Effects of Two Foliar Pathogens on Seed Yield of Sunflower

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ABSTRACT

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Yield reductions in sunflower resulting from leaf and stem spot caused by *Alternaria zinniae* and leaf spot caused by *Septoria helianthi* were assessed in separate experiments by inoculating plots of two sunflower genotypes (inbred line HA89A and hybrid 894) at different plant growth stages during 1981 and 1983. Seed yields of hybrid 894 were reduced 12% by *S. helianthi* when inoculated at the V2 growth stage in 1981 and 16% by *A. zinniae* when inoculated at the V6 growth stage in 1983. Seed yields, oil content, and seed weights were not consistently correlated with assessments of percent disease severity or areas under the disease progress curve. Septoria leaf spot severities were consistently greater than those caused by *A. zinniae* leaf and stem spot. Though capable of reducing sunflower seed yield and quality, these two pathogens do not appear as threatening as other foliar pathogens.

Additional key words: *Helianthus annuus*, *Septoria helianthi*

Alternaria zinniae Pape and *Septoria helianthi* Ell. & Kell. are two of several fungi that cause foliar lesions on sunflower (*Helianthus annuus* L.). Both pathogens are widely distributed wherever sunflowers are grown (1,6,8,11–13, 15,16,18,19) and can be seedborne (19). They are routinely found causing generally low levels of disease in sunflower fields in the primary sunflower production area of North America: the Dakotas, Minnesota, and adjacent provinces of Canada.

The importance of these two pathogens to sunflower production in North America is not well documented. *A. zinniae* was considered the principal fungus responsible for an outbreak of leaf and stem spotting of sunflower in Manitoba in 1960 (10); however, the researchers felt that additional studies to determine prevalence and relative importance were warranted. Determination of the importance of *A. zinniae* is further complicated by references in the literature to "Alternaria leaf blight" or "Alternaria leaf and stem spot" without mention of the particular species of *Alternaria* causing the problem. Several *Alternaria* species have been reported to cause leaf and stem spotting of sunflower, including *A. zinniae*, *A. helianthi*, *A. alternata*, and *A. leucanthemi* (18,19). *S. helianthi* has caused damaging levels of leaf spot in Minnesota (5), Manitoba (6), Yugoslavia, Czechoslovakia (8), Turkey (1), Iran (12), and India (13). In Canada, neither pathogen is considered important enough to warrant control measures (9).

Because both *A. zinniae* and *S. helianthi* are common sunflower pathogens in the principal sunflower production area of North America, and there is no quantitative information on the potential impact of these pathogens on sunflower yield, experimental yield loss assessment trials were conducted. The objective of this research was to obtain quantitative information on the potential of *A. zinniae* and *S. helianthi* to reduce sunflower seed yield, oil content, and seed weight after artificial inoculation.

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MATERIALS AND METHODS

Separate experiments to measure the effects of *A. zinniae* and *S. helianthi* on sunflower seed yield, respectively, were planted during the first week of June on the South Dakota State University Plant Pathology Farm at Brookings in both 1981 and 1983. Each experiment consisted of a 4×2 factorial arrangement of inoculation treatments (initial inoculation at the V2, V6, and R5 growth stages [14] and uninoculated check) and sunflower genotypes (USDA hybrid 894 and the inbred line HA89A) replicated four times in a randomized complete block design. Check plots of each genotype were sprayed weekly from the V6 growth stage to the R8 growth stage with a mixture of mancozeb (Dithane M-45 80WP, 1.8 kg a.i./ha) and benomyl (Benlate 50WP, 0.3 kg a.i./ha) in 1 L of water per plot using a hand-held sprayer. Plots consisted of four rows 6.1 m long and either 1 m (1981) or 0.9 m (1983) apart. Only the two center rows of each plot received inoculation treatments and were rated for disease severity. Plots were seeded with 30 seeds per row and were not thinned. Resulting plant populations averaged 43,000 plants per hectare with the exception of plots of HA89A in 1981 in which stands were much reduced.

All plants in the center two rows of each inoculated plot were inoculated with either *A. zinniae* or *S. helianthi* by placing 20–30 grains of a sterilized sorghum grain culture of the pathogen onto the two uppermost leaves at the proper growth stage. Plots initially inoculated at the V2 or V6 growth stages were also inoculated a second time on the subsequent inoculation date. Plots initially inoculated at the R5 growth stage were inoculated only once. Plots were visually rated (weekly) for disease severity and plant growth stage each week from 21 July to 8 September in 1981 and from 14 July to 1 September in 1983 using the Horsfall-Barratt scale (7) and the system of Schneiter and Miller (14), respectively. Disease ratings were later converted to percent disease severity using Elanco conversion tables (Eli Lilly & Co., Indianapolis, IN). Areas under the disease progress curves (AUDPC) were calculated from disease severity ratings from each plot using the formula of Wilcoxson et al (17). Total rainfall amounts received from 1 June to 31 August were 26.9 and 29.9 cm for 1981 and 1983, respectively. Plots were hand-harvested (both center rows in 1981, a single center row in 1983), heads dried, threshed, and weighed, and seed yields converted to kilograms per hectare. Yield data were not taken from plots of HA89A in 1981 because of poor stands and excessive bird damage. Oil contents were measured using nuclear magnetic resonance and 100-seed weights determined from seed samples from each plot.

Data collected were analyzed by analysis of variance and means of traits from inoculated plots compared with check plot means using single degree of freedom contrasts in the analysis of variance to test for statistical significance. Simple correlation coefficients between yield, oil content, 100-seed weight, and percent disease severities on each of the eight rating dates and AUDPC values were also computed to determine the relationship of disease severity and agronomic performance.

RESULTS AND DISCUSSION

Yield reductions resulting from inoculation with *S. helianthi* ranged upward to 15.5% (HA89A inoculated at

the V2 growth stage in 1983), although only losses on hybrid 894 inoculated at the V2 growth stage in 1981 were statistically ($P \leq 0.05$) significant (Table 1). Leaf spot development as measured by the AUDPC was always significantly greater on inoculated than on check plots. Seed oil content of HA89A inoculated at the V2 growth stage in 1983 was significantly ($P \leq 0.10$) reduced compared with check plots. Oil content of hybrid 894 was unaffected by Septoria leaf spot in either year. Hybrid 894 100-seed weights were significantly reduced by Septoria leaf spot in all inoculation treatments in 1981, but no significant reductions were detected in 1983. A significant ($P \leq 0.10$) increase in seed weight was observed on plots of HA89A inoculated at the V2 growth stage in 1983. This may have been the result of a reduction in the number of seeds per head, resulting in increased seed weight.

Leaf spot caused by *A. zinniae* also significantly ($P \leq 0.10$) reduced seed yields of hybrid 894 by 15.8% when inoculated at the V6 growth stage in 1983 (Table 2). AUDPC values were significantly greater in all inoculated plots except hybrid 894 inoculated at the R5 growth stage in 1983 compared with check plots. Oil contents were not significantly reduced by any of the *A. zinniae* inoculation treatments in either year. Hundred-seed weights of HA89A were significantly reduced by all inoculation treatments in 1981 but were not significantly affected in 1983. Seed weights of hybrid 894 were not significantly reduced in either year.

The lack of consistent effects of these two pathogens on agronomic performance is also reflected in the correlation coefficients between disease severity and yield, oil content, and 100-seed weight (Table 3). Yield of hybrid 894 was consistently negatively correlated with percent Septoria leaf spot severity in 1981, although only correlation coefficients with disease severity on 4 August (DS3) and 11 August (DS4) were statistically significant ($P \leq 0.05$). Severity of leaf and stem spot caused by *A. zinniae* on HA89A on 21 July 1983 (DS2 in table) was also significantly negatively correlated with yield. Hundred-seed weight of hybrid 894 was significantly negatively correlated with Septoria leaf spot severities on five of the eight rating dates and with AUDPC values in 1981, indicating that seed weight rather than yield may be a more sensitive measure of the deleterious (negative) effects of Septoria leaf spot. Seed weights of both genotypes in 1981 were significantly negatively correlated with percent *A. zinniae* disease severity on certain later rating dates and with AUDPC values, even though no significant yield reductions were detected (Table 2). Significant positive correlations between oil content and disease severity were detected at certain dates on hybrid 894 inoculated with *S. helianthi* in 1983 and HA89A inoculated with *A. zinniae* in 1983, although no significant reductions or increases in oil content were detected on those genotypes in those experiments (Tables 1 and 2). The lack of consistent association between disease severity and agronomic performance may be due in part to the lack of precision in measuring sunflower yield in these experiments (experimental coefficients of variation ranged from 15.4 to 21.4%) and the relatively low levels of yield reductions observed.

These data indicate that *S. helianthi* and *A. zinniae* are two foliar pathogens capable of reducing yield, oil content, and seed weights of sunflower under conditions present in the Minnesota-Dakotas production area. Although

Table 1. Effects of Septoria leaf spot epidemics initiated at different plant growth stages on seed yield, percent seed oil content, and 100-seed weights of two sunflower genotypes in 1981 and 1983

	1981					1983				
Genotype	Growth stage at inoculation	Yield (kg/ha)	Oil content (%)	100-Seed weight (g)	AUDPC[a]	Growth stage at inoculation	Yield (kg/ha)	Oil content (%)	100-Seed weight (g)	AUDPC
HA89A	V2	...[b]	43.4	4.07	214***[c]	V2	550	43.7*	3.60*	239***
	V6	...	43.1	4.21	145***	V6	587	44.1	3.18	183***
	R5	...	43.3	4.07	113***	R5	632	44.7	3.33	153***
	Check	...	44.3	4.37	29	Check	651	45.2	3.13	75
Hybrid 894	V2	2,157*	41.1	4.04***	237***	V2	1,178.5	42.0	3.30	191***
	V6	2,369	40.8	3.94***	183***	V6	971.2	41.8	3.25	96**
	R5	2,438	40.8	4.03***	118***	R5	943.1	40.5	3.00	121***
	Check	2,448	41.5	5.03	15	Check	1,101.7	40.8	3.05	50

[a] AUDPC = area under the disease progress curve calculated by the formula of Wilcoxson et al (17).
[b] Yield data not taken because of poor stands and excessive bird damage to HA89A in 1981.
[c] Mean significantly different from the check mean at * = $P = 0.10$, ** = $P = 0.05$, and *** = $P = 0.01$ as determined by single degree of freedom contrasts in the analysis of variance.

Table 2. Effects of epidemics of leaf and stem spot, caused by *Alternaria zinniae*, initiated at different plant growth stages on seed yield, percent seed oil content, and 100-seed weights of two sunflower genotypes in 1981 and 1983

	1981					1983				
Genotype	Growth stage at inoculation	Yield (kg/ha)	Oil content (%)	100-Seed weight (g)	AUDPC[a]	Growth stage at inoculation	Yield (kg/ha)	Oil content (%)	100-Seed weight (g)	AUDPC
HA89A	V2	...[b]	41.0	4.59*[c]	119***	V2	722	43.9	3.10	143***
	V6	...	43.5	4.44**	109***	V6	797	44.1	3.20	125***
	R5	...	43.1	4.48**	103***	R5	763	43.4	3.10	141***
	Check	...	42.7	5.05	30	Check	639	44.6	3.25	60
Hybrid 894	V2	2,209	40.5	4.34	134***	V2	1,454	41.3	3.23	100***
	V6	1,986	40.3	4.46	99***	V6	1,267*	40.3	3.30	84**
	R5	2,077	39.3	4.61	99***	R5	1,403	40.1	3.03	67
	Check	2,296	40.4	4.66	19	Check	1,505	41.5	3.25	38

[a] AUDPC = area under the disease progress curve calculated by the formula of Wilcoxson et al (17).
[b] Yield data not taken because of poor stands and excessive bird damage to HA89A in 1981.
[c] Mean is significantly different from the check mean at * = $P = 0.10$, ** = $P = 0.05$, and *** = $P = 0.01$ as determined by single degree of freedom contrasts in the analysis of variance.

Table 3. Simple correlation coefficients between agronomic characters of two sunflower genotypes and percent disease severity on eight weekly rating dates and AUDPC[a] of two foliar diseases in 1981 and 1983

Disease	Year	Genotype	Agronomic trait	Disease severity								
				DS1[b]	DS2	DS3	DS4	DS5	DS6	DS7	DS8	AUDPC
Septoria leaf spot	1981	Hybrid 894	Yield vs.	−0.46	−0.49	−0.50*[c]	−0.56*	−0.41	−0.38	−0.43	−0.27	−0.45
			Oil content vs.	−0.05	−0.02	−0.03	−0.10	−0.17	−0.21	−0.25	−0.27	−0.20
			100-Seed weight vs.	−0.42	−0.49	−0.45	−0.51*	−0.61*	−0.72**	−0.79**	−0.86**	−0.74**
	1981	HA89A	Oil content vs.	−0.15	−0.09	−0.20	−0.09	−0.10	−0.16	−0.15	−0.23	−0.17
			100-Seed weight vs.	−0.21	−0.14	−0.25	−0.31	−0.43	−0.33	−0.38	−0.44	−0.39
	1983	Hybrid 894	Yield vs.	0.43	0.35	0.29	0.47	0.05	0.10	−0.11	0.45	0.27
			Oil content vs.	0.38	0.54*	0.59*	0.42	0.33	0.13	−0.08	0.30	0.36
			100-Seed weight vs.	0.38	0.37	0.44	0.45	0.21	0.18	−0.25	0.34	0.29
	1983	HA89A	Yield vs.	−0.24	−0.12	−0.17	−0.09	−0.47	−0.46	−0.42	−0.36	−0.43
			Oil content vs.	−0.39	−0.26	−0.30	−0.29	−0.40	−0.21	−0.07	−0.28	−0.34
			100-Seed weight vs.	0.41	0.42	0.38	0.43	0.17	−0.06	0.01	0.20	0.25
A. zinniae leaf spot	1981	Hybrid 894	Yield vs.	−0.26	−0.26	−0.26	−0.38	−0.21	−0.05	−0.10	−0.19	−0.16
			Oil content vs.	0.16	0.16	−0.18	−0.20	−0.07	0.02	0.18	0.16	0.11
			100-Seed weight vs.	−0.41	−0.41	−0.24	−0.03	−0.32	−0.46	−0.56*	−0.49	−0.52*
	1981	HA89A	Oil content vs.	−0.32	−0.19	−0.48	−0.07	−0.20	−0.14	−0.04	−0.09	−0.07
			100-Seed weight vs.	−0.33	−0.39	−0.05	−0.39	−0.49	−0.53*	−0.63**	−0.68**	−0.66**
	1983	Hybrid 894	Yield vs.	0.13	0.00	0.37	−0.13	0.15	0.07	−0.19	−0.11	−0.06
			Oil content vs.	0.25	0.46	−0.11	−0.17	−0.37	−0.48	−0.34	−0.32	−0.41
			100-Seed weight vs.	−0.15	−0.05	0.33	0.00	0.35	0.29	−0.15	0.09	0.11
	1983	HA89A	Yield vs.	−0.30	−0.60*	−0.46	0.23	0.22	0.25	0.33	−0.02	0.24
			Oil content vs.	0.53*	0.38	0.27	0.10	0.10	0.09	−0.06	−0.24	0.01
			100-Seed weight vs.	0.05	−0.09	−0.13	0.16	−0.01	−0.07	−0.23	−0.29	−0.14

[a] AUDPC = area under the disease progress curve calculated by the formula of Wilcoxson et al (17).
[b] DS1 = percent disease severity on first rating date (21 July 1981 or 14 July 1983).
[c] Correlation coefficient is significantly different from zero at * = $P = 0.05$ and ** = $P = 0.01$.

direct statistical comparisons between the two pathogens were not possible, plots inoculated with *S. helianthi* were consistently more diseased (had greater AUDPC values) than similar plots inoculated with *A. zinniae*, indicating that *S. helianthi* is probably the more important of the two pathogens under these experimental conditions.

Although significant yield reductions were observed on hybrid 894 when inoculated with *S. helianthi* or *A. zinniae*, the magnitude of these losses (12–16%) is relatively small compared with those caused by other sunflower foliar pathogens such as *A. helianthi* (2) or by rust (*Puccinia helianthi*) (4) in similar yield loss trials. Furthermore, the results presented here were obtained by exposing plants to abnormally high inoculum levels as a result of inoculation. Actual losses under conditions of natural infection in the environment of the Northern Great Plains are probably less. Therefore, these two diseases cannot be considered of primary importance in the Minnesota-Dakotas sunflower production area at this time. The development of resistant hybrids would be the most economical means of control should disease control be warranted. Resistance to *S. helianthi* among sunflower inbred lines has been reported (3,19). These data do not rule out the possibility, however, that these pathogens may become more important in the future as a result of changing cultural practices, changes in the hybrid sunflower germ plasm base, or genetic shifts in the pathogen population.

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