Survival and Infection of Late Blight Spores in Field Water

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Late blight of potato caused by *Phytophthora infestans* is one of the most costly and damaging potato diseases in the Columbia Basin. Spores of *P. infestans* called sporangia, (singular is sporangium) can infect both foliage and tubers. *P. infestans* uses two modes of infection. At temperatures around 60°F and greater, direct germination of sporangia is favored. During direct germination, a germ tube protrudes from a sporangium and infects potato plant parts. At temperatures near 60°F and less, indirect germination is favored. During indirect germination an individual sporangium will release six or more motile zoospores each of which is capable of infection.

Late blight is favored by cool, wet conditions. Standing water in potato fields provides the wet conditions favoring late blight development. Standing water is common in center pivot irrigated fields along the wheel lines, within 80-100 feet from the center pivot, where overlapping pivots occur, in field depressions, and in over-irrigated potato fields.

There are many factors that impact the development and survival of sporangia and zoospores in water and soil. The major factors affecting spore survival in and on soil include: UV-radiation, temperature, moisture, soil chemistry, and soil microorganisms. During a recent study, survival of zoospores and sporangia of *P. infestans* in water was determined under field conditions. The affects of UV-radiation, temperature, and soil on spore survival in water were critically evaluated.

The survival of zoospores and sporangia of an US-8 and US-11 isolate of *P. infestans* in water was observed under natural environmental conditions in two separate experiments in July and October of 2001. The sporangia from each of the isolates were obtained from sporulating lesions on detached Ranger Russet leaves that had been previously inoculated with the respective isolates. The sporangia from each isolate were washed from the leaves into separate glass beakers using distilled water. Half of the inoculum rinsed from the leaves of each isolate was chilled at 50°F, and the other half was kept at room temperature (74°F). The inoculum kept at room temperature didn't produce zoospores but the chilled inoculum produced zoospores.

Glass petri plates (3.5" diameter, 3/4" depth) were buried with the top rim level with a sandy soil in an outdoor courtyard in Pullman, WA. A total of 16 treatments were tested with four replicates per treatment. The treatments were: 1) US-8/shade/soil/zoospore 2) US-8/shade/soil/sporangia 3) US-8/sunlight/soil/zoospore 4) US-8/sunlight/soil/sporangia 5) US-8/shade/no soil/zoospore 6) US-8/shade/no soil/sporangia 7) US-8/sunlight/no soil/zoospore

8) US-8/sunlight/no soil/sporangia 9) US-11/shade/soil/zoospore 10) US-8/shade/soil/sporangia 11) US-8/sunlight/soil/zoospore 12) US-8/sunlight/soil/sporangia 13) US-11/shade/no soil/zoospore 14) US-11/shade/no soil/sporangia 15) US-11/sunlight/no soil/zoospore 16) US-11/sunlight/no soil/sporangia. Explanations for each component of the above treatments are listed below:

Explanation of treatment components:

US-8= US-8 isolate of *Phytophthora infestans* collected from southeastern Washington.
US-11= US-11 isolate of *Phytophthora infestans* collected from western Washington.
Sunlight= Petri plates were exposed to direct sunlight with no protection.
Shade= Petri plates were place under a board (8'x4'x0.5") that prevented direct sunlight from hitting the petri plates but was open on three sides to allow reflected solar radiation to hit the plates.
Soil= Fifteen grams of a sandy soil (taken from Paterson, WA) was added to the petri plates, which resulted in a soil depth of 2-3mm in the bottom of each petri plate.
No soil= No soil was added to the petri plates.
Zoospore= Inoculum added to petri plates was chilled at 10°C for two hours to induce zoospore formation.
Sporangia= Inoculum added to petri plates was left at room temperature at which temperature no zoospore formation took place.

Each petri plate received 100,000 sporangia from a single, selected isolate. Sporangia survival was determined by taking samples from each of the petri plates at 1,2,3,6,8,10,13,16, and 20 days following the day the sporangia were added to the petri plates. The water level in each petri plate was maintained near the upper rim during the entire sampling period. During each sampling period, the water or water-soil mixture in each petri plate in the courtyard was stirred and a milliliter of solution removed and added to the surface of a Ranger Russet tuber slice.

The petri plates for each sampling period were put into a clear, sealed, plastic container (15"x 9" x 8.5") with wetted paper towels in the bottom. The tuber slices were incubated at 60°F with an eighteen-hour light and six hour dark period. After incubation for five days, the tuber slices were observed and the percentage of infected tuber tissue (determined by the percentage of sporulating tuber surface area) was determined. If there was no infection, the plates were again observed at six days after inoculation and if needed at 12 days following inoculation to observe if any infection had taken place. Infection levels were given ratings of: 1) 75-100% 2) 50-74% 3) 25-49% 4) 5-24% 5) 1-4% 6) 0%.

The effect of light, soil, spore type, and pathogen isolate on survival length and level of tuber infection were assessed. The length of survival was defined as the number of days that spores survived. The level of tuber infection was related to the number of spores that survived and infected tuber disks, resulting in a measurable sporulating area on the disks.

Phytophthora infestans survived in water under natural environmental conditions for two to three weeks (Fig. 1). *P. infestans* survival and level of tuber infection were significantly greater for shaded than direct sunlight treatments. *P. infestans* survived in direct sunlight between 8 to 16 days and in the shade for 13 to 20 days (Figs. 2 & 3). Following a one day exposure period, the level of tuber infection for shaded treatments in July and October respectively were 62% and 26% greater compared to direct sunlight treatments. After two days, for both trials, the level of tuber infection for direct sunlight treatments was below seven percent. In shaded treatments, the level of tuber infection was maintained above 18 % after eight days in July but in October was 14% after three days.

In July, levels of tuber infection for direct sunlight treatments decreased to approximately 6% after 2 days. During the same exposure period, levels of tuber infection for shaded treatments were approximately 83%. After eight days, levels of tuber infection for the shaded treatments were 18.3%. Levels of tuber infection for both shaded and direct sunlight treatments were lower in October than in July. We found that October was much cooler than July and favored zoospore formation. Zoospores do not survive as well as sporangia, which may accounts for the lower survival levels (Fig.3).

The presence of soil in the water had a tremendous impact on length of spore survival and level of tuber infection. Soil microorganisms and metal ions have been implicated in reducing the survival of *P. infestans*, however, soil protected sporangia from UV-radiation which was a more important factor under our conditions than metal ions and microorganisms. In July the maximum survival of *P. infestans* in water exposed to direct sunlight, with no soil, was between 1 and 2 days for both zoospores and sporangia, however, in October the survival was 6 to 8 days (Figs. 6&7). Treatments with soil-water in direct sunlight increased survival an additional 3-8 days in July compared to treatments with no soil. In October there were no differences in survival lengths, this is likely due to a decrease in direct sunlight due to shorter days and cloudier environmental conditions, both of which reduce spore exposure to UV-radiation (Figs.4&5).

The differences between zoospore and sporangium survival were analyzed for July. The natural environmental conditions in October favored zoospore formation so it was impossible to test sporangium survival by itself. In July, there were no significant difference between zoospore and sporangium treatments for survival length and percent tuber infection, although zoospore treatments were consistently lower in percent tuber infection (Fig. 8).

The US-11 isolate had a significantly greater level of tuber infection than did the US-8 isolate but no difference in survival length. The US-8 isolate tested has been shown to be more aggressive than the US-11 on tuber and foliage but in terms of survival it was significantly less. More US-8 and US-11 isolates need to be tested to determine if US-11 isolates exhibit better levels of tuber infection than US-8 isolates.

In summary, sporangia of *P. infestans* survive in field water for extended time periods. Shade from plants and soil in water increases survival duration. Field water contaminated with *P. infestans* spores facilitates disease spread and tuber infections. Practices such as not planting within 80-100 feet from the center pivot, avoidance of over-lapping irrigation, and not over-irrigating fields reduce standing water in potato fields and are important in managing late blight. Not following these guidelines can promote unnecessary levels of standing water that favor infection, sporulation, and survival of sporangia.

Figures:

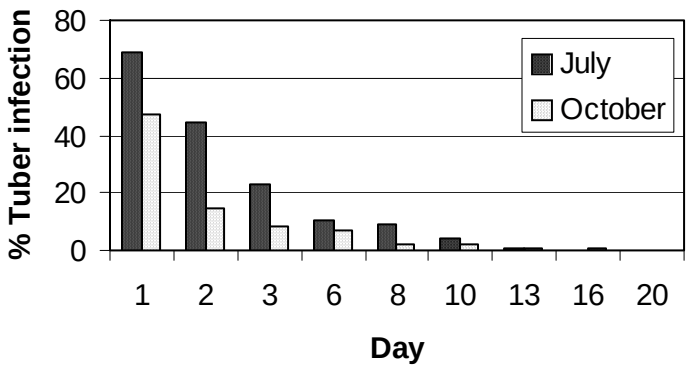

Figure 1. Survival of *Phytophthora infestans* in water exposed to natural environmental conditions in July and October of 2001 all treatments combined.

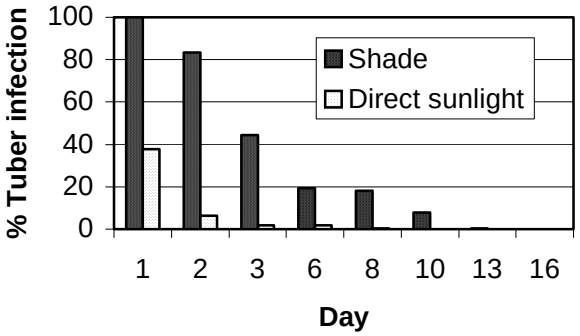

Figure 2. Percent tuber infection when sporangia of *Phytophthora infestans* were exposed to direct sunlight or shaded conditions in July of 2001 for various lengths of time and then assayed for viability on potato tuber slices.

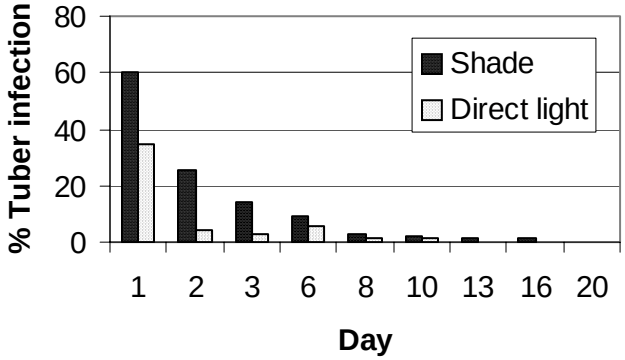

Figure 3. Percent tuber infection when sporangia of *Phytophthora infestans* were exposed to direct sunlight or shaded conditions in October of 2001 for various lengths of time and then assayed for viability on potato tuber slices.

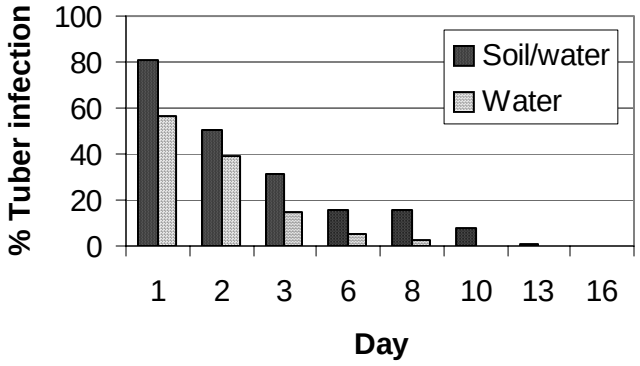

Figure 4. Effect of soil and water on the survival of *Phytophthora infestans* sporangia exposed to natural environmental conditions in July, 2001.

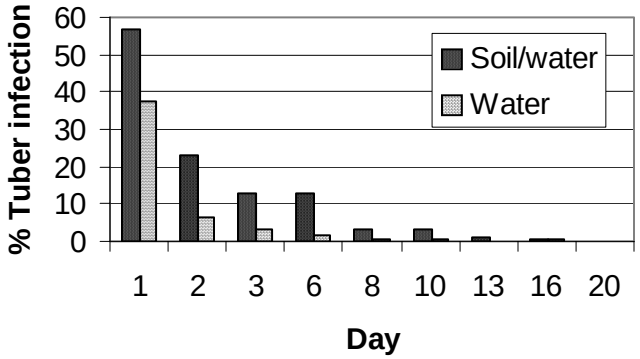

Figure 5. Effect of soil and water on the survival of *Phytophthora infestans* sporangia exposed to natural environmental conditions in October, 2001.

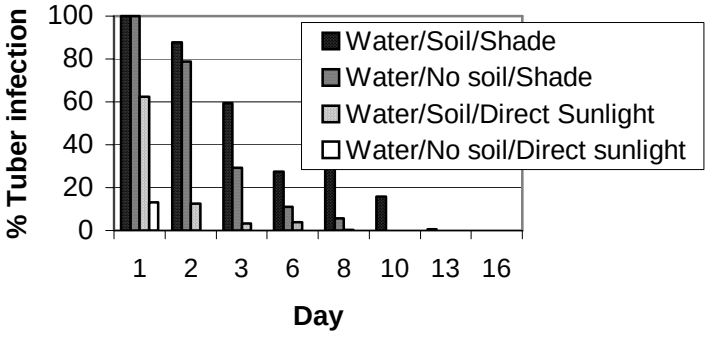

Figure 6. Effects of sunlight and soil on the survival of *Phytophthora infestans* sporangia in water exposed to natural environmental conditions in July, 2001.

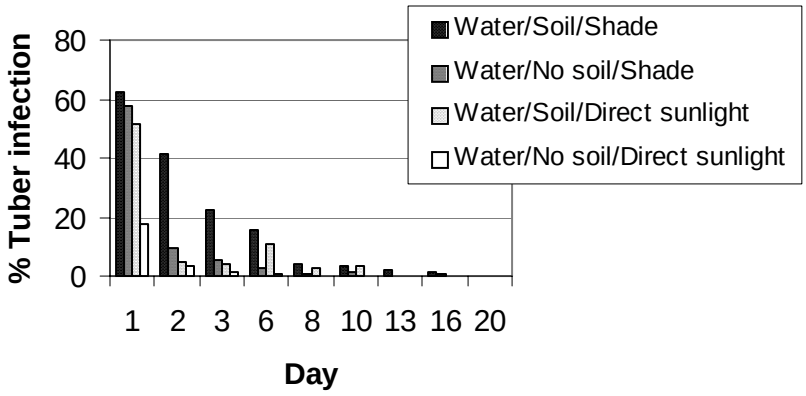

Figure 7. Effects of sunlight and soil on the survival of *Phytophthora infestans* sporangia in water exposed to natural environmental conditions in October, 2001.

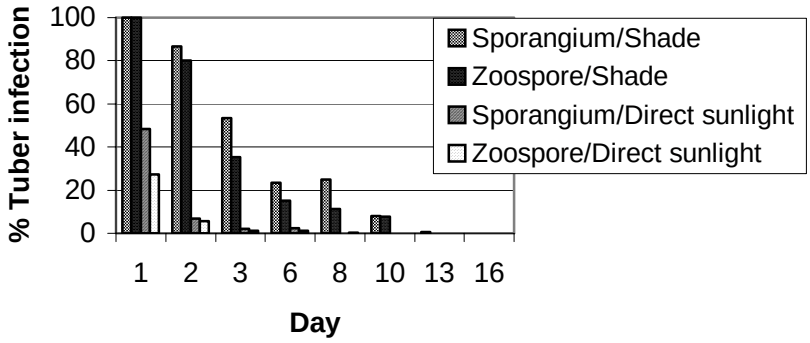

Figure 8. Effects of sunlight and spore type on the survival of *Phytophthora infestans* in water exposed to natural environmental conditions in July, 2001.