POPULATION DYNAMICS OF THE LATE BLIGHT FUNGUS IN THE COLUMBIA BASIN

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Late blight is a serious concern in the Columbia Basin. Severe epidemics of the disease in 1993 and 1995 have led to increased research aimed at learning more about the disease and finding new ways to control it. One of these research efforts has been to study the population dynamics of the late blight fungus (*Phytophthora infestans*) to better understand why this pathogen which caused so much damage recently, as compared to previous years.

Three major questions which population dynamics attempts to answer are:

1. What strains of the late blight fungus are present in the Basin?
2. Where do new strains come from?
3. What is the impact of new strains as related to disease management?

A strain can be defined as a group of fungal isolates which are similar to each other (Agrios, 1988). The late blight fungus can be characterized by mating type (A1 or A2), sensitivity to Ridomil (sensitive or resistant), and certain molecular traits (enzymes, DNA patterns). These characteristics combined have been used to define different strains. Many researchers have referred to these strains as genotypes. The characteristics of the different late blight fungus strains (or genotypes) which have been found on potatoes in the Columbia Basin are shown in Table 1.

What strains of the late blight fungus are present in the Basin?

The strains of the late blight fungus present in the Columbia Basin from 1992 to 1996 are given in Table 2. The findings from 1992 to 1995 have been discussed previously (Miller *et al.*, 1996). In 1996, 91% of the isolates found on potatoes were of the US-8 strain. The other 9% appear to belong to a new strain we have tentatively designated as US-16. The US-16 strain was first found in 1995, while the US-8 strain has been present in the Basin since 1994 (Table 2).

New molecular data suggests that two strains detected in 1993, tentatively designated as US-12 and US-13, were the products of sexual reproduction between the US-6 and US-7 strains. This is the first evidence of sexual recombination for the late blight fungus in the Columbia Basin. The US-7, US-12, and US-13 strains were not detected again after 1993, while the US-6 strain was present from 1992 to 1994.

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Where do new strains come from?

Reviewing which strains have been present in the Basin over the past few years has given some insight as to where the strains are coming from. Before strains began to be identified, only the US-1 strain was found in the Basin. In the early 1990's new strains began to appear. Some strains must have been imported on either potato tubers or tomatoes. New strains were found in 1992 (US-6), 1993 (US-7), and 1994 (US-8). These strains were not found in the Basin during their respective preceding years. Additionally, some strains have not survived from one growing season to the next in detectable levels. Since these strains are not surviving, other strains must be replacing them when late blight starts the next year. Potato seed must be considered as an important source of inoculum.

Some strains, such as the US-1, US-6, and US-8 have been found in the Basin for more than two successive years. It is possible that after these strains were introduced they survived from one growing season to the next by overwintering in volunteer potatoes or cull piles.

Two strains found in 1993, US-12 and US-13, apparently arose from sexual recombination. It is possible that the US-15 and US-16 strains (found in 1995) arose from sexual recombination between US-8 and US-11 strains. Further genetic analysis needs to be performed to confirm this possibility.

What is the impact of new strains as related to disease management?

Oospores. Normally, the late blight fungus reproduces asexually. Sporangia formed from asexual reproduction are identical to the parent fungus and are very sensitive to desiccation. However, sexual reproduction can occur when a strain of each mating type (A1 and A2) come in contact. Up through 1992 this was not possible since the strains present in the Basin (US-1 and US-6) had the same mating type. Strains with both mating types have been found in the Basin every year since 1992, making sexual reproduction possible. As stated previously, it has most likely already occurred in 1993. When sexual reproduction occurs, offspring are formed through structures called oospores. The offspring inherit characteristics of both parents, leading to the creation of new, diverse strains.

Oospores are resistant structures which may increase the survival ability of the late blight fungus during adverse weather conditions. Oospores have been shown to infect plant material anywhere from a few days to several months after formation and can survive in the soil for several months without any plant material (Drenth *et al.*, 1995). Normally the late blight fungus survives only in plant tissue. Effective spray programs are needed to slow the growth of the late blight fungus and reduce the likelihood the two different mating types from coming in contact with each other. This is especially true when strains with different mating types are found in close proximity to each other.

Overwintering ability. New strains, particularly the US-8 strain, appear to overwinter and infect the following spring more effectively than other strains. One recent study reported that when tubers were inoculated with different strains of the late blight fungus, the US-8 strain produced significantly more disease on the developing sprouts of those tubers (Marshall *et al.*, 1996). This characteristic may allow new strains to initiate late blight epidemics more effectively than old strains. The newer US-14 and US-16 strains may also overwinter and infect foliage in the spring better than the old US-1 strain. More research needs to be done in this area.

Aggressiveness. New strains have also been shown to be more aggressive relating to disease caused on foliage (Miller *et al.*, 1996) and in tubers (Miller, *unpublished*). New strains grow faster on leaves, sporulate faster, and produce more sporangia (spores) than the old US-1 strain. As a result, intervals between sprays will need to be shortened when weather favors late blight development. Strains aggressive on foliage are also aggressive on tubers. Tubers infected with the newer strains will rot faster.

Stem lesions. The US-8 strain forms more stem lesions than the US-1 strain. In humid conditions, the US-8 stem lesions sporulate faster than US-1 stem lesions (Miller, *unpublished*). Individuals scouting for late blight need to examine the stems, especially in the lower canopy. In August of 1996, a potato field in southern Idaho was examined which had severe late blight damage. One corner of the field had a few 'holes' where the late blight fungus had completely destroyed the foliage. The other side of the field appeared quite healthy. When the upper vines were pulled back, however, several late blight stem lesions could be seen in the lower canopy.

Stem lesions have the potential to live longer in the potato canopy than leaflet lesions. When the late blight fungus has grown throughout a leaflet, the leaflet will dry up and fall off the petiole. When the fallen leaflet decomposes, the fungus dies. Stem lesions, however, do not fall off the plant. They can grow and spread for a longer period of time than leaflet lesions. Stem lesions may also allow the late blight fungus to survive long periods of hot, dry weather. For these reasons, it is essential that the fungicides applied to control the late blight fungus are covering the stems. Stem coverage with fungicides can reduce the incidence and severity of stem lesions.

Conclusions

The late blight fungus population in the Columbia Basin is composed of different strains. These strains may have been brought into the Basin initially on potato seed. When certain strains are together, then sexual reproduction is likely. Sexual reproduction leads to oospore formation and the production of diverse offspring. Some strains are more aggressive as pathogens than others and some cause more stem lesions than others. Stem lesions can make late blight control more difficult. When late blight is found, the fungus needs to be isolated so the strain can be identified. Strain identification will help to assess the threat of sexual reproduction and may give further information on the inoculum sources.

References

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Table 1. Characteristics of strains found in the Columbia Basin of Washington and Oregon from 1992 to 1996.

Strain (Genotype)	Mating Type	Ridomil (metalaxyl) Sensitivity**	Gpi Alleles***	Year Collected
US-1	A1	Sensitive	86/100	1992-94
US-6	A1	Resistant	100/100	1992-94
US-7	A2	Resistant	100/111	1993
US-8	A2	Resistant	100/111/122	1994-96
US-11	A1	Resistant	100/100/111	1993-94
US-12*	A1	Resistant	100/111	1993
US-13*	A2	Resistant	100/100	1993
US-14	A2	Resistant	100/122	1995-96
US-15*	A2	Resistant	100/100/111	1995
US-16*	A1	Resistant	100/111/122	1995-96

*These strains designations are tentative. More molecular data is needed to confirm these classifications.

**Isolates were grown on media with 10 μg/ml of Ridomil and without Ridomil. The amount of growth on media with Ridomil was compared to the amount of growth on media without Ridomil. Sensitive isolates on Ridomil media had 10% or less of the growth on media without Ridomil. Isolates resistant to Ridomil had more than 10% of the growth on media without Ridomil.

***These numbers represent different forms of the enzyme *Glucose-6-phosphate isomerase* (*Gpi*).

Table 2. Frequencies of *Phytophthora infestans* strains by year the Columbia Basin. Values are given as percentages.

Strain (Genotype)	1992	1993	1994	1995	1996
US-1	97	3	37	0	0
US-6	3	10	11	0	0
US-7	0	11	0	0	0
US-8	0	0	33	97	95
US-11	0	6	19	0	0
US-12*	0	26	0	0	0
US-13*	0	3	0	0	0
US-14	0	0	0	2	0
US-15*	0	0	0	<1	0
US-16*	0	0	0	<1	5

*These strains designations are tentative. More molecular data is needed to confirm these classifications.