Effects of Cultivars and Cultural Practices on Sclerotinia Stem Rot of Soybean

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ABSTRACT

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Sclerotinia stem rot of soybean was studied in naturally infested field plots at two locations. Soybean cultivars Hodgson and Corsoy were less diseased than Wells, SRF-200, Steele, and Asgrow 2656. Disease severity indices (DSI) (0 = no disease, 100 = 100% death) were greater for all cultivars planted at row widths of 25–38 cm compared with DSI at row widths of 76 cm for 2 of 3 yr. Yields were lower for soybeans grown at row widths of 25–38 cm than for row widths of 76 cm for all years. Disease severity was greater in irrigated plots than in plots that were not irrigated either before or after flowering. Yields were improved 10–22% by reducing disease severity through reduced irrigation before the R1 growth state (early flowering). Although the amount of precipitation and supplemental irrigation influenced disease severity, air temperatures were also associated with disease development.

Sclerotinia stem rot of soybean (*Glycine max* (L.) Merr.), caused by *Sclerotinia sclerotiorum* (Lib.) de Bary (= *Whetzelinia sclerotiorum* (Lib.) Korf & Dumont), is not a common disease (5,10,12,13,20), but its incidence and severity have increased in several regions of Wisconsin, especially when soybeans have been grown following another susceptible crop that was severely diseased (11). Wisconsin's soybean acreage has expanded into the central and northern regions of the state, where susceptible crops such as snap bean (*Phaseolus vulgaris* L.) or sunflower (*Helianthus annuus* L.) are grown in rotation with soybean. Cool temperatures that favor Sclerotinia stem rot prevail in these areas (1,22). The disease was also observed in eastern Wisconsin, especially in counties that border Lake Michigan.

Along with an expanding soybean acreage in Wisconsin, changes have occurred in cultural practices for maximization of yield. Such cultural practices include planting soybeans at narrow row widths (38 cm or less) rather than the traditional row widths of 76–97 cm (6,7,15). Severity of white mold has been reported greater for Great Northern beans planted at narrow row widths (19) or where a dense canopy structure was present (8,18,21,22). Disease reactions of soybean (10,11) and Great Northern bean (3,18) cultivars are reported to differ, but the influence of row width on their relative ranking has not been reported.

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Soybeans are frequently irrigated in Wisconsin when grown in rotation with vegetable crops on sandy soils. The effect of irrigation management on Sclerotinia stem rot of soybean has not been investigated, but cool temperatures and moisture that favor the disease are expected to occur with irrigation (1,17,22).

This report describes our findings on the effects of soybean cultivars, row width, and irrigation regimes on Sclerotinia stem rot and on the relationship between disease severity and soybean yield.

MATERIALS AND METHODS

Plots were established in fields naturally infested with *S. sclerotiorum* in Racine County (loam soil) in 1977, 1978, and 1980 and at the University of Wisconsin Experimental Farm at Hancock (Plainfield sandy loam) in 1979 through 1981. Field locations were initially selected because *S. sclerotiorum* had caused severe disease in the previous year's crop, creating a high disease potential at each location.

Field preparation, weed control, and planting. Seedbeds were prepared by fall plowing and disking twice before planting at both locations. At Racine, trifluralin was preplant incorporated at 0.84 kg a.i./ha for weed control. Linuron and alachlor were applied before emergence at rates of 1.2 and 3.3 kg a.i./ha, respectively, at the Hancock experimental farm. Bentazon was applied for postemergence weed control 3 wk after planting at a rate of 1.65 kg a.i./ha in 2.2 L crop oil per hectare at Racine in 1980 and Hancock in 1981. Plots were hand weeded as necessary throughout the growing season.

Soybeans were planted with a V-belt hand planter at Racine and a John Deere Max-Emerge planter at the Hancock experimental farm. Seeding rates were 12, 20, 30, and 32 seeds per meter of row for row widths of 25, 38, 76, and 91 cm, respectively.

Effects of cultivar and row width on Sclerotinia stem rot. Cultivar and row-width studies were all conducted in Racine County. Soybean cultivars Corsoy, Wells, Hodgson, Steele, Asgrow 2656, and SRF 200 were planted on 20 May 1977 in plots 6 m long consisting of two rows 76 cm apart or four rows 38 cm apart. In 1978, only Wells soybeans were planted on 22 May at identical row widths. The design for both years was a randomized complete block with four replicates of each cultivar and row width.

In 1980, Corsoy and Wells soybeans were planted on 22 May and plots were 11.7 m long and 5 m wide with row spacings of either 76 or 25 cm. Each plot was separated by 1.3 m on each side to minimize the influx of inoculum from outside each plot. A randomized complete block design was used and each cultivar replicated six times within each row width.

Effects of irrigation regimes on severity of Sclerotinia stem rot. The effect of irrigation on Sclerotinia stem rot of soybean was studied at the University of Wisconsin Experimental Farm at Hancock. Wells soybeans were planted between 15 and 19 May 1979 through 1981. Plots consisted of six rows 91 cm apart and 10–11 m long. Irrigation regimes employed and the combined amount of precipitation and irrigation water applied in 1979, 1980, and 1981, respectively (in parentheses), were 1) biweekly irrigation throughout the growing season (63.5, 79.2, and 58.1 cm), 2) preflower irrigation only on a biweekly basis (55.6, 68.8, and 37.3 cm), and 3) post flower irrigation only on a biweekly basis (59.8, 66, and 48 cm). Each regime was replicated six times in a randomized complete block design. Solid-set irrigation equipment was used and irrigation treatment areas were separated by a 15.4-m buffer area planted to soybean.

Disease severity evaluation. At the Racine County locations, disease severities were estimated on 10 September 1977, 8 September 1978, and 3 September 1980, when plants were in the R6 (full seed) stage of growth (9). Fifty consecutive plants in the two center rows of each plot were rated for disease. In 1977 and 1978, the following classes were used: 0 =

no symptoms; 1 = lesions only on lateral stems: and 2 = lesions on main stem, wilt, or death. In 1980 the following classes were used: 0 = no symptoms; 1 = lesion only on lateral stems; 2 = lesions on main stem, wilt, or death but some pod-fill; and 3 = lesions on main stem, wilt, or death and poor or no pod-fill.

Disease severity evaluations at the Hancock experimental farm were made on 50 consecutive plants (R8 growth stage) from each of the two center rows of each plot. Disease severities were calculated using the 0–3 class system described before.

The disease severity index (DSI) ranged from 0 (no disease) to 100 (all plants killed and with poor pod-fill) (11), according to the method described by Sherwood and Hagedorn (16):

$$DSI = \frac{\Sigma \text{ class} \times \text{no. of plants in class} \times 100}{\text{total no. of plants} \times \text{no. of disease classes}}.$$

Harvest. Harvest dates at the Racine locations were 13 October 1977 and 2 October 1980. Area harvested per replicated plot was 2.3 m^2 and 10.8 m^2 for 1977 and 1980, respectively. Yield was not determined in 1978. Soybeans were threshed in a portable bundle plot thresher and seeds were dried to 13% moisture and weighed.

Irrigation plots at the Hancock experimental farm were harvested between 14 and 23 October 1979 through 1981. Plot areas harvested were 9.1 m^2, 18.2 m^2, and 10 m^2 in 1979, 1980, and 1981, respectively. Plots were harvested with a plot combine. Seed moisture was calculated and seed weights adjusted to 13% moisture content.

RESULTS

Effect of row width and cultivars on disease severity and yield. In 1977, the mean DSI was three times greater and the mean yields were 42% lower for all cultivars grown at 38-cm row widths compared with cultivars grown at 76-cm row widths (Table 1). DSI and yields were statistically different between row widths within all cultivars. Yields and DSI among cultivars differed statistically within row widths, but mean differences between cultivars were greater at the 76-cm compared with the 38-cm row width. The relative ranking of cultivars within each row width remained similar except for Steele; DSI changed dramatically from 6 to 70 for 76- and 38-cm widths, respectively (Table 1).

In 1978, Wells soybeans were evaluated for disease severity at 38- and 76-cm row widths. Disease severity indexes were 54 and 41 for 38- and 76-cm row widths, respectively. Mean comparisons were statistically significant using Tukey's test for mean comparison ($P = 0.05$).

In 1980, row width did not affect DSI within cultivars but Corsoy was less diseased than Wells at both row widths (Table 2). Yields were similar for Corsoy grown at each row width, but the yield of Wells was 21% lower in plantings at the 25-cm row width than in plantings at the 76-cm row width. Yields for Corsoy and Wells were not statistically different at 76-cm row widths, although DSI did differ statistically between cultivars. Yield was 24% higher for Corsoy compared with Wells grown at 25-cm row widths (Table 2).

Effect of irrigation on Sclerotinia stem rot. Severity of Sclerotinia stem rot was greatly affected by timing of overhead irrigation in relationship to time of flowering (Table 3). In 1979 and 1981, disease severity was greatest when plots were irrigated biweekly throughout the growing season. Sclerotinia stem rot developed but was less severe in plots receiving supplemental irrigation only during the preflower or postflower stages of growth. Differences in disease severity resulting from irrigation timing resulted in 10 and 22% yield differences in 1979 and 1981, respectively. Sclerotinia stem rot did not develop in 1980 (Table 3); however, no irrigation after flowering resulted in lower yield and was presumably due to soil-moisture deficits throughout the growing season.

Table 1. Effect of row width on disease severity indices (DSI) and yield for six soybean cultivars grown in a field naturally infested with *Sclerotinia sclerotiorum* in 1977

	Row width[x]				
	38 cm		76 cm		
Cultivar	DSI[y]	Yield (g/plot)	DSI	Yield (g/plot)	Correlation coefficient[z]
Hodgson	41 a	775 a	3 a	1,206 ab	−0.74*
Corsoy	52 ab	637 ab	15 ab	1,327 a	−0.88**
SRF-200	54 ab	734 ab	26 bc	1,172 ab	−0.78**
Wells	65 bc	692 ab	30 bc	1,083 ab	−0.86**
Steele	70 bc	411 bc	6 a	1,073 bc	−0.97**
Asgrow 2656	76 c	642 ab	46 c	898 c	−0.87**
$\bar{x}$	60	649	21	1,127	−0.80**

[x]Each value is the mean of four replicates. Means followed by different letters are statistically different ($P = 0.05$) using Tukey's test for comparison of treatment means. Mean values for DSI and yield within each cultivar were statistically different ($P = 0.05$) between row widths for each cultivar.
[y]DSI range from 0 (no disease) to 100 (all plants killed and with poor pod-fill).
[z]Correlation coefficients within cultivars for the relationship of DSI and yield. * = Statistical significance at $P = 0.05$ and ** = statistical significance at $P = 0.01$.

Table 2. Effect of row width on disease severity indices (DSI) and yield for two soybean cultivars grown in a field naturally infested with *Sclerotinia sclerotiorum* in 1980

	Row width[x]				
	76 cm		25 cm		
Cultivar	DSI[y]	Yield (kg/plot)	DSI	Yield (kg/plot)	Correlation coefficient[z]
Corsoy	37 a	2.54 a	36 a	2.55 a	−0.06
Wells	56 b	2.43 a	54 b	1.93 b	−0.39
$\bar{x}$	47	2.49	45	2.24	−0.46*

[x]Each value is the mean of six replicates. Means with the same letters are not significantly different ($P = 0.10$) according to Duncan's multiple range test.
[y]DSI range from 0 (no disease) to 100 (all plants killed and with poor pod-fill).
[z]Correlation coefficients within cultivars for the relationship of DSI and yield. * = Statistical significance at $P = 0.10$. Mean yield for Wells grown at the 76-cm row width is statistically significant compared with yield at the 25-cm row widths.

Table 3. Effect of three irrigation regimes on disease severity indices (DSI) and subsequent yield for Wells soybean grown in a field naturally infested with *Sclerotinia sclerotiorum*

	1979		1980		1981	
Irrigation	DSI[y]	Yield (kg/plot)	DSI	Yield (kg/plot)	DSI	Yield (kg/plot)
All season	34 a[z]	5.33 a	0	7.50 a	39 a	4.61 a
Preflower	13 b	5.89 b	0	5.18 b	3 b	5.36 b
Postflower	3 b	5.68 ab	0	7.30 a	10 b	5.93 b

[y]DSI range from 0 (no disease) to 100 (all plants killed and with poor pod-fill).
[z]Values with the same letters are not significantly different ($P = 0.05$) using Tukey's test for comparison of treatment means.

Relationship between disease severity and yield loss. Disease severity indices and yield were negatively correlated for individual cultivars between row widths and for all cultivars within each row width (Table 1). However, yield and disease severity were not correlated for individual cultivars grown at both row widths in 1980 but were correlated ($r = -0.46$, $P = 0.10$) for the means of both cultivars (Table 2). Higher correlation coefficients were calculated for DSI and yield data collected from the irrigation experiments at the Hancock location ($P = 0.05$), $r = -0.61$ and -0.74 in 1979 and 1981, respectively (Table 3).

DISCUSSION

The relative susceptibility of soybean cultivars to Sclerotinia stem rot was reported previously (10,11) but these reports made no mention of how disease severity related to seed yield. In this report, we have demonstrated that *S. sclerotiorum* reduces yield of susceptible soybean cultivars and that disease severity and yield are statistically correlated. In addition, DSI values differed for soybean cultivars and the relative ranking of cultivars agreed with previous reports (10,11). However, different approaches to the measurement of Sclerotinia stem rot should be investigated and regressed against seed yield and the component of yields similar to what has been reported for Great Northern beans (14).

Sclerotinia stem rot was more severe in soybeans planted at closer row widths in 1977 and 1978 but not in 1980. Previous reports indicate greater white mold development in Great Northern beans at narrow row widths (19) and where a dense crop canopy developed (4,18,21). The effect of row width on the canopy microclimate is a likely explanation for our findings; however, Adams (2) reported that sclerotia near the soil surface may perish because of alternating drying and wetting of the soil. Thus, we also speculate that soil moisture fluctuated less between the more shaded rows of soybeans planted at reduced row widths, resulting in less mortality of sclerotia during the growing season.

In 1977, greater disease severity at narrow row widths resulted in lower yields compared with yield at wide row widths. Yield differences may be magnified if increased yield potentials of narrow rows over wide rows for soybean production are considered. Yield trials in Wisconsin show a mean yield increase of 21% occurred when soybeans were grown at 25-cm compared with 76-cm row widths in the absence of disease (15). Yields for the same cultivars were reduced 42% when grown at narrow row spacing in the presence of *S. sclerotiorum.* However, not only were yields reduced an average of 42%, but an expected 21% yield increase for narrow rows was negated by Sclerotinia stem rot. In 1980, there were no differences in disease severity for row-width comparisons for both cultivars; however, yield was lower for Wells grown at the 25-cm row spacing compared with 76 cm. Disease ratings were determined once at the R6 growth stage. Rate of disease development may have influenced the final yield more than the final level of disease. Yield compensation by uninfected plants may have been greater in wide-row environments than in narrow-row environments. Information is needed on the relationship of crop-growth stage and disease progress and severity to yield.

As expected, disease severity was greatest in plots irrigated twice a week throughout the growing season in 1979 and 1981. Regulation of overhead irrigation during the R1 growth stage (early flower) suppressed the development of Sclerotinia stem rot. The absence of Sclerotinia stem rot in 1980 was not expected, however, especially because optimally irrigated plots received more precipitation and irrigation water (79.2 cm) compared with 1979 (63.5 cm) and 1981 (58.1 cm). Minimum and maximum air temperatures recorded 2 wk before and 4 wk after flowering at the Hancock experimental farm were higher in 1980 than in 1979 and 1981. Minimum/maximum temperatures during this period were 12/22 C in 1979, 20/34 C in 1980, and 18/30 C in 1981. Canopy closure was slowed because 90-cm row widths were employed; thus, it is likely the temperatures of the ambient air and canopy were similar. Soil and canopy temperatures would possibly be influenced more by ambient air temperatures at 90-cm row widths compared with a lesser row width. Apothecial formation, ascospore liberation, infection, and disease development caused by *S. sclerotiorum* are favored by cool to moderate temperatures (1,22). Sclerotinia stem rot development was predicted better from air temperature than from seasonal precipitation and water applied by overhead irrigation. Irrigation management, row spacing, and selection of soybean cultivars are feasible strategies for control of Sclerotinia stem rot of soybean.

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