Late Blight of Potatoes and Prediction of Epidemics in Arid Central Washington State

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ABSTRACT

Easton, G. D. 1982. Late blight of potatoes and prediction of epidemics in arid central Washington state. Plant Disease 66:452-455.

A late blight epidemic occurred in arid central Washington state in 1975 on an estimated 800 ha of potatoes under center pivot sprinkler irrigation. Infected seed used to plant the 1973 and 1974 crops apparently provided the primary inoculum. In the spring of 1975, many volunteer plants from overwintering tubers were pushed aside during harvest. Some of these tubers apparently had been infected and had not frozen during the mild winter of 1974–1975, thus providing inoculum for the epidemic. Rains in August, heavy irrigation, and dense foliage on potatoes relatively free of Verticillium wilt, which ordinarily reduces foliage, created an ecoclimate favorable for blight. In 1976 and 1977, only a trace of blight recurred on about 80 ha, and blight disappeared after the severe winter of 1978–1979. Under conditions in central Washington, blight forecasting is not now possible. Occasional epidemics can be expected after mild winters on the cultivar Russet Burbank planted in new soils initially free of Verticillium wilt.

Additional key words: epidemiology, *Phytophthora infestans*

Late blight caused by *Phytophthora infestans* (Mont.) de Bary was first identified in arid central Washington state in 1947 by J. D. Menzies (1). Cloudy, rainy periods were associated with that occurrence. Late blight was not reported again until 26 yr later when *P. infestans* was identified from rotted tubers grown in central Washington and stored near Hermiston, OR, in the winter of 1973–1974 (A. Bartlett, Oregon State Department of Agriculture, *personal communication*). On 3 August 1975, a few leaves infected with late blight were collected from a center pivot irrigation circle of potatoes in Walla Walla County, WA (G. Hokanson, Area County Agent, Pasco, WA, *personal communication*). The grower had seen similar symptoms in 1974. I grew isolates from diseased foliage on lima bean agar media and identified them as *P. infestans* (11,28).

Sprinkler irrigation has been shown to increase late blight (22,23) and early blight caused by *Alternaria solani* (12) on potato. Late blight is generally scarce or absent with rill irrigation in arid climates. Sparse foliage at later stages of growth also discourages late blight on potato (22).

Scientific paper 5861, Project 1709. Washington State University College of Agriculture, Agriculture Research Center.

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Accepted for publication 19 August 1981.

0191-2917/82/06045204/$03.00/0

In Washington, side roll systems accelerated the use of sprinkler irrigation about 1954; use of center pivot systems started about 1956 (M. Hagood, Extension Irrigation Water Use Specialist, Prosser, WA, *personal communication*). Fewer than 10 center pivot systems (about 50 ha per system) were in use in the Columbia Basin in 1965, but this number increased to 906 by 1974 (13) and to 1,854 by July 1976 (counts by Earth Resources Technology Satellite; M. Hagood, *personal communication*).

Forecasting has been used in other areas to aid in the control of late blight. Such forecasting assumes that the fungus is being introduced annually. Inoculum increase can be reduced with timely fungicide application (20). Meteorologic data of temperature, relative humidity (RH), and rainfall are used to forecast periods favorable for blight development and to time fungicide applications (7,15,18,20). The conditions favorable for sporulation of *P. infestans* are an ambient RH above 90%; temperatures of 7–12 C for 14 consecutive hours, 12–15 C for 12 hr, or 16–21 C for 10 hr (19); and a 10-day total rainfall of 3 cm or more (18). Temperatures above 24 C are considered unfavorable for blight (6); however, viable sporangia have been found at temperatures up to 27 C on unshaded leaves (26). Temperatures below 7 C are also unfavorable for late blight (6,18).

Late blight may cause considerable rot in stored tubers harvested from green, infected vines (2). Tuber infection is controlled if blighted foliage is killed by frost or herbicides (4,7). Applications of fungicides control foliar blight but do not kill all the sporangia; therefore, they do not prevent tuber infection (4,5,17).

Inoculum can overwinter in infected tubers left in the field at harvest whenever and wherever winters are mild. Volunteer plants from these tubers can perpetuate late blight epidemics from year to year (7).

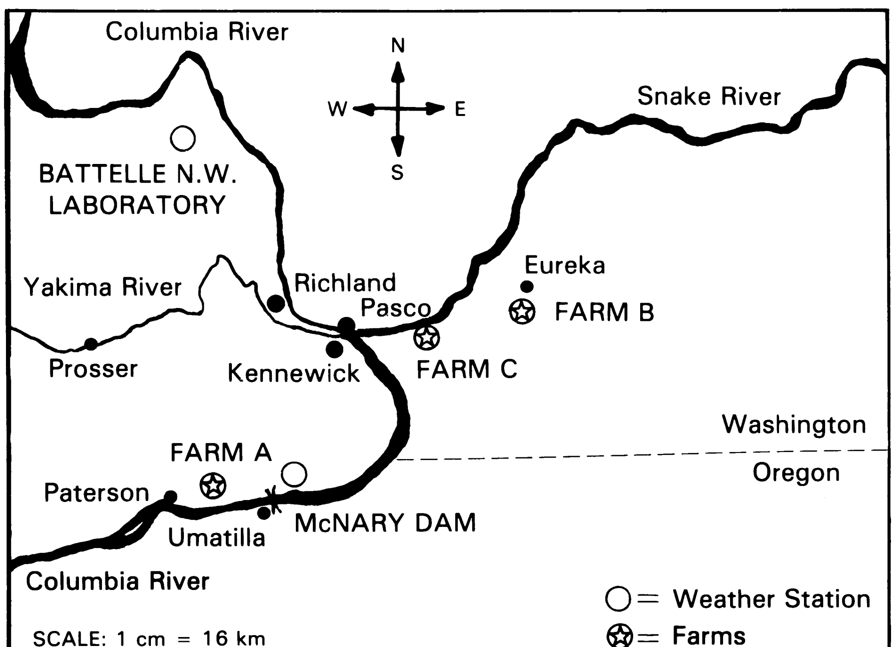

Fig. 1. Sites of farms A, B, and C, where late blight occurred in 1975, and of meteorology stations at Battelle Northwest Laboratory and McNary Dam, where weather records were taken.

Primary inoculum for late blight epidemics has been considered to originate from infected seed potatoes; however, only 0–1% of the sprouts from infected tubers planted in the field become blighted (3,16). *P. infestans* and other organisms usually rot the tubers, preventing sprouting and, thus, infection of sprouts (21,24). Only a few areas of local infection develop in the field from such infected sprouts (3,16).

Sporangia produced on rotted and cull tubers in dump piles are considered the most important source of primary inoculum in the field in the spring (3). The spread of infection from dump piles into fields is limited to about 180 m. Blight in fields that are a considerable distance from dump piles may be initiated by leaves touching soil infested by spores from overwintering tubers (21) or by a very low percentage of infected seed tubers. Probably only one diseased shoot per square kilometer is sufficient to start an epidemic (25).

This paper discusses meteorologic data collected before and after the 1975 late blight epidemic, shows possible reasons why the epidemic occurred, and describes conditions under which other epidemics might be predicted. The epidemic of 1975 was previously reported in an abstract (8).

MATERIALS AND METHODS

Sites of epidemic. Most fields on the three farms (A, B, and C) where late blight occurred in 1975 had raised at least three crops of potatoes previously (Fig. 1). Crops alternating with potatoes on farm A were sugar beets and wheat and on farms B and C, wheat only. Aerial infrared photographs were taken periodically of fields on farm A to evaluate plant health.

Irrigations were applied by growers every 1–3 days depending upon weather conditions. In 1976 and 1977, the rates of each irrigation were determined by volumetric measurement of water collected into catch bottles.

Meteorologic data. Data for temperature and precipitation during August in 1958–1978 were obtained from the McNary Dam Meteorology Station near Umatilla, OR (Fig. 1) and from the records of the U.S. Department of Commerce, National Climatic Center, Asheville, NC (Climatological Data, Volumes 62–83). Data on RH were obtained from records kept by the Battelle Northwest Laboratory, Richland, WA (Fig. 1). Minimum temperatures and number of days at or below 0 C during January and February in 1970–1979 were collected at the McNary Dam Station; these data were used to determine mild winters when infected overwintering tubers would not freeze and, therefore, furnish inoculum for the next season.

Climate under plants. In 1976 and 1977, hygrothermographs (cat. no. 5-594, Belfort Instrument Co., Baltimore, MD) housed in weather-protected, louvered, white boxes (36 cm long × 23 cm wide × 28 cm high) were placed on the soil underneath potato foliage for the constant recording of temperature and RH in center pivot irrigation circles on farms A, B, and C, where late blight epidemics had occurred in 1975. Hygrothermographs were underneath foliage to provide accurate readings of RH within the crop (15). Periods of five consecutive days of daily temperatures between 7 and 26 C (5-day running means), combined with 10 or more continuous hours of at least 90% RH every day, were selected as critical for late blight infection (7,14,15,18). Data were recorded from 15 July to 24 August, the period during which infection was considered most likely to occur.

RESULTS

Sites of epidemic. Blighted foliage was observed and collected, and *P. infestans* was isolated and identified on lima bean agar media, from numerous center pivot irrigation circles of potatoes on farm A along the Columbia River in Benton County on 27 August 1975 (Figs. 2 and 3). The disease was also found in several

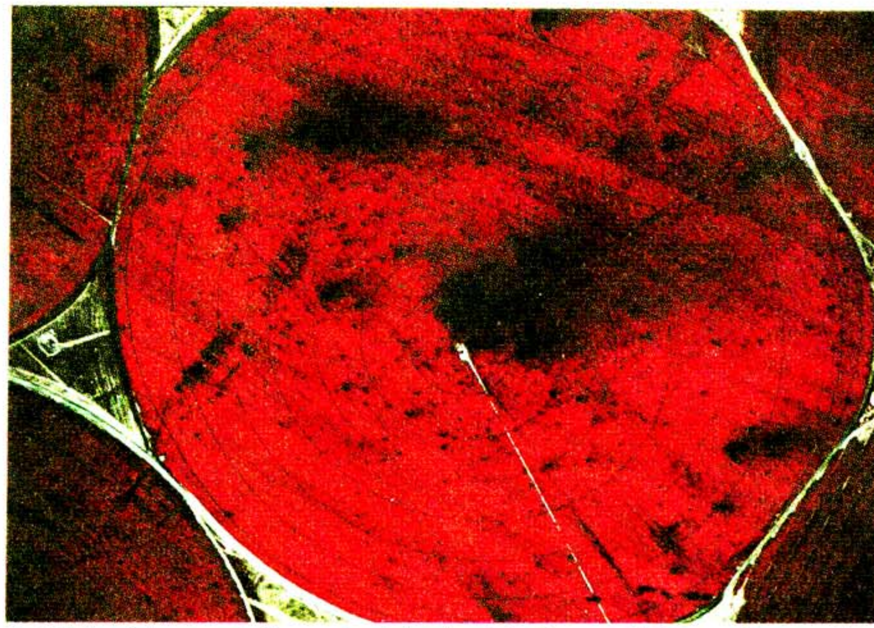

Fig. 2. Infrared photograph of center pivot irrigation circle of potatoes (40 ha) near Paterson, WA, on 27 August 1975 showing two large, dark blotches and many small, dark streaks caused by late blight. Note the influence of prevailing westerly winds (bottom left to top right) on direction of spread from initial infection sites.

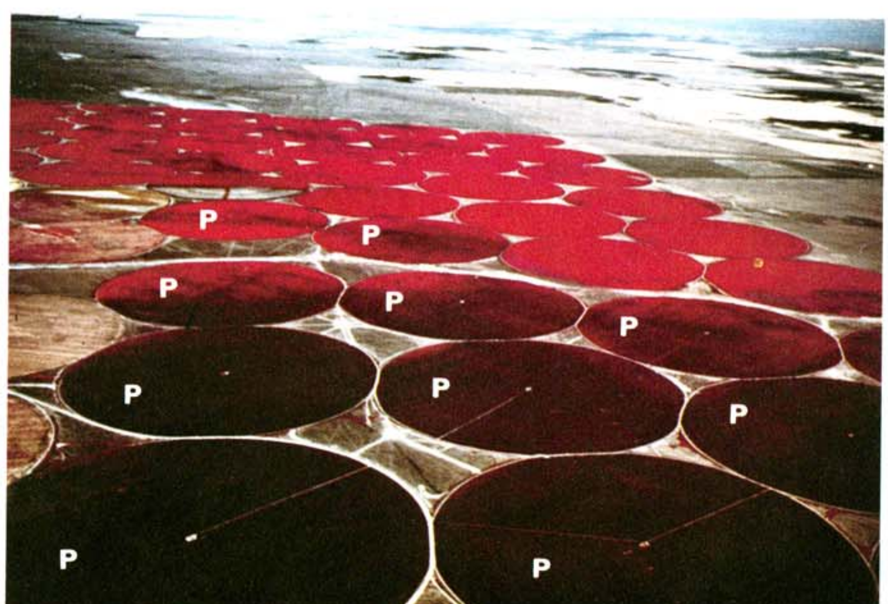

Fig. 3. Infrared photograph taken 27 August 1975 showing 10 center pivot irrigation circles of potatoes (P) in foreground infected with late blight. Unlabelled, brightest red circles in background are in corn.

circles on farms B and C in Walla Walla County. Late blight, ranging in severity from a few lesions on the foliage to death of many plants, occurred on about 800 ha on these three farms.

In 1976, late blight recurred on farm A and was found about 160 km north of farm A in a circle near Othello, WA, in Adams County. About 120 ha of potatoes was slightly infected in 1976. A trace of blight occurred on less than 40 ha on one farm in 1977. There have been no further reports of the disease through 1981.

Late blight tuber rot was not reported from fields or storages from 1975 to 1978.

Meteorologic data. During August 1975, mean daily temperatures were 21 C and total natural precipitation was 1.7 cm at McNary Dam, 16 km east of infected field A (Table 1). The mean RH at Battelle Northwest Laboratory, 64–96 km northwest of blighted fields A, B, and C, was 42% (Table 1). Similar weather conditions occurred during August in 1960, 1962, 1968, and 1976. In 1959 and 1969, August was as cool as August in 1975, but there was less precipitation and lower RH. Precipitation during August in 1965, 1977, and 1978 was equal to or more than that in 1975, but temperatures were higher.

December and January at McNary Dam were relatively warm. There were fewer days at or below 0 C in 1969–1970, 1970–1971, 1977–1978, and especially in 1974–1975 and 1975–1976 than in 1971–1972, 1972–1973, 1976–1977, and 1978–1979 (Table 2). Winters of 1972–1973 and 1978–1979 were especially cold.

Climate under plants. No field weather records had been kept during the blight epidemic of 1975, but in 1976, a year of similar weather patterns, monitoring equipment was maintained in the plant canopy of representative circles. Many blight periods of 10 or more consecutive hours per day with more than 90% RH and temperatures of 16–21 C occurred on farm A from 15 July to 24 August 1976 (Fig. 4A). The circle with monitoring equipment received a total of 21.6 cm of irrigation water during this period, and prevailing winds drifted additional irrigation mist from a nearby circle. A trace of blight appeared by 2 August on this circle and on parts of five other circles that received additional irrigation mists. Irrigation was stopped for about 10 days immediately after discovery of blight, and further infection was arrested. The foliage was dead by the last of August. Isolations that I made in previous years showed that more than 80% of stems were infected by *Verticillium albo-atrum* (microsclerotial type) on this farm.

In 1976, the circles monitored on farms B and C had only a few blight periods of 10 or more consecutive hours per day with more than 90% RH, even though temperatures were 17–23 C (Figs. 4B and C). Total irrigation on these two circles was 19.4 and 40.2 cm, respectively. No blight developed on these circles or other circles on these farms in 1976.

In 1977, different circles were monitored on farms A, B, and C. All had numerous blight periods with high RH and favorable temperatures of 16–24 C from 15 July to 24 August (Figs. 5A–C). These circles received 30.7, 34.9, and 34.4 cm of water during this period, respectively. No blight developed within these circles or other circles on these farms.

Table 1. Average daily temperature, precipitation, and relative humidity (RH) for the month of August during 1958–1978[a]

Year	Temperature (C)	Precipitation (cm)	RH (%)
1958	27	0.0	32
1959	22	0.4	36
1960	22	1.1	39
1961	27	0.2	33
1962	21	1.7	42
1963	23	0.3	35
1964	21	0.4	38
1965	24	1.6	39
1966	24	0.1	30
1967	27	0.0	24
1968	22	1.6	44
1969	22	0.0	33
1970	23	0.1	30
1971	26	0.6	30
1972	24	1.3	37
1973	23	0.0	31
1974	24	0.0	33
1975	21	1.7	42
1976	21	1.6	48
1977	26	3.3	35
1978	23	4.1	42

[a]Temperature and precipitation were recorded at McNary Dam and RH at Battelle Northwest Laboratory meteorology stations (see Fig. 1).

Table 2. Mean minimum temperature and number of days at or below 0 C during December and January in winters of 1970–1979 at the McNary Dam Meteorology Station

Winter	Minimum temperature (C)	Number days at or below 0 C
1969–1970	−1	19
1970–1971	−1	16
1971–1972	−2	15
1972–1973	−5	22
1973–1974	−1	12
1974–1975	0	15
1975–1976	0	17
1976–1977	−3	26
1977–1978	−1	17
1978–1979	−3	19

DISCUSSION

Weather during the growing seasons of 1960, 1962, 1968, and 1976 was similar to that in 1975, when the epidemic of late blight occurred. However, late blight was not noted in the 1960s and recurred only in 1976 and 1977 (Table 1). Blight probably would not have developed in the 1960s, even if inoculum had been

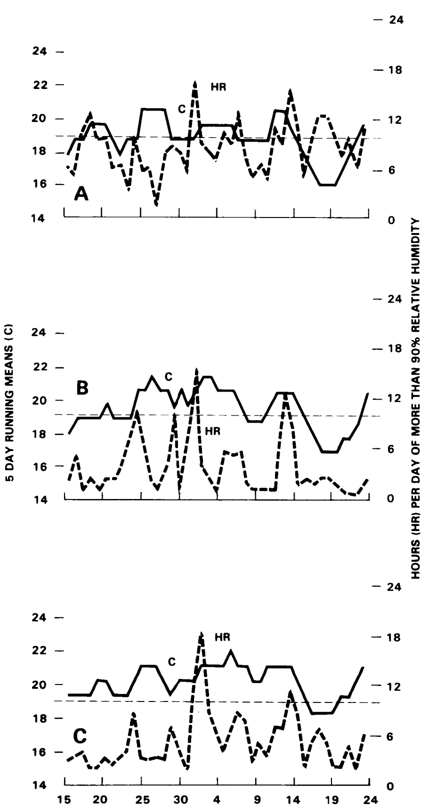

Fig. 4. Five-day running means of daily temperatures (C) and hours (HR) per day of more than 90% relative humidity in the potato vine canopy on three farms (A, B, and C) in July and August 1976.

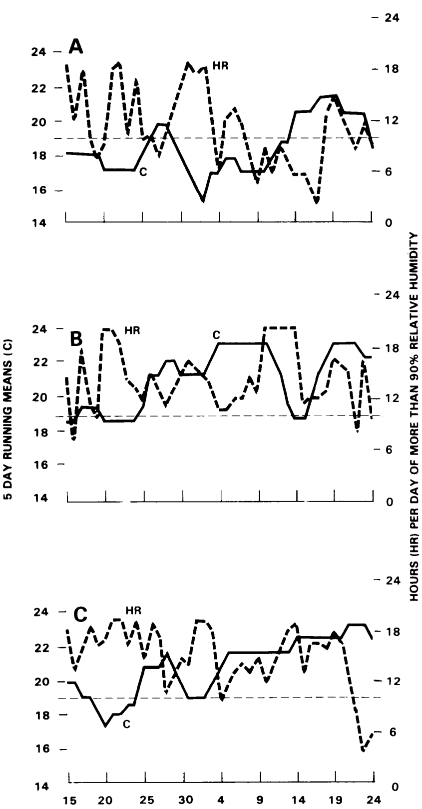

Fig. 5. Five-day running means of daily temperatures (C) and hours (HR) per day of more than 90% relative humidity in the potato vine canopy on three farms (A, B, and C) in July and August 1977.

present, because very few sprinkler irrigation systems had been installed (13).

Inoculum was apparently introduced into the area on seed potatoes planted in 1973 and 1974. A few infected, unharvested tubers that survived the mild winter of 1974–1975 probably provided the primary inoculum for the 1975 epidemic. Seed from midwestern states and northwestern Washington, where late blight occurs annually, was planted during these years (9,27). Late blight found in rotted tubers in storage during the winter of 1973–1974 indicates the presence of inoculum in 1973. Infected tubers in dump piles were probably not an important source of primary inoculum for the 1975 field epidemic. If infected tubers were in dump piles in 1974–1975, they would have been 8–16 km away and not in the prevailing wind pattern toward fields subsequently found infected (3). Other farms in Washington and across the Columbia River in Oregon nearer to dump piles reported no blight in 1975.

No late blight tuber rot was reported from the many tons of tubers stored from blighted fields in 1975. However, either a few infected tubers remained in the field and did not freeze or new inoculum was introduced on seed potatoes, because a trace of blight was found in a few circles in 1976 and 1977.

In 1975, late blight on farm A was more severe on vines from virgin soil cultivated for the first time than on vines that died by the last of August in soil cropped three to five times to potatoes. Previous stem isolations I have made from fields on this farm after three or more croppings of potatoes have shown a high incidence of *V. albo-atrum* (microsclerotial type). Sparse foliage caused by other diseases has changed the ecoclimate to arrest or limit severity of late blight (15,22).

In central Washington, late blight is apparently controlled by cold winters that destroy overwintering inoculum in the field, because it has not been reported after the colder winter of 1978–1979. Inspection of and isolations from unfrozen tubers after mild winters might determine whether inoculum has survived in the field. Careful inspection of seed lots would be equally important.

Occasional epidemics can be expected in the cultivar Russet Burbank after mild winters, especially if Verticillium wilt is controlled by chemicals or when Russet Burbank is planted on new soils. This disease might also be more important as potato cultivars resistant to Verticillium wilt become available.

Presently, our ability to forecast the occurrence and incidence of late blight is inadequate to serve as a basis for either effective or economical application of foliar fungicides. Early blight is not controlled by applications of fungicides either from aircraft (10) or through the irrigation system (G. D. Easton, *unpublished*).

ACKNOWLEDGMENT

I wish to thank Martin Pitney, Crop Protection, Umatilla, OR, for the aerial infrared pictures showing fields with late blight (Figs. 2 and 3).

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