Epidemiology of Pythium Root Rot of Mature Sugar Beets

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ABSTRACT

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Root rot epidemics of mature sugar beets, caused by *Pythium aphanidermatum*, occurred during 1978 and 1979 in Arizona. In both years, approximately 70% of the plants were either dead or infected within 30 days after the onset of infection. A mortality rate of about 2% of the sugar beet population daily was calculated. Disease onset occurred about 9 mo after planting and coincided with the occurrence of soil temperatures of at least 27 C for 12 hr or more per day at the 10-cm soil depth. Adequate soil moisture, in addition to conducive soil temperatures, was required for a sustained epidemic of root rot.

Although the genus *Pythium* is regarded primarily as a pathogen of seeds, seedlings, and immature plant tissues, some species are capable of inciting diseases of mature plant tissues. In Arizona, *Pythium aphanidermatum* (Edson) Fitzp. has been identified as the cause of a rot of taproots of mature sugar beets (*Beta vulgaris* L.) (2,4).

In central Arizona, sugar beets, an irrigated crop, are planted in late August through October. Harvest begins in mid-April and is usually completed by mid-August. Under field conditions, root rot occurs only during the summer months (June, July, and August) when ambient temperatures commonly exceed 42 C. However, the specific soil temperature(s) governing disease onset, which can vary from year to year, is not known. This paper reports the relation between specific soil temperatures and the onset and subsequent development of root rot epidemics of mature sugar beets under field conditions.

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MATERIALS AND METHODS

Temperature determinations. Temperature measurements were made primarily in an irrigated (every 12–14 days) sugar beet plot located at the University of Arizona Experiment Farm in Mesa. Soil and internal sugar beet temperatures were recorded primarily during the latter part of the growing season on an electronic recorder using copper-constantan wire thermocouples. Soil temperatures at depths of 5, 10, and 20 cm, located between adjacent sugar beets, and internal root temperatures, obtained by inserting wire thermocouples at various distances (5-, 20-, and 40-mm horizontal levels) into five 7-mo-old taproots at the 10-cm soil depth, were recorded in 1978 and 1979. In 1980, only the soil temperatures at the 10-cm depth were recorded. Soil temperatures in irrigated commercial sugar beet fields were taken at the 10-cm depth with permanently placed soil thermometers.

Disease survey and monitoring. Twenty-five commercial sugar beet fields were surveyed starting during the last week of May in 1978, 1979, and 1980. Fields were irrigated every 14–21 days. If a field was found to have a trace amount of root rot and would not be harvested for at least 21 days, a plot consisting of 20 contiguous rows, each 403 m long, was randomly selected and marked. At about 3-day intervals, between 90 and 140 sugar beets were systematically dug and assessed as follows: A sugar beet was selected every 10 m while traversing the length of two or three rows chosen arbitrarily within the plot. Sugar beets were recorded as healthy, infected (root lesions observed), or dead. These data provided an estimate of the incidence of infection on each sampling date and the mortality rate. From these values, coupled with acreage and sugar production data from the refiner, we estimated losses due to root rot.

RESULTS

Temperature data. Mean soil temperature at the 10-cm depth in an irrigated sugar beet field for 1978 and 1980 (Fig. 1) increased approximately 0.5 C per day during the latter part of the growing season. In 1978, the rapid increase in temperatures started in mid-May, whereas in 1979 and 1980 it started about 3 wk later. Soil temperatures in 1979 were comparable to those in 1978. The internal temperatures of mature sugar beet taproots were nearly the same as the soil temperature at the 10-cm depth (Fig. 2). No significant differences were recorded in the temperatures recorded at various internal depths within the taproot. Soil temperature differences between the 5- and 20-cm soil depth varied by as much as 4.6 C on any given day during the growing season and by as much as 3 C between the 10- and 20-cm soil depth (Fig. 2).

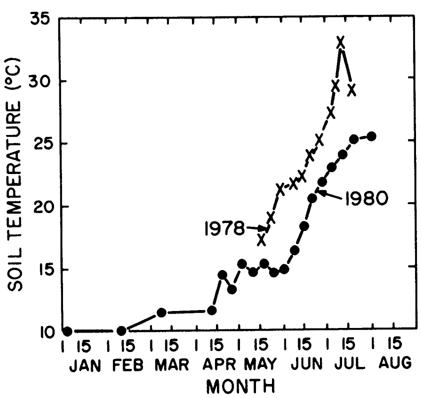


Fig. 1. Mean weekly temperatures at the 10-cm soil depth in an irrigated sugar beet field in Arizona.

Onset of disease. The onset of disease in commercial sugar beet fields occurred during the last week of June in 1978 and approximately 3 wk later in 1979 (Fig. 3). In these 2 yr, the onset of disease coincided with the occurrence of a mean soil temperature at the 10-cm depth of about 27 C. No disease occurred in 1980, a year in which the mean soil temperature at the 10-cm depth never exceeded 25 C.

On the basis of examination of more detailed temperature data (Fig. 4), the onset of disease in 1978 and 1979 coincided with soil temperatures of 27 C or greater for at least 12 hr per day. Prior to the onset of disease, irrigation had a dramatic effect on reducing the number of hours per day in which the soil temperature exceeded 27 C. As the season progressed, however, the time of recovery of soil temperatures to preirrigation values (i.e., hours per day greater than 27 C) decreased until little or no reduction was recorded (Fig. 4).

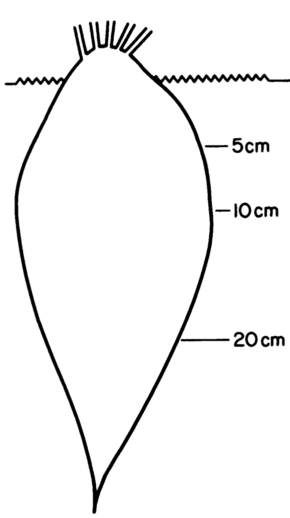
Disease development. In 1978 and 1979, approximately 70% of the sugar beet populations in the survey plots were either dead or infected within 30 days of the onset of the disease. Figure 3 shows the progress of both epidemics measured as percent mortality and percent live beets infected.

In 1978, the incidence of disease (percentage of the living population infected) approached an asymptote of approximately 27% within 6–7 days after the onset of the epidemic. A similar pattern was emerging in 1979, but the incidence of disease declined about 7 days after the onset of the epidemic. At that time, irrigation had been cut off for 2.5 wk. When irrigation was resumed on 27 July, the incidence of disease steadily increased and reached an asymptote of about 27%. In both 1978 and 1979, the asymptote coincided with the occurrence of soil temperatures of 27 C or greater for 24 hr per day at the 10-cm depth.

The mortality rates for the 2 yr were numerically similar. For 1978, the linear relationship between Y (percent dead) and t (time in days from the start of measurement) was: $Y = 9.57 + 2.25\ t$, $R^2 = 0.95$. For 1979, the relationship was described by: $Y = 2.77 + 1.49\ t$, $R^2 = 0.98$. These equations indicate a mortality rate in the vicinity of 2% of the population per day. Because the mean sugar yields per unit area are known for these years, as are the mean plant densities, the loss per hectare was calculated. In 1978, a mortality rate of 225/10,000 beets/day (1,500/ha/day) resulted in a sugar loss rate of 150 kg/ha/day. In 1979, a mortality rate of 150/10,000 beets/day (1,000/ha/day) gave a sugar loss rate of 90 kg/ha/day.

DISCUSSION

Root rot of mature sugar beets, caused by *P. aphanidermatum*, occurs only within the latter 2–3 mo of the summer harvest season. The disease does not occur in every field, and onset, if and when disease does occur, can vary from



Depth	June 8	June 14	June 23	June 28	July 3	July 8	July 12	
5cm	23.8	24.0	27.5	28.1	28.4	31.2	33.8	SOIL
10cm	22.6	22.8	25.7	26.0	27.3	30.0	32.5	SOIL
	22.4	22.7	25.3	26.0	26.8	29.5	32.0	BEET
20cm	21.6	22.0	23.6	24.5	25.5	26.8	29.2	SOIL

Fig. 2. Mean soil and internal sugar beet taproot temperatures on selected dates during the last 2 mo of the 1978 growing season in Arizona.

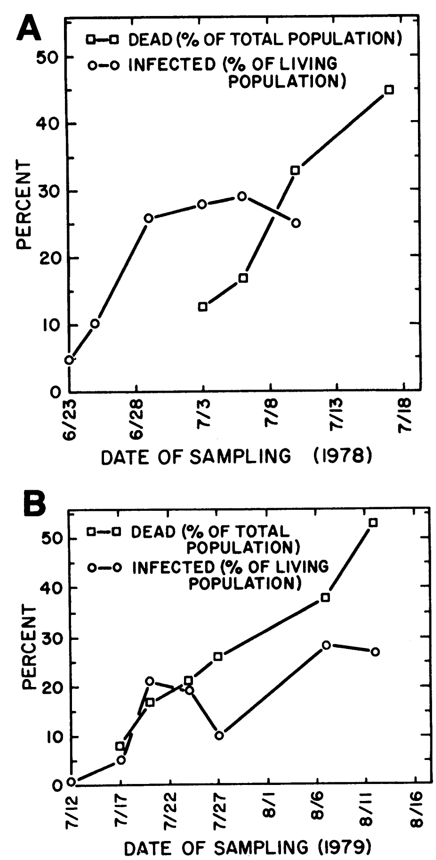


Fig. 3. *Pythium aphanidermatum* infection and mortality of mature sugar beets in a commercial field during **(A)** 1978 and **(B)** 1979.

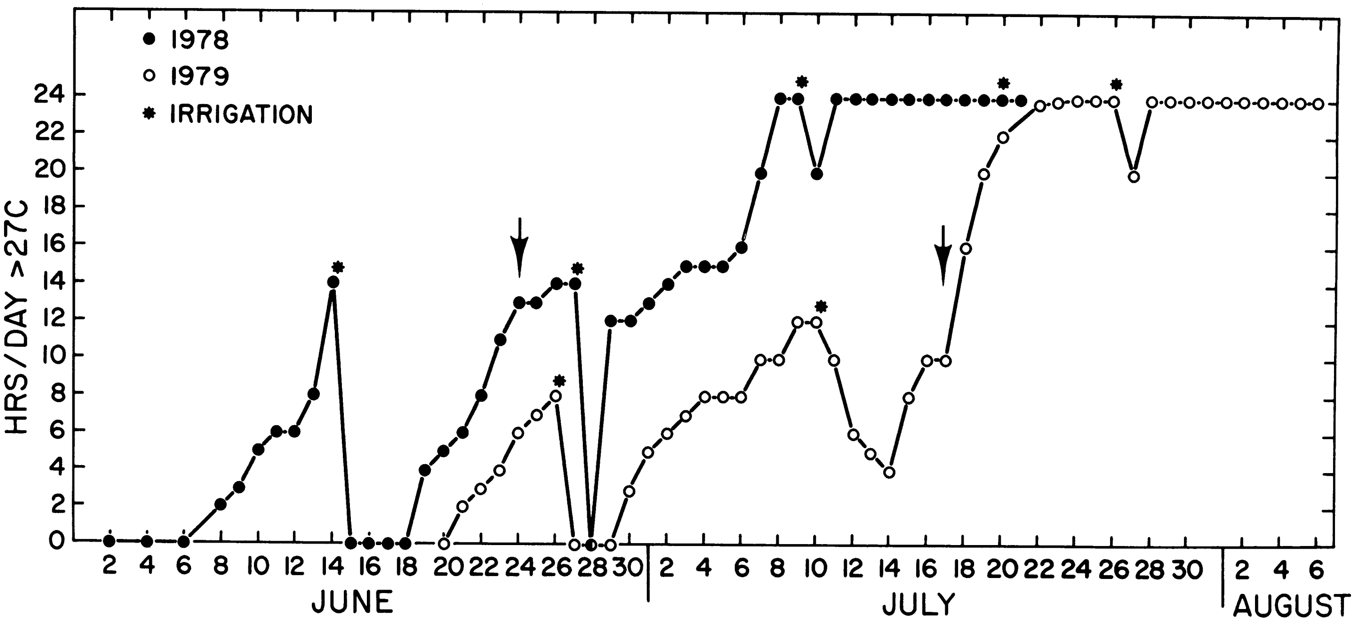


Fig. 4. Number of hours per day in 1978 and 1979 in which temperatures of 27 C or greater were recorded at the 10-cm soil depth in an irrigated sugar beet field. Arrows indicate the onset of root rot caused by *Pythium aphanidermatum.*

year to year. Previous studies (4) provided an explanation for the interfield variation: The pathogen is not present in every field. The fungus was not found in 26 of 52 fields surveyed, and the mean inoculum densities in infested fields varied from 1 to 25 oospores per gram of soil. Although the inoculum density necessary for an epidemic has not yet been established, in vitro estimates of the absolute inoculum potential (3) indicate an LD_{50} of 7.4 oospores per gram of soil. The oospore population density at the onset of the epidemic in 1979 (none was estimated in 1978) was 17 ± 3 oospores per gram of soil (authors, *unpublished*).

The results of our current investigation indicate that the seasonal variation in the onset of disease in infested fields is apparently governed by the onset of specific soil temperatures that are conducive to infection and subsequent disease development. The onset of infection, which occurred approximately 9 mo after planting in 1978 and 1979, coincided with the occurrence of soil temperatures of 27 C for at least 12 hr per day at the 10-cm soil depth. The occurrence of such temperatures varies from year to year, and in some years (e.g., 1980) such temperatures are not reached before harvest. These results indicate that the fungus, under field conditions, is very exacting in its requirements for successful penetration and infection. The extreme sensitivity of *P. aphanidermatum* to soil temperature is dramatically illustrated by a highly unusual outbreak of sugar beet root rot in a commercial field in late April 1981. The mean soil temperature at the 10-cm depth in April was 18 C. Dead and infected sugar beets (approximately 40% of the population) were confined to the head end (first 30 m) of a 40-ha field, rather than the more common occurrence at the tail end of an irrigated field. The reason for this apparent anomaly between the onset of disease and presumed suboptimal soil temperatures most likely resides in the fact that this particular field was irrigated with water from a geothermal well, the temperature of which was 38 C. Apparently, the soil temperature at the head end of the field was elevated sufficiently, at least for the first 30 m, to trigger the onset of root rot approximately 2 mo in advance of the normal occurrence of the disease.

Although a conducive temperature is required for the onset of an epidemic, it is not the only determining environmental parameter. Analysis of the epidemic in 1979 indicates that soil moisture, a known environmental factor favoring the absolute inoculum potential of *P. aphanidermatum* (3), is equally important. In 1979, the infection rate fell dramatically (Fig. 3B) when irrigation was cut off, even in the presence of conducive soil temperatures. When irrigation was resumed, the infection rate returned to its original level. Thus, both adequate soil moisture and temperature are required for a sustained epidemic of root rot. Obviously, when both environmental factors are acting in concert, root rot can be extremely destructive. As shown in Figure 3, approximately 70% of the crop was either infected or dead within 30 days after the onset of infection. Although the proximity of disease occurrence to harvest precludes chemical control, various cultural methods of control may be feasible. Known infested fields, once an inoculum threshold has been established, could be avoided, scheduled for early harvest, or scheduled for immediate harvest at the onset of disease-conducive soil temperatures. Additionally, the frequency and duration of irrigation could be manipulated, which may reduce soil temperatures and/or plant stress. Sugar beets, in addition to other crops in Arizona, are commonly irrigated every 14–21 days for periods ranging from 24 to 48 hr. Saturated soil conditions for such extended durations would tend to favor the fungus and possibly increase host susceptibility. Increased host susceptibility after saturated soil conditions for 24 hr or longer, particularly after a water stress imposed by infrequent application of water, has been reviewed (1). Thus, decreasing the duration and increasing the frequency of irrigation may reduce plant stress.

LITERATURE CITED

1. Duniway, J. M., and Gordon, T. R. 1986. Water relations and pathogen activity in soil. Pages 119-137 in: Water, Fungi and Plants. P. G. Ayres and L. Boddy, eds. Cambridge University Press, London. 413 pp.
2. Hine, R. B., and Ruppel, E. G. 1969. Relationship of soil temperature and moisture to sugarbeet root rot caused by *Pythium aphanidermatum* in Arizona. Plant Dis. Rep. 53:989-991.
3. Stanghellini, M. E., Stowell, L. J., Kronland, W. C., and von Bretzel, P. 1983. Distribution of *Pythium aphanidermatum* in rhizosphere soil and factors affecting expression of the absolute inoculum potential. Phytopathology 73:1463-1466.
4. Stanghellini, M. E., von Bretzel, P., Kronland, W. C., and Jenkins, A. D. 1982. Inoculum densities of *Pythium aphanidermatum* in soils of irrigated sugar beet fields in Arizona. Phytopathology 72:1481-1485.