Martin-Gatton
College of Agriculture, Food and Environment
Cooperative Extension Service

Plant Pathology Research Report **PPRR-13**

Effects of High Tunnel Soil Solarization on *Sclerotinia sclerotiorum* in the Temperate Climate of Central Kentucky

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Introduction

Sclerotinia diseases have been reported to cause severe losses in a wide range of crops. They are especially problematic in high tunnels, where vegetable crops are planted in early spring to extend the growing season and achieve earlier harvests. *Sclerotinia sclerotiorum* forms temperature- and fungicide-resistant sclerotial structures that can persist in the soil for up to 10 years. In Kentucky, the Sclerotinia disease lettuce drop occurs in high tunnels from early-April to mid-May, when soil temperatures are cool (Figure 1).

Sclerotinia spp. favor soil conditions ranging from 42°F to 64°F, with optimal temperatures at 56°F to 59°F. Viability significantly decreases as soil temperatures reach 100°F. This makes the pathogen a suitable target for solarization. Soil solarization uses thin, transparent plastic tarps to trap heat and solar radiation to raise soil temperatures, killing soilborne pathogens. A 95% decrease in the *Sclerotinia* spp. survival rate has been achieved under solarization in warmer climates such as the southern and western United States. The effectiveness of solarization against Sclerotinia diseases had not been studied in the moderate climate of Kentucky. This study aimed to determine the maximum temperature potential of solarization at various soil depths and for different durations during different seasons and to identify temperatures at which *Sclerotinia sclerotiorum* sclerotia are killed.

Figure 1. Lettuce head showing symptoms of lettuce drop. Leaves are dulled, yellowed, and wilted, with the head flattening from the outer leaves inward.
(photo: Kim Leonberger, UK).

Methods and Materials

Experiments examining the effects of soil solarization on *S. sclerotiorum* were conducted in 2022 and 2023 at the University of Kentucky Horticulture Research Farm in Lexington, KY.

Each year, experiments were conducted in spring (April), summer (July), and fall (September), with solarization durations of 2, 4, and 6 weeks. Plots were irrigated to reach soil moisture of 70% field capacity and then sclerotia were buried in mesh packets (Figure 2A) at 2, 4, and 6 inches. Solarization treatment plots were covered with a single layer of clear 6-mil polyethylene plastic, and all edges of the plastic tarp were buried in shallow trenches to seal and maintain heat and moisture (Figure 2B). The tunnel was completely closed during solarization. After solarization at each time point was complete, sclerotia were removed and, viability was accessed assessed daily under lab conditions.

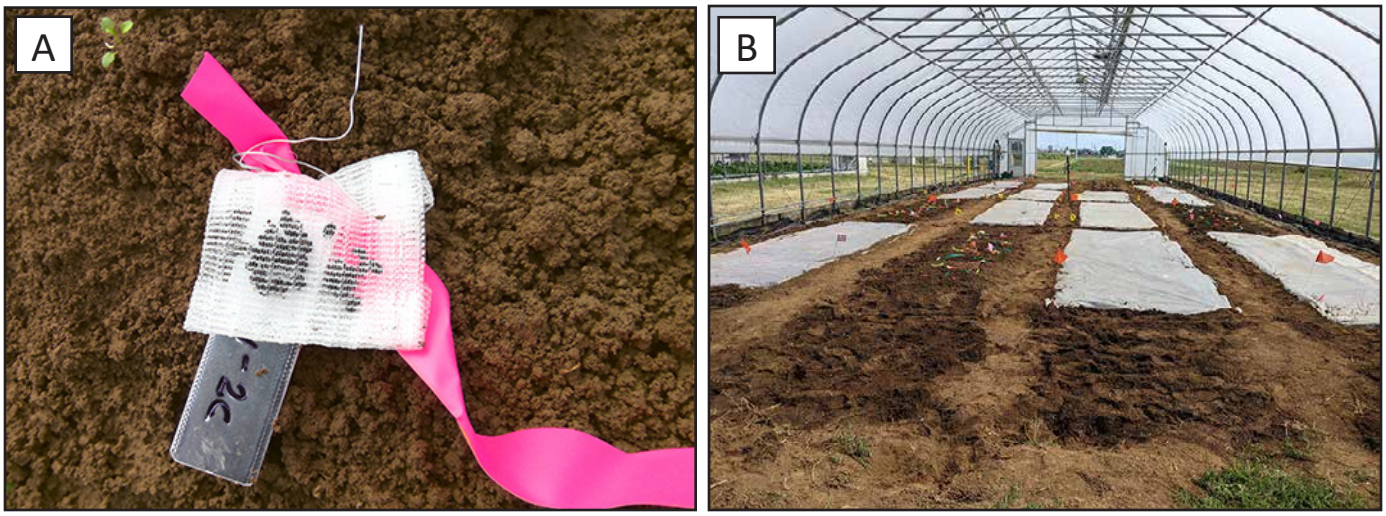

Figure 2. High tunnel soil solarization conducted in Lexington, Kentucky, in 2022 and 2023. (**A**) Mesh packets with sclerotia of *Sclerotinia sclerotiorum* were buried in each treatment plot. (**B**) Solarized plots were covered with plastic, while nonsolarized plots were bare soil. (Photos: Kim Leonberger, UK)

Results

In both years, accumulation of hours ≥ 104 °F was greatest in summer, followed by fall and spring. Overall, soil temperatures were highest in July for both years. The highest average daily maximum soil temperature was 120° F during the summer 6-week solarization treatment in 2022. A summary of results regarding the survival of sclerotia under specific treatments follows.

- **Solarized vs. Nonsolarized:** Sclerotial survival was generally reduced in solarized treatments compared to nonsolarized treatments.

- **Duration:** Fewer sclerotia survived in the 4- and 6-week solarization treatments than in the 2-week treatments. However, the 4- and 6-week solarizations were similar in effectiveness.

- **Depth:** Soil temperatures were highest at the 2-inch depth and lowest at the 6-inch depth. Sclerotia had a lower survival rate under solarization in the shallow soil than at greater depths.

Practical Applications for Growers

This study examined soil temperatures and the survival of *S. sclerotiorum* under solarization in a closed high tunnel. Summer solarization effectively reduced sclerotial survival in as few as two weeks.

Results from nonsolarized treatments also suggested that closing high tunnels during the hottest period of summer may effectively reduce soilborne pathogens. Spring and fall solarization treatments yielded more variable results. Temperatures were lower in the spring and fall compared to summer, requiring longer solarization durations to reduce sclerotia survival. Soil solarization likely becomes more effective in the spring as temperatures increase and less effective in the fall as temperatures decrease.

As Sclerotinia diseases become more prominent and effective fungicides are limited for use in high tunnels, solarization should be considered for disease management for both conventional and organic high tunnel growers in temperate climates.

Table 1. Maximum temperatures at different depths during soil solarization at different times of the year for different durations compared to nonsolarized bare soil in a high tunnel in Lexington, Kentucky, in 2022 and 2023: (**A**) Spring 2022 (**B**) Summer 2022 (**C**) Fall 2022 (**D**) Spring 2023 (**E**) Summer 2023 (**F**) Fall 2023.

(A) Spring 2022

Treatment[i]	Soil depth (in)	Daily temperature (°F)			Accumulated hours[ii]		
		Maximum	Minimum	Mean	≥ 86 °F	≥ 104 °F	Sclerotial Survival (%)
2-wk solarized	2	80.8	64.6	71.8	28	0	26
	4	80.9	64.6	71.8	30	0	18
	6	75.9	65.7	70.2	0	0	23
4-wk solarized	2	93.4	72.1	81.5	221	37	5
	4	93.9	72.3	81.9	224	41	27
	6	86.5	73.9	79.5	215	0	29
6-wk solarized	2	100.4	76.3	86.9	376	150	0
	4	97.5	76.8	86.2	397	112	2
	6	91.4	78.1	84.2	433	38	22
2-wk nonsolarized	2	73.2	57.9	64.9	0	0	33
	4	73.4	58.1	64.9	0	0	31
	6	69.1	60.3	64.4	0	0	37
4-wk nonsolarized	2	80.9	63.9	71.6	57	0	27
	4	80.8	63.7	71.4	66	0	11
	6	75.6	65.8	70.3	1	0	22
6-wk nonsolarized	2	84.7	67.8	75.6	185	0	16
	4	85.5	67.8	75.9	198	0	8
	6	80.1	69.8	74.7	105	0	22

(B) Summer 2022

Treatment[i]	Soil depth (in)	Daily temperature (°F)			Accumulated hours[ii]		
		Maximum	Minimum	Mean	≥ 86 °F	≥ 104 °F	Sclerotial Survival (%)
2-wk solarized	2	118.2	91	103.3	178	137	0
	4	114.6	90.9	101.8	193	124	0
	6	107.4	92.7	99.5	225	97	0
4-wk solarized	2	118.2	92.1	103.6	377	275	0
	4	115.7	92.8	102.9	387	266	0
	6	109.2	94.8	101.1	421	236	0
6-wk solarized	2	118.2	90.9	102.7	599	384	0
	4	112.3	92.5	101.3	651	341	0
	6	105.3	93.4	98.8	772	218	0
2-wk nonsolarized	2	102.6	80.8	90.3	149	43	1
	4	104.7	80.9	91.4	142	56	0
	6	93.7	83.7	88.3	217	0	5
4-wk nonsolarized	2	102	82	90.7	348	80	0
	4	101.8	82.9	91.2	377	84	0
	6	94.1	84.9	89.2	496	0	1
6-wk nonsolarized	2	100	81.5	89.6	527	80	0
	4	97.3	82.8	89	575	84	1
	6	92.1	84.6	87.9	688	0	6

[i]Treatments included solarized soil and a nonsolarized bare soil control for 2-weeks, 4-weeks, and 6-weeks.
[ii] Number of hours when the temperature was within each temperature interval.

Table 1. (cont'd) Maximum temperatures at different depths during soil solarization at different times of the year for different durations compared to nonsolarized bare soil in a high tunnel in Lexington, Kentucky, in 2022 and 2023: (**A**) Spring 2022 (**B**) Summer 2022 (**C**) Fall 2022 (**D**) Spring 2023 (**E**) Summer 2023 (**F**) Fall 2023.

(C) Fall 2022

Treatment[i]	Soil depth (in)	Daily temperature (°F)			Accumulated hours[ii]		
		Maximum	Minimum	Mean	≥ 86 °F	≥ 104 °F	Sclerotial Survival (%)[iii]
2-wk solarized	2	105.8	**84.4**	**94.3**	224	56	
	4	102	85.8	93.6	257	36	3
	6	98.4	87.3	92.7	298	2	14
4-wk solarized	2	103.8	82.2	91.9	396	87	0
	4	101.1	84.2	92.1	467	61	1
	6	96.6	86	91	522	15	4
6-wk solarized	2	99.1	79.2	88.2	440	107	2
	4	94.8	80.8	87.3	496	49	1
	6	95.7	81.9	88.2	563	41	2
2-wk nonsolarized	2	93.2	74.5	82.8	113	0	3
	4	90	76.3	82.6	94	0	15
	6	87.3	77.5	82.2	62	0	6
4-wk nonsolarized	2	89.2	71.2	79.2	152	0	5
	4	86.5	73.2	79.3	132	0	9
	6	84.2	75	79.3	94	0	8
6-wk nonsolarized	2	84.6	68.2	75.7	149	0	1
	4	82.6	70.5	76.1	136	0	8
	6	80.4	72.5	76.3	97	0	2

(D) Spring 2023

Treatment[i]	Soil depth (in)	Daily temperature (°F)			Accumulated hours[ii]		
		Maximum	Minimum	Mean	≥ 86 °F	≥ 104 °F	Sclerotial Survival (%)[iii]
2-wk solarized	2	98.2	69.4	82.2	95	28	12
	4	92.5	70.9	80.8	101	10	26
	6	86	71.4	78.1	73	0	19
4-wk solarized	2	97	70.9	82.6	187	39	6
	4	92.8	72	81.7	189	18	15
	6	85.1	73.4	78.8	115	0	14
6-wk solarized	2	95.2	72.5	82.8	308	34	5
	4	90.9	73.2	81.3	278	8	7
	6	84.7	74.3	79.2	135	0	8
2-wk nonsolarized	2	82.4	59.2	70	38	0	36
	4	79.5	60.8	69.6	18	0	31
	6	75.9	62.4	68.7	0	0	26
4-wk nonsolarized	2	83.1	60.6	70.9	68	0	18
	4	80.4	62.2	70.7	34	0	17
	6	76.6	64	70	0	0	16
6-wk nonsolarized	2	84.6	63	72.9	115	0	7
	4	81.7	64.6	72.5	8	0	10
	6	78.1	66	71.6	0	0	8

[i]Treatments included solarized soil and a nonsolarized bare soil control for 2-weeks, 4-weeks, and 6-weeks.
[ii] Number of hours when the temperature was within each temperature interval.

Table 1. (cont'd) Maximum temperatures at different depths during soil solarization at different times of the year for different durations compared to nonsolarized bare soil in a high tunnel in Lexington, Kentucky, in 2022 and 2023: (**A**) Spring 2022 (**B**) Summer 2022 (**C**) Fall 2022 (**D**) Spring 2023 (**E**) Summer 2023 (**F**). Fall 2023.

(E) Summer 2023

Treatment[i]	Soil depth (in)	Daily temperature (ºF)			Accumulated hours[ii]		
		Maximum	Minimum	Mean	≥ 86 °F	≥ 104 °F	Sclerotial Survival (%)[iii]
2-wk solarized	2	115.2	91.2	102.2	202	127	0
	4	109.4	92.1	100.2	231	99	0
	6	105.3	92.1	98.2	257	71	0
4-wk solarized	2	114.8	91.9	102.4	397	267	0
	4	110.5	93.6	101.5	431	235	0
	6	107.8	94.3	100.8	455	210	0
6-wk solarized	2	111.9	90.9	102.9	665	327	0
	4	109	92.1	102	709	291	0
	6	104	92.7	98.1	802	195	0
2-wk nonsolarized	2	96.8	80.8	88.2	184	2	2
	4	93.2	82	87.4	191	0	3
	6	91	82.6	86.5	182	0	3
4-wk nonsolarized	2	96.4	81.5	88.5	405	2	2
	4	92.8	82.8	87.6	417	0	0
	6	91	83.5	87.1	424	0	1
6-wk nonsolarized	2	94.5	81.1	88.5	526	2	2
	4	91	82.2	87.6	496	0	0
	6	89.4	82.9	87.1	480	0	2

(F) Fall 2023

Treatment[i]	Soil depth (in)	Daily temperature (ºF)			Accumulated hours[ii]		
		Maximum	Minimum	Mean	≥ 86 °F	≥ 104 °F	Sclerotial Survival (%)[iii]
2-wk solarized	2	104.2	80.4	91.8	169	45	15
	4	100.8	81.5	91	202	25	25
	6	96.3	82.8	89.8	246	0	21
4-wk solarized	2	105.1	81.1	91.8	344	92	2
	4	100.9	82.9	91.2	445	33	9
	6	97	84.2	90.3	526	0	14
6-wk solarized	2	97.5	78.4	87.1	418	78	9
	4	95.4	79.3	86.7	478	38	13
	6	93.2	80.6	86.5	541	0	16
2-wk nonsolarized	2	91.2	72.5	81	89	0	15
	4	88.7	74.3	81	81	0	23
	6	86	75.6	80.6	40	0	24
4-wk nonsolarized	2	91.9	73.2	81.5	197	0	7
	4	90	75	81.9	186	0	16
	6	86.7	76.3	81.3	110	0	9
6-wk nonsolarized	2	88	70.5	78.3	211	0	12
	4	86.4	72.5	78.8	194	0	7
	6	83.5	73.9	78.4	110	0	10

[i]Treatments included solarized soil and a nonsolarized bare soil control for 2-weeks, 4-weeks, and 6-weeks.
[ii] Number of hours when the temperature was within each temperature interval.

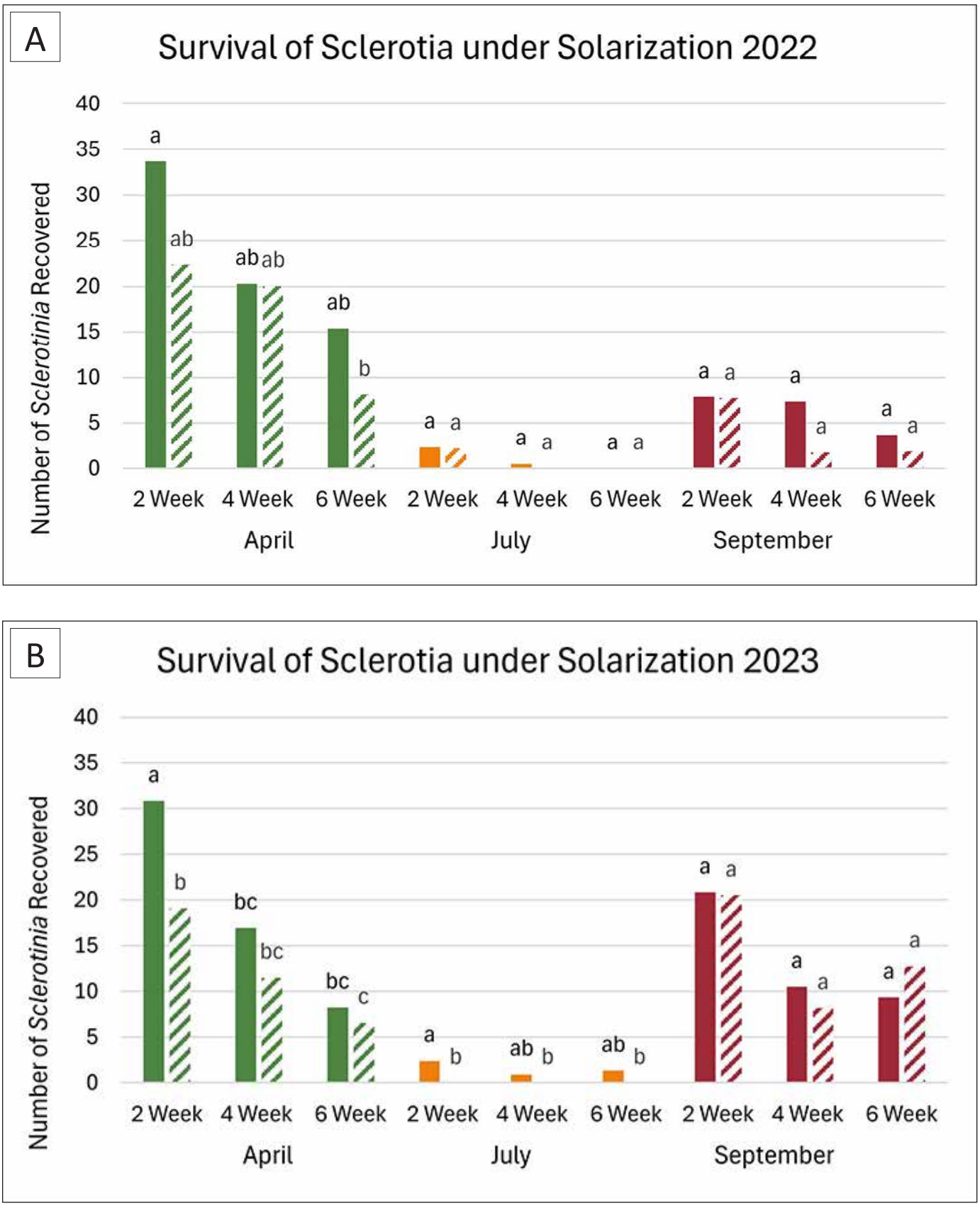

Figure 3. Percentage survival of *S. sclerotiorum* sclerotia from the closed high tunnel for 2-week, 4-week, and 6-week solarized and nonsolarized plots in the spring, summer, and fall of 2022 and 2023. Percent recovery for each plot within each month with the same letters are not statistically different. Solid bars denote nonsolarized treatment and striped bars denote solarized treatments: (**A**) 2022 (**B**) 2023.

Table 2. Comparison of *Sclerotinia sclerotiorum* sclerotial viability, measured as percent germination, in nonsolarized and solarized treatments within each depth, solarization, and duration-month-year condition. Numbers in bold indicate significant differences in survival between solarized and nonsolarized treatments.

Time	Treatment	Percent Survival								
		2 week			4 week			6 week		
		2 in	4 in	6 in	2 in	4 in	6 in	2 in	4 in	6 in
Apr 2022	Nonsolarized	33	**31**	37	**27**	11	22	**16**	8	22
	Solarized	26	**18.3**	22.8	**5.3**	26.5	29	**0.3**	1.8	22.3
Apr 2023	Nonsolarized	**35.5**	30.8	26.3	**18.3**	16.8	15.8	7	9.5	8.3
	Solarized	**11.8**	26.3	19.3	**5.8**	15.3	13.5	5	6.5	8.3
Jul 2022	Nonsolarized	1	0.3	5.3	0.3	0.3	1	0	1	6
	Solarized	0	0	0	0	0	0	0	0	0
Jul 2023	Nonsolarized	1.5	3.3	2.5	2	0.3	0.5	1.5	0.3	2.3
	Solarized	0	0	0	0	0	0	0	0	0
Sep 2022	Nonsolarized	3	14.8	**5.8**	**4.8**	**9**	8.3	1.3	**7.8**	2
	Solarized	6	3	**14**	**0**	**1**	4.3	2.3	**1**	2.3
Sep 2023	Nonsolarized	15	23.3	24.3	**7**	**15.8**	**8.8**	11.5	7	9.5
	Solarized	15.3	25	21.3	**1.8**	**8.5**	**14.3**	9	13.3	16

July 2025

Complete research study can be found at

Rachel E. Rudolph, Edward Dixon, Kimberly Leonberger, Misbakhul Munir, Kathryn Pettigrew, Martín Polo, Henry S. Smith, April Lamb, Nicole A. Gauthier. Effects of High Tunnel Soil Solarization on *Sclerotinia sclerotiorum* in the Temperate Climate of Central Kentucky. Plant Disease. https://doi.org/10.1094/PDIS-07-24-1550-RE