EFFECT OF SOIL TEMPERATURE ON POTATO RING ROT[1]

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INTRODUCTION

Ring rot of potatoes (*Corynebacterium sepedonicum* [Spiek. and Kotth.] Skapt. and Burkh) has been investigated but little in the United States during the past 5 years, possibly indicating that it is now of little economic importance. On the other hand, potato ring rot is becoming of increasing importance in northern Europe, especially in the Soviet Union. Seed control officials in Sweden were aware of the existence of the disease in that country in 1958 (Gunnar Nielsson-Leissner, personal communication) but expressed optimism concerning its control in the light of the success the Germans had by planting whole seed tubers and carefully roguing infected plants. In 1965 the disease was still a problem in Sweden (E. Hagsand, personal communication).

Control of ring rot, either by roguing (which has not been effective in the United States) or by seed certification (which has resulted in commercial control) is dependent upon detection of diseased plants. For practical reasons, detection depends upon visible symptoms in the growing plant although for some purposes staining or serological techniques may be used to detect the bacteria. The development of symptoms depends upon a number of factors, one of which is temperature.

The optimum temperature for the causal organism is 20-23 C, according to Bergey's Manual (1). According to Sherf (3) it is 18 C. According to tests with isolates from Minnesota and Alaska, the optimum temperature is between 10 C and 15 C. Obviously there are different temperature optima, depending upon isolates or on testing techniques, but in any case the optimum temperature is lower than that for the growth of the potato plant.

In tests made during the present studies, the optimum soil temperature for top growth of potatoes was 28 C. This agrees very closely with Gaumann (2) who reported the optimum to be 28.3 C. The best temperature for tuberization probably is lower than that for foliar growth.

Although ring rot has not been a serious problem in Alaska for at least 5 years, it still causes occasional serious loss to individual growers. It is the purpose of this paper to present information on the effect of temperature on potato ring rot which indicates why the disease is more difficult to control in northern areas like Alaska than it is farther south.

MATERIALS AND METHODS

Thirty-two seed pieces were inoculated and planted in Wisconsin type, soil temperature tanks at each of the following temperatures: 16, 19, 22, 25, 28, 31, and 34 C. The seed pieces were single eyes cut from tubers of the variety Irish Cobbler. The seed pieces were cone shaped so the

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vascular ring was exposed all around the eye and about ½ inch from it. They were inoculated by soaking 3 minutes in a suspension of bacterial ooze from infected tubers and planted immediately after inoculation. Forty-two days after planting symptoms of wilt had appeared on plants at each temperature except 34 C. Thereafter for 11 days severity of symptoms was estimated, once a day for the first four days and then twice a day, using a scale shown in Table 2. Plants were harvested 52 days after planting and gram stains made of smears from tubers and three locations in each stem.

Another study was made of the effect of soil temperature by planting 24 inoculated seed pieces at each of the above temperatures. Plants were removed at weekly intervals, beginning when 95% had emerged, and gram stains made of smears from stems at the base, at the ground line, and at each node.

Results

More plants had symptoms, and symptoms appeared sooner, at 25 C than at any other temperature (Table 1). Twenty-six of a possible 31 plants at 25 C had symptoms 42 days after planting whereas only one of 32 plants at 16 C and none at 34 C had symptoms at that time. Although 34 C is above the maximum temperature according to Bergey's Manual (1), the temperature of the foliage may have been less than 34 C since air temperature was not subject to the same control as the soil temperature. The data show that at 34 C the maximum number of plants with symptoms was 11 on the 48th day. This decreased to seven on the 52nd day because affected leaves died and fell off. Fluctuations in the number of plants with symptoms at 16 and 19 C was because some leaves wilted and then regained turgidity.

Not only did more plants have symptoms at 25 C but the average severity of symptoms was much greater at that soil temperature than at others tested (Table 2). At 25 C most of the diseased plants wilted completely, but at 16 C most of the affected plants were only partly wilted (Fig. 1).

Gram stains made of the tubers and stems of these plants 52 days after planting showed that the total amount of infection of stems varied with soil temperature in much the same way the symptoms did. There was very little difference in tuber infection, however, between 16 C and 25 C. (Table 3).

The rate of invasion of the stem from the seed piece and the spread of the bacteria up to the first node was conditioned by soil temperature; the higher the temperature, the more rapid the spread (Table 4). Infection reached the first node about the same time at 16, 19, 22, and 25 C soil temperature. In one plant grown at 31 C, bacteria were found after 80 days at the first 3 nodes and at the fifth and seventh nodes. None were found at the fourth and sixth nodes.

Discussion and Conclusions

The optimum temperature for the development of foliage symptoms of potato ring rot is very close to 25 C. Soil temperatures in the Matanuska Valley, Alaska seldom are that high during the growing season, ranging from 10 to 20 C at a depth of 2 inches. The same is very probably true

TABLE 1.—*Number of plants with ring rot symptoms at different soil temperatures.*

Date	Days after planting	Soil temperature (° C)						
		16	19	22	25	28	31	34
March 31*	42	1	7	12	26	14	4	0
April 1	43	8	15	18	28	22	12	2
April 2	44	6	12	16	27	21	10	2
April 3 (P.M.)	45	10	15	21	28	24	13	3
April 4	46	10	14	21	28	23	14	5
April 5	47	14	17	25	30	23	15	5
April 6	48	21	23	27	30	25	19	11
April 7	49	22	25	28	30	28	24	6
April 8	50	26	27	28	31	30	26	7
April 9	51	25	26	30	31	29	22	7
April 10	52	24	25	30	31	29	24	7
Total possible		32	32	31	31	32	32	30

*Planted February 17.

TABLE 2.—*Effect of soil temperature on the average severity of symptoms at different dates.*

Date	Soil temperature (°C)						
	16	19	22	25	28	31	34
3-31 P.M.	.03*	.36	.89	2.16	1.02	.17	0
4-1 P.M.	.25	.77	1.37	2.53	1.42	.53	.06
4-2 A.M.	.19	.56	.94	2.37	1.03	.59	.06
4-3 P.M.	.41	.81	1.71	2.63	1.70	.64	.10
4-4 A.M.	.36	.83	1.81	2.66	1.98	.72	.17
4-4 P.M.	.75	1.31	2.42	2.90	2.13	.77	.18
4-5 A.M.	.59	1.28	2.34	3.23	2.02	.84	.18
4-5 P.M.	1.11	1.75	2.35	3.31	2.27	1.14	.25
4-6 A.M.	1.08	1.98	2.63	3.39	2.45	1.34	.42
4-6 P.M.	1.16	1.75	2.61	3.40	2.50	1.38	.32
4-7 A.M.	1.13	1.95	2.65	3.37	2.52	1.48	.30
4-7 P.M.	1.39	2.20	3.00	3.50	.269	1.69	.42
4-8 A.M.	1.66	2.22	3.23	3.37	2.70	1.81	.38
4-8 P.M.	1.42	2.06	2.66	3.32	2.63	1.73	.43
4-9 A.M.	1.44	2.06	2.90	3.39	2.67	1.19	.45
4-9 P.M.	1.42	2.03	2.73	3.44	2.63	1.70	.45
4-10 A.M.	1.93	2.03	2.55	3.39	2.58	1.81	.47
4-10 P.M.	1.30	2.11	2.92	3.26	2.63	1.73	.50
Total number of plants	32	32	31	31	32	32	30

*Each plant was rated according to the following scale and the total ratings divided by the number of plants. 0 - no symptoms; 1 - part of the plant wilted but without chlorosis or necrosis; 2 - part of the plant wilted with chlorosis or necrosis; 3 - entire plant wilted without chlorosis or necrosis; 4 - entire plant wilted with chlorosis or necrosis; 5 - entire plant dead.

FIG. 1 EFFECT OF SOIL TEMPERATURE ON THE PERCENTAGE OF PLANTS WITH PARTIAL OR COMPLETE WILT

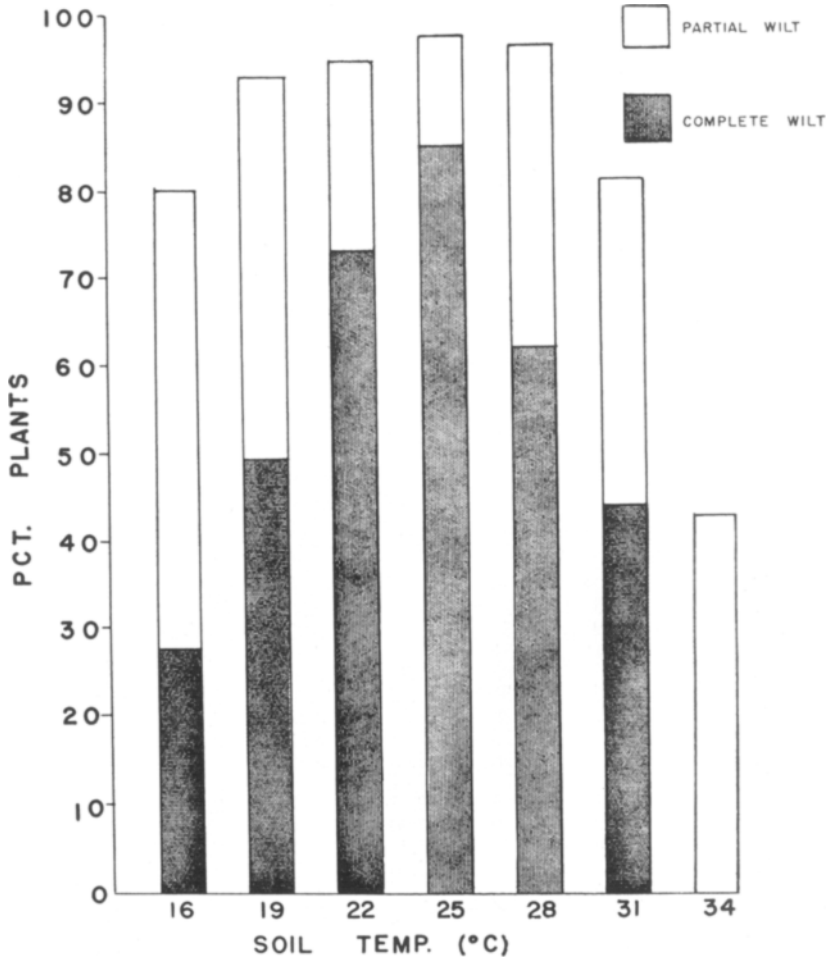

FIG. 1.—Effect of soil temperature on the percentage of potato plants with partial or complete wilt caused by *Corynebacterium sepedonicum*.

TABLE 3.—*The effect of soil temperature on the distribution of bacteria in the plants.*

	Soil temperature (°C)						
	16	19	22	25	28	31	34
Total number of plants	32	32	31	31	32	32	30
Per cent of plants with bacteria in the stems	78.1	87.5	96.8	100.0	93.8	65.6	50.0
Per cent of plants with bacteria in the tubers	50.0	56.3	51.6	54.8	56.3	28.1	13.3
Per cent of plants with bacteria in either stems or tubers	87.5	93.8	96.6	100.0	96.8	68.7	60.0
Per cent of plants with bacteria in the stems but not in the tubers*	48.0	42.9	46.7	45.2	43.3	61.9	93.3
Per cent of plants with bacteria in both the stems and the tubers	40.6	50.0	51.6	54.8	53.1	25.0	3.3

*Percentage based on the number of plants with bacteria in the stems.

TABLE 4.—*The number of days between inoculation of the seed pieces and the first appearance of the bacteria at different levels in the plant.*

	Soil temperature (°C)						
Location in plant	16	19	22	25	28	31	34
Base of stem	59	52	52	52	52	52	52
Ground line	66	73	59	59	52	52	52
First node	80	80	80	80	73	66	59

in the areas of Sweden and the Soviet Union where ring rot is now a problem.

At these temperatures symptoms would not readily be seen and roguing or detection for the purposes of certification would be correspondingly difficult. However, because just as many tubers become infected in this range of temperatures as at 25 C (Table 3) the chances of perpetuating or increasing infection within a seed lot are even greater where soil temperatures ar low.

Ring rot is, therefore, a potentially greater threat in cool areas than in warm. Where soil temperatures are 25 ± C it may be possible to eliminate ring rot by planting whole tubers and roguing infected plants. Control by this method in cool climates is extremely unlikely to succeed and detection for certification purposes very difficult.

SUMMARY

Foliage symptoms of bacterial ring rot of potatoes appear much earlier and are more severe at a soil temperature of 25 C than at 16, 19, 22, 28, 31, or 34 C. Percentages of tubers infected is about the same at temperatures between 16 and 28 C. In cold climates this could result in the spread of the disease without its detection in the field.

RESUMEN

Síntomas del follaje para pudrición de anillo bacterial de la papa (bacterial ring rot) aparecen mas pronto y son mas severos a 25 C que a 16, 19, 22, 28, 31, ó 34 C. Porcentajes de tubérculos infectados son casi los mismos a temperaturas entre 16 y 28 C. En climas frios ésto podría resultar en una dispersión no detectada de la enfermedad en el campo.

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