**Potato Late Blight: how long can sporangia survive?**

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The fungus-like organism *Phytophthora infestans* has been studied extensively since the mid-1800s when it was recognized as the causal agent of potato late blight. *P. infestans*, and therefore late blight, spreads beyond neighboring potato plants by means of human transport of infected seed tubers and wind transport of sporangia. Sporangia are microscopic, lemon-shaped spores that propagate the life cycle of *P. infestans*. Studying the ability of *P. infestans* sporangia to survive atmospheric conditions is important for evaluating the risk of potato late blight spreading between fields and regions within the Columbia Basin of Washington and Oregon. Our project was the first to test the survival ability of *P. infestans* sporangia under semi-arid, outdoor conditions.

**Long-distance spread of sporangia**

Sporangia are not equipped for survival; they have thin walls and are colorless, meaning that they are susceptible to drying and solar radiation (possibly UV-B radiation in particular). However, they are produced in staggering numbers on infected potato tissue and can be carried by wind to new locations and other potato plants. If sporangia survive the journey and water is present on the potato foliage or tubers that they land on, they can germinate, infect the plant, and start the cycle again. Under favorable environmental conditions such as cool temperature (60 to 72 F) and high humidity (95 to 100%), this cycle can occur repeatedly in a short period of time ( 4 days) and the disease may reach epidemic proportions. Most sporangia that become airborne are deposited within about 10 to 15 feet of the inoculum source, but researchers do not know exactly how far the remaining percentage can travel and still remain viable. Recently in England, *P. infestans* from a cull pile was observed infecting potato fields over 0.5 miles away. Also, sporangia of a similar organism, *Peronospora tabacina*, probably traveled a few hundred miles before causing epidemics of tobacco blue mold in Connecticut in 1979 and 1980.

**Previous studies**

Researchers have studied the survival ability of *P. infestans* sporangia since the 1930s but most work has been conducted under controlled laboratory conditions rather than natural field conditions. The most common way of testing survival is by placing sporangia on agar, following exposure, and determining the number that germinate. The longest survival time reported was 48 hours; the conditions were 50±F and 50 or 80% relative humidity (RH). More commonly, sporangia survived 6 hours or less. Under moderate conditions of 59 or 68±F and 40 or 88% RH, sporangia were capable of surviving at least 5 or 6 hours. Recently, solar radiation was reported to be a more important factor influencing survival than temperature and humidity; only 1 hour of exposure to sunlight decreased germination by 95% and sporangia survived longer on cloudy days than sunny days. In general, sporangia were reported to survive longer at cooler temperatures, higher humidity, and/or lower levels of solar radiation.

**Research methods**

Our study was the first to evaluate the survival ability of sporangia under semi-arid, outdoor conditions that are similar to those in the Columbia Basin. The objective of our study was to determine how long *P. infestans* sporangia survive when exposed to outdoor conditions in southeastern Washington. On numerous days during the summer months of 1998 through 2000, we transferred sporangia from infected leaflets to either filter paper squares or glass coverslips by means of gentle contact. This was done so that we could test the sporangia detached from the stalks that they develop from, as they would be during wind transport. We then tested the survival ability of the sporangia by exposing them outside for various lengths of time up to 48 hours and seeing if they could infect potato tuber slices or leaflets. The use of host tissue infection, rather than germination on agar, as a measure of survivability had been reported for *P. infestans* only once before.

**Results**

The longest survival time we observed was 24 hours. During the daytime the conditions were sunny, cool, and very dry (59°F and 16% RH, on average) and during the nighttime the conditions were slightly cooler and moister (48°F and 20% RH). This result was not expected because sporangia had not previously been reported to survive exposure to RH below 30% for any length of time and survival for this duration or longer had been reported only once. In our study, sporangia survived exposure to RH below 20% for various lengths of time (Table 1).

Overall, sporangia survival was uncommon. Over all three years, only 25 of 566 (4.4%) filter papers and coverslips with sporangia resulted in infection of tuber slices or leaflets following exposure to sunlight. Most host tissue infection was caused by sporangia exposed directly to sunlight for 4 hours or less. Sporangia did not cause infection following exposure to sunlight for 4 hours or longer at ambient temperature at or above 95°F. However, sporangia survived for at least 2 hours in the shade at 98°F. This finding supports the recent study that suggested solar radiation might be more important than temperature or humidity as a factor influencing survival.

**Discussion**

Our results suggested that long-term survival of sporangia might occur only on occasion in the field and only under certain weather conditions. However, infection of host tissue distant from an inoculum source requires the transport and survival of only one sporangium. Considering that an infected potato field could potentially produce billions of sporangia, the possibility of long-term transport and survival exists given the right weather conditions. At wind speeds of 12 to 25 mph in the transport layer of the atmosphere, sporangia surviving 24 hours could potentially travel about 300 to 600 miles while sporangia surviving 4 hours could travel about 50 to 100 miles. Considerable spread of late blight has been observed within the Columbia Basin during cool, cloudy, and rainy weather. Further studies need to be conducted over a broader range of conditions, including cool rainy weather, to obtain a more detailed view of sporangia survival ability.

**Table 1.** Survival times and daytime weather conditions during each exposure-day in which potato tissue infection was observed for at least one positive control or treatment experimental unit when sporangia of *Phytophthora infestans* were exposed to ambient conditions for different lengths of time. [a]

| Date [b] | Exposure period [c] | Weather conditions | Temp (°F) | RH (%) | SI ($Wm^{-2}$) [d] | Longest survival time (h) [e] |
|---|---|---|---|---|---|---|
| 07/15/98 | 1244-1444 (2 h) | Hot, sunny | - [f] | - | 949 | 2S [g] |
| 07/16/98 | 1136-1536 (4 h) | Hot, sunny | - | - | 944 | 1, 2S |
| 07/17/98 | 1151-1551 (6 h) | Hot, sunny | - | - | 913 | |
| 07/21/98 | 1151-1451 (5 h) | Hot, sunny | - | - | 958 | 3, 3S |
| 07/23/98 | 1510-2210 (7 h) | Warm, sunny | - | - | 117 | |
| 07/31/98 | 1242-1742 (7 h) | Warm, cloudy | - | - | 442 | |
| 08/11/98 | 1111-1411 (5 h) | Hot, sunny | - | - | 880 | 3 |
| 09/04/98 | 1441-1641 (2 h) | Hot, sunny | - | - | 731 | |
| 09/30/98 | 1230-1630 (6 h) | Warm, sunny | - | - | 602 | 4 |
| 10/02/98 | 1512-1512 (48 h) | Cool, rainy | - | - | 118 | 1 |
| 10/07/98 | 1200-1300 (1 h) | Warm, sunny | - | - | 513 | |
| 10/12/98 | 1530-1930 (4 h) | Mild, cloudy | - | - | 118 | |
| 10/16/98 | 1245-1845 (6 h) | Cool, cloudy | - | - | 250 | 4 |
| 05/12/99 | 1030-1030 (24 h) | Cool, sunny | 52 | 17 | 786 | 6 |
| 05/19/99 | 1005-1005 (24 h) | Cool, sunny | 59 | 16 | 716 | 24, 24S |
| 05/21/99 | 0920-0920 (24 h) | Cool, sunny | 66 | 26 | 716 | |
| 05/26/99 | 1020-1020 (24 h) | Cool, sunny | 79 | 13 | 789 | |
| 05/27/99 | 0930-0930 (24 h) | Mild, sunny | 82 | 19 | 735 | |
| 06/04/99 | 1000-1000 (24 h) | Mild, sunny | 68 | 14 | 765 | |
| 06/09/99 | 0825-0825 (24 h) | Cool, sunny | 57 | 16 | 713 | 2 |
| 07/02/99 | 1025-2225 (36 h) | Cool, cloudy | 63 | 31 | 645 | |
| 07/05/99 | 0950-1550 (6 h) | Mild, sunny | 79 | 23 | 921 | |
| 07/06/99 | 0955-1455 (5 h) | Hot, sunny | 90 | 17 | 949 | |
| 09/08/99 | 1220-1620 (4 h) | Warm, sunny | - | - | 787 | |
| 09/29/99 | 1200-1600 (4 h) | Mild, sunny | - | - | 645 | |
| 10/06/99 | 1010-1510 (5 h) | Cool, cloudy | - | - | 141 | 1 |
| 10/20/99 | 1145-1145 (24 h) | Mild, cloudy | - | - | 292 | |
| 05/31/00 | 0955-1755 (8 h) | Cool, rainy | 57 | 61 | 434 | 1 |
| 06/06/00 | 1125-1525 (4 h) | Warm, sunny | 82 | 21 | 607 | 4S |
| 06/13/00 | 1000-1400 (4 h) | Mild, cloudy | 64 | 50 | 768 | |
| 06/19/00 | 1055-1455 (4 h) | Warm, sunny | 66 | 36 | 832 | |
| 06/22/00 | 1035-1435 (4 h) | Warm, sunny | 75 | 20 | 977 | |
| 06/29/00 | 1115-1515 (4 h) | Hot, hazy | 84 | 28 | 878 | |
| 06/30/00 | 1320-1520 (2 h) | Hot, sunny | 82 | 23 | 838 | 0.5, 1.5S |
| 07/12/00 | 1200-1400 (2 h) | Hot, sunny | 84 | 21 | 842 | |

[a] Mean daytime weather conditions from start to end of exposure period or 1900 military time, depending on exposure length.
[b] Date of exposure day (MM/DD/YY).
[c] Four-digit numbers = military time of day; end time is for the longest exposure length that day.
[d] Solar irradiance (SI) measures the level of solar radiation.
[e] Longest survival time observed for each exposure day.

[f] Missing data due to technical difficulty with weather recording equipment.
[g] S = shaded treatment.