between the treatments. The overall trends from these tests are reflected in the five tests discussed below.

In Aggressiveness Test 1, the A1 metalaxyl sensitive isolate was the least aggressive for both AULEC and latent period (Fig. 1). The most aggressive isolates were A2 metalaxyl resistant and A1 metalaxyl resistant. The A1 metalaxyl resistant isolate had the US-11 genotype.

Another test was run using two different A2 metalaxyl resistant isolates and four different A1 metalaxyl resistant isolates. In this test, the A2 isolates were more aggressive than all A1 isolates (Fig. 2).

The highly aggressive US-11 isolate from the first test was then tested against a representative isolate from each of the three population classes for Aggressiveness Test 3 (Fig. 3). As in Test 1, it was the most aggressive isolate for the AULEC. Unlike the previous two tests, however, the A2 isolate tested relatively weak for aggressiveness. This may be explained by the fact that this isolate had the US-7 genotype. The US-7 genotype is more of a tomato pathogen rather than a potato pathogen. The highly aggressive A2 isolates from the first two tests had the US-8 genotype. The A1 metalaxyl sensitive isolate in this test was moderately aggressive. Similar to the first two tests, the standard isolate had a relatively low AULEC. The sporulation capacity was also significantly lower than for the standard than for the other isolates (Fig. 4).

Aggressiveness Test 4 was expanded to include eight new isolates. The aggressive US-11 and US-8 isolates were compared with three A1 metalaxyl sensitive isolates, another A2 isolate, another A1 metalaxyl resistant isolate and the standard (Fig. 5). For AULEC, the US-11 and US-8 again tested to be the most aggressive isolates, along with the additional A2 isolate. The genotype for this isolate was an unusual one, and did not match any of the known banding patterns. The metalaxyl sensitive isolates demonstrated moderate aggressiveness, with two of them not differing significantly from the most aggressive isolate. The standard isolate scored low for AULEC and high for latent period, as it had done previously. The additional A1 metalaxyl resistant isolate was the weakest of all isolates tested.

The five most aggressive isolates from this test (which did not differ significantly from each other) were then examined in the greenhouse on entire plants. Disease ratings were taken for the entire plant, not just one leaflet as with the lab tests. Only the area under the disease progress curve (AUDPC) showed any significant differences. In this setting the US-11 and US-8 isolate were the most aggressive, with the US-11 scoring slightly higher for disease progression (Fig. 6). The A2 with the unknown genotype was moderate and the sensitive isolates were weak for aggressiveness.

Grouping the standardized scores for all the isolates tested showed that the A2 isolates were more aggressive than the A1 isolates for the AULEC and latent period (Table 3). For sporulation capacity and lesion size, the A1 metalaxyl sensitive isolates were more aggressive than the A1 metalaxyl resistant isolates and were similar to the A2 isolates. The sensitive isolates did have the lowest AULEC standardized scores, however.

The data indicate that the A2 isolates as a group are more aggressive than the A1 isolates. This may be one reason the A2 isolates are replacing the A1 isolates. However, the US-11 A1 isolate was just as aggressive as the most aggressive A2 isolate. This would suggest that if aggressiveness is the only factor favoring the replacement of the new A2 population, some A1 isolates with the US-11 genotype should be found. Unfortunately only three US-11 isolates were found between 1992 and 1995, and only two of these were included in aggressiveness tests.

Both isolates used in the tests had high aggressiveness scores. With such a small sample size, however, it is difficult to make reliable inferences about this genotype.

It is possible that weather is playing an important role in the replacement of the A1 isolates with the A2 metalaxyl resistant isolates. As mentioned above, all aggressiveness tests were performed at 18°C. At cool temperatures such as this, the old A1 populations grew well. For this reason, late blight was never expected to be problematic in hot environments. The new A2 population may be better adapted to grow at the higher temperatures prevalent in the Columbia Basin throughout the potato growing season. This idea will be tested in future research.

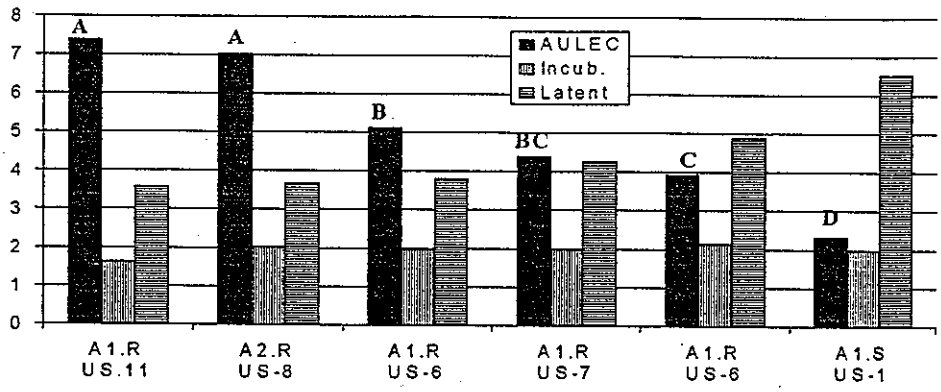
Table 1. Phenotypic population characteristics of *Phytophthora infestans* collected from the Columbia Basin.

	Mating Type		Metalaxyl	
Year	A1	A2	Sensitive	Resistant
1992	100	0	100	0
1993	92	8	3	97
1994	68	33	32	68
1995	1	99	0	100

Table 2. Allozyme Genotypes for Isolates of *Phytophthora infestans* found in the United States

Genotype	Mating Type	Allozyme genotype		Response to Metalaxyl
		Gpi	Pep	
US-1	A1	86/100	92/100	Sensitive
US-6	A1	100/100	92/100	Resistant
US-7	A2	100/111	100/100	Resistant
US-8	A2	100/111/122	100/100	Resistant
US-11	A1	???	???	Resistant

Figure 1. Isolate aggressiveness test 1. Isolates were tested on detached leaflets in the incubator.



The first two digits represent the mating type of the isolate. The letter after the decimal point represtents the metalaxyl sensitivity (S = sensitive, I = intermediate, and R = resistant. The letters underneath the three digit coding represent the allozyme genotype of the isolate.

Figure 2. Isolate aggressiveness test 2. Isolates were tested on detached leaflets in the incubator.

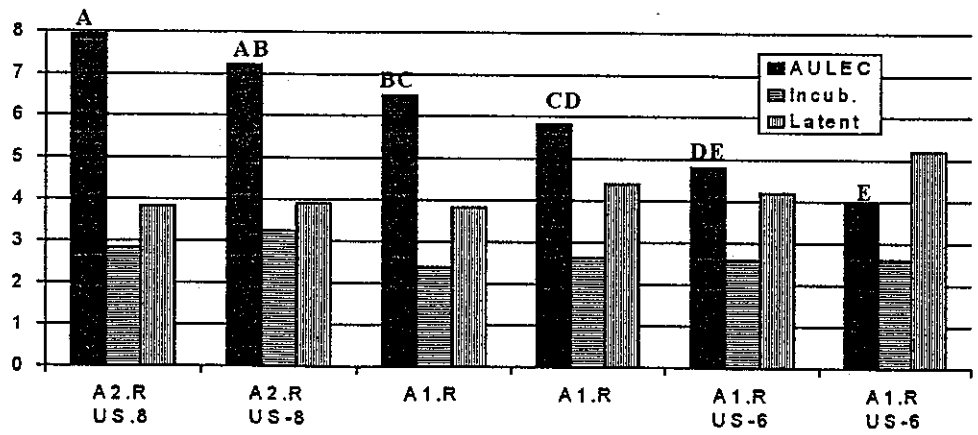


Figure 3. Isolate aggressiveness test 3. Isolates were tested on detached leaflets in the incubator.

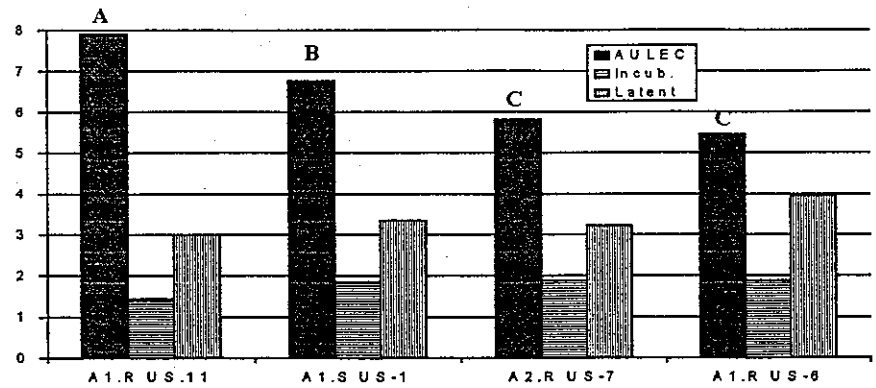


Figure 4. Isolate aggressiveness test 4. Isolates were tested on detached leaflets in the incubator.

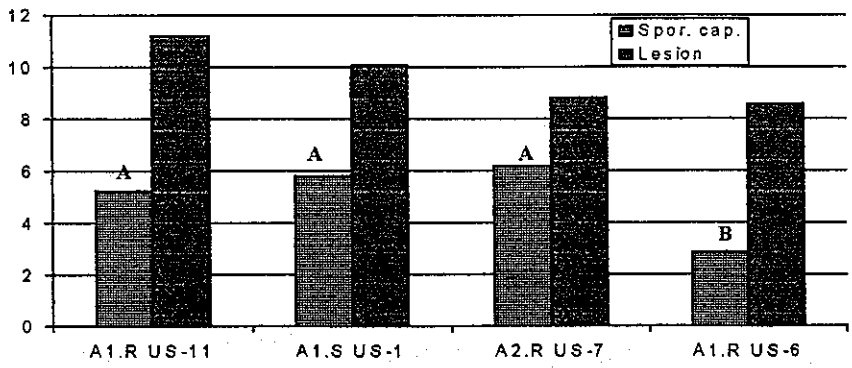


Figure 5. Isolate aggressiveness test 5. Isolates were tested on detached leaflets in the incubator.

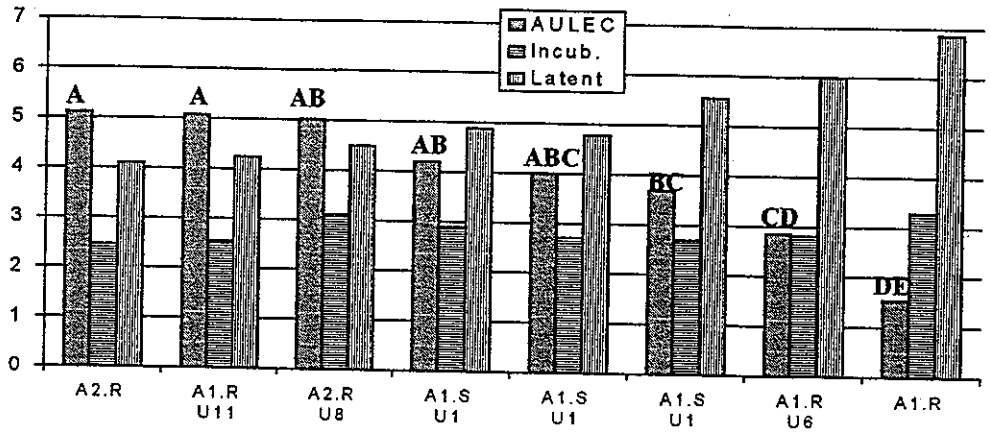


Figure 6. Isolate aggressiveness test 6. Isolates were tested on entire potato plants in the greenhouse.

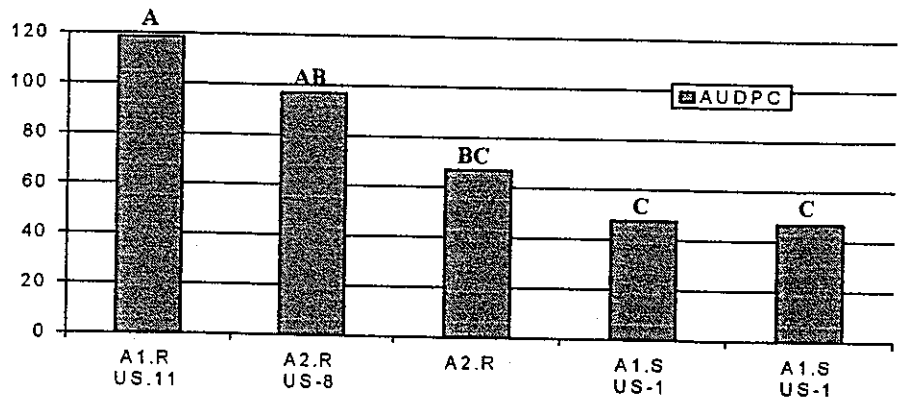


Table 3. Standardized Aggressiveness Scores for Isolate Tests.

	AULEC	Incubation Period	Latent Period	Sporulation Capacity	Lesion size
A2,R	1.54	1.01	0.81	2.57	1.57
A1,R	1.33	1.09	0.90	1.24	1.11
A1,S	1.13	1.11	0.99	2.60	1.52

R = metalaxyl resistant, S = metalaxyl sensitive.

References:

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2. Goodwin, S. B., Schneider, R. E., and Fry, W. E. 1995. Use of cellulose-acetate electrophoresis for rapid identification of allozyme genotypes of *Phytophthora infestans*. Plant Disease 79:1181-1185.

3. Speilman, L. J., Drenth, A., Davidse, L. C., Sujkowski, L. J., Gu, W., Tooley, P. W., and Fry, W. E. 1991. A second world-wide migration and population displacement of *Phytophthora infestans*? Plant Pathology 40:422-430.