Cercospora Blight Development on Asparagus Fern and Effects of Fungicides on Disease Severity and Yield

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ABSTRACT

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Disease progress of Cercospora blight of asparagus was studied in field plots, using an assessment system developed to estimate disease on asparagus ferns during 1984 and 1985. Logistic and Gompertz models were compared for goodness of fit for linear regression of disease proportions in fungicide-treated and control blocks for cultivars UC 157 F_2 and Mary Washington. Gompertz models fit the data better according to standard error of estimate values, but neither model fit all data. Rates of increase of disease were significantly lower in chlorothalonil blocks. Areas under the disease progress curves (AUDPC) were determined from untransformed percent disease values and were significantly less in fungicide treated blocks. Reducing the in-row density of crowns did not significantly reduce disease progress rates or AUDPC. Conidial densities of *Cercospora asparagi* were monitored with a Kramer-Collins 7-day spore sampler. Large increases in conidial densities occurred from mid-August through October during 1982–1985; however, disease in control blocks was estimated to be 72–94% by 1 September. Protection of ferns by fungicides was correlated to yield increases in UC 157 F_2 blocks during 1982–1985 and in Mary Washington in 1985.

Commercial production of asparagus (*Asparagus officinalis* L.) has increased in Oklahoma from 60 ha in 1981 to more than 200 ha in 1984 and is located primarily in the eastern half of Oklahoma. Cercospora blight of asparagus caused by *Cercospora asparagi* Sacc. has been reported from several southern states and as far north as Missouri (1,3–5,11,15). Damage to asparagus has been described as minor (15), and few reports have been published concerning this disease. Severity of the disease has been reported to increase with overhead irrigation (11), and preliminary evaluations indicated that fungicides can control this disease (1). Cooperman et al (5) have shown that burial of crop residue can decrease survival of *C. asparagi* and reduce initial inoculum levels. The disease was first identified in Oklahoma at the Vegetable Research Station at Bixby in 1980.

In Oklahoma, the pathogen overwinters on ferns. Before harvest in the spring, ferns are mowed and the residue is left on the surface. This residue is a source of initial inoculum when fern growth resumes in June. Lesions caused by *C. asparagi* can occasionally be found on seedling asparagus during harvest (March through May). After harvest, the ferns grow rapidly and appear disease-free, because initial infections are small discrete lesions on the secondary and needlelike (cladophylls) branches of the lower portions of the ferns. The fern canopy closes between rows during July, and symptoms increase rapidly after row closure. Symptoms appear as a general browning of the lower fern by the first of August, and this browning continues upward with numerous lesions occurring on the stems and needlelike branches. Defoliation of needlelike branches from the ferns can be severe.

Asparagus is a perennial crop and may remain active for more than 15 yr. Yield is dependent on age of the crowns and the amount of carbohydrate stored in the root system by the fern during the previous season. A commercial planting should produce 2,800 kg/ha of snapped asparagus during its most productive years (9). The epidemiology and control of *C. asparagi* and the effect of disease on yield were investigated because of the severity of this disease during 1980–1985 at Bixby. A preliminary report has been published (3).

MATERIALS AND METHODS

A planting of cultivar UC 157 F_2 was available for research starting in 1982. The planting consisted of five blocks, each containing five rows 25 m long with 1.5 m between rows. Blocks were separated from each other by 5-m alleys. The first three blocks had normal in-row crown spacings of 30 cm (22,222 crowns per hectare), and the last two blocks had low-density in-row crown spacings of 46 cm (14,493 crowns per hectare). Blocks 1, 3, and 5 were treated on an approximately 14-day interval (June through September) with chlorothalonil (Bravo 500) at 3.5, 0.87, and 1.75 kg a.i./ha, respectively, during 1982 and 1983. Eight fungicide applications were made during 1982 and 12 were made during 1983. In 1984, blocks 1 and 5 were sprayed with chlorothalonil at 1.75 kg a.i./ha and block 3 was sprayed with mancozeb (Dithane M-45) at 2.24 kg a.i./ha on a 11- to 14-day schedule from 28 June to 4 September, for a total of six applications. Treatments and rates were the same in 1985 but were applied only four times (1 and 22 July and 8 and and 30 August). Fungicides were applied with an airblast sprayer (15.8 kg/cm^2) directed into the ferns from one side of the blocks.

Conidial densities of *C. asparagi* in the air at 0.5 m above the soil were monitored during the period of fern growth (June through October 1982–1985) with a Kramer-Collins 7-day spore sampler (8). The sampler was placed between blocks 2 and 3 of the UC 157 F_2 planting and was calibrated to sample the air hourly for 1 min. Conidial densities were calculated daily, using the total of the conidia trapped during the 24 sampling periods each day and adjusting the volume of air sampled to a cubic meter. The asparagus plantings used for this study were part of a larger asparagus production area (2.1 ha) used by the Department of Horticulture and Landscape Architecture for cultivar evaluations.

A rating system was developed to assess the amount of disease on individual ferns in each of the treatments

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in the UC 157 F_2 planting during 1984. Each block of asparagus was divided into two subplots, each about 11 m long, that were separated by a 3-m buffer zone. Four plants randomly chosen from two inner rows of each subplot were visually rated for disease development from 24 July to 28 August in 1984 and 1985. Analyses of disease progress were expanded to the Mary Washington planting in 1985. The fern canopy was divided into thirds by a system similar to that developed for peanut (12). Our system was based on the location of three types of symptoms on the fern (lesions, browning, and defoliation). A single number was given for the location of each symptom on the fern, where 0 = absence of symptoms, 1 = bottom, 2 = middle, and 3 = top third of fern. (i.e., 3,2,1 would indicate lesion development in all three canopy layers, visible browning extending upward to the middle, and defoliation occurring on the bottom third of the fern). The average number for each symptom location from the four plants was inserted into the formula

$$X_T = 5.5L_L + 11.0L_B + 16.5L_D,$$

where X_T = total percent disease, L_L = location of lesions, L_B = location of browning, and L_D = location of defoliation on the ferns. The constant numbers of the equation were used to show increasing severity of disease based on symptom expression and location. For instance, when all three symptoms were visible in the lower third of the canopy (i.e., L_L, L_B, and $L_D = 1$), then $X_T = 33.0$. Values of X could range from 0 to 99%.

Values of X_T for each treatment were changed to proportions and transformed using both logistic (14) and Gompertz (2) models. Linear regression lines were determined by plotting logit or gompit values against time. The standard error of estimate and the coefficient of determination were calculated for each regression line and were used to evaluate the goodness of fit for each model. Comparisons of disease progress (slope values of simple linear regression lines) were performed for subplots within treatments, and treatments were compared with their appropriate controls (based on crown spacing), using a "dummy" variable multiple-regression analysis (6). The area under the disease progress curve (AUDPC) was calculated according to Shaner and Finney (13), using a Biostatistics 3 program (A2 Devices, P.O. Box 2226, Alameda, CA) and an Apple IIe computer.

Asparagus spears, hand-harvested by snapping, were trimmed to a maximum length of 22.5 cm. Total yield of marketable spears from individual rows of all blocks was recorded at each picking date. The yield from row 1 nearest the sprayer was not included in yield data. In 1983, four blocks of cultivar Mary Washington were available for research. These blocks had been planted in 1978 and consisted of four rows 25 m long with between-row width of 1.5 m and in-row crown spacing of 30 cm. Each block was separated by 5-m alleys. No fungicides were applied during 1983, and baseline yield data were obtained in 1984 by hand-harvesting the middle two rows of each of the four blocks. During the summers of 1984 and 1985, mancozeb (2.24 kg/ha) and chlorothalonil (1.75 kg/ha) were applied separately to ferns in two blocks. Fungicides were applied on the same schedule as the UC 157 F_2. Spears were hand-harvested in 1985, and yield data were collected to determine the effects of the fungicides applied during 1984.

Yield was recorded for each treatment, and trends in yield response were noted. Statistical comparisons of yields were not possible because of the experimental design and spacings of the cultivar plantings, except for yield of Mary Washington in 1985. Development of the disease within the fern canopy made single-row treatment impractical.

RESULTS

Conidial densities (number of conidia per cubic meter per day) of *C. asparagi* trapped in the air canopy of asparagus ferns, rainfall, and percent disease during 1984 and 1985 are shown in Figures 1 and 2. Numbers of conidia trapped in 1982 and 1983 are not presented because they were similar to those in 1984 and 1985 except that rainfall in 1983 was less than in the other 3 yr. Increases in conidial numbers during 1983 did not occur until late August. Rainfall for the period June through September was 29.2, 14.2, 21.4, and 42.5 cm during 1982, 1983, 1984, and 1985, respectively. Increases in conidial densities during all 4 yr were usually closely associated with prior periods of rainfall. Numbers of conidia were not

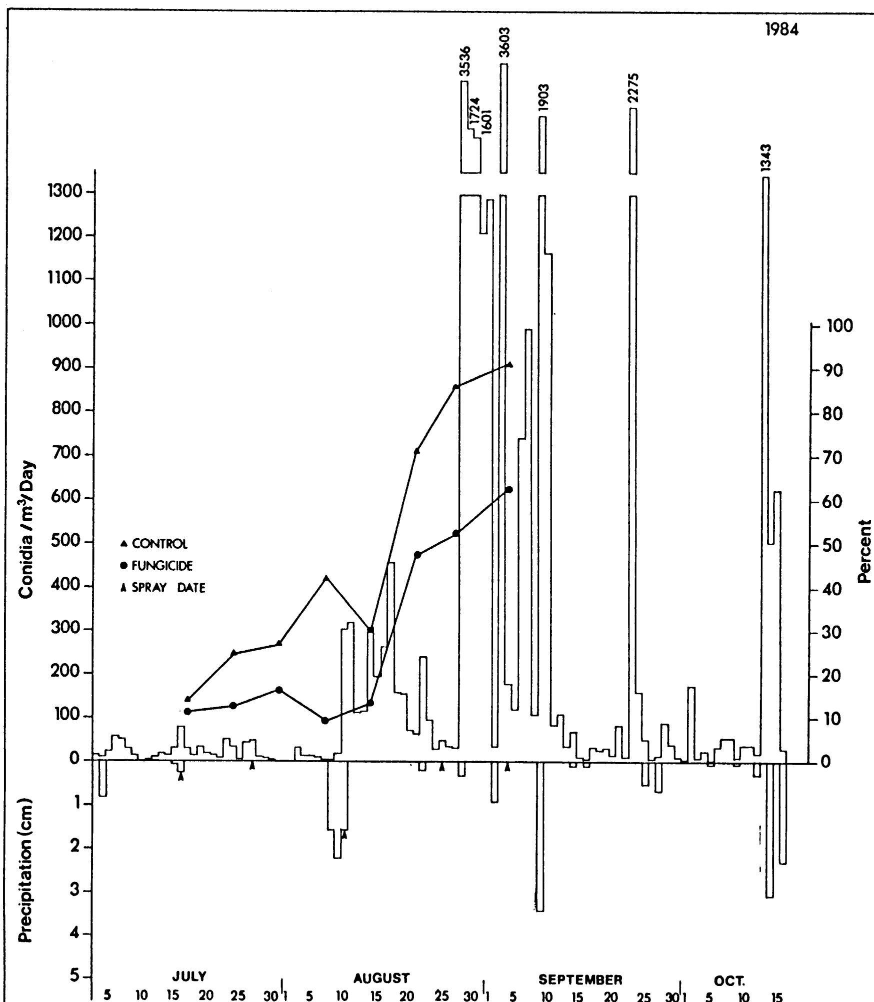

Fig. 1. Number of conidia of *Cercospora asparagi* per cubic meter trapped in the air each day from within asparagus plots at the Vegetable Research Station at Bixby, OK, and amounts (cm) and frequency of rainfall during July through October 1984. Densities of conidia were determined with a Kramer-Collins 7-day spore sampler calibrated to sample air hourly for 1 min. Untransformed percent disease severity is presented for block 1 (chlorothalonil-treated, 1.75 kg a.i./ha) and block 2 (unsprayed control) of cultivar UC 157 F_2. Arrows indicate dates of fungicide application; not shown is an application on 28 June 1984.

available during periods of 1985 because of spore sampler malfunctioning.

Daily conidial densities trapped during 1984 and 1985 showed large initial increases in early August after rainfall. Conidial densities were greatest during late August and early September. Disease levels had reached 72–94% infection per fern during this time in control blocks.

There were significant reductions (P= 0.01) in disease progress rates between the fungicide-treated blocks and their appropriate untreated controls during 1984. Both fungicides were effective in controlling Cercospora blight. Disease progress was similar for both control areas regardless of crown spacing. Intercept values on 17 July 1984 were not significantly different for any of the treatments, indicating that disease progress was not affected by the first two sprays on (28 June and 15 July). The next three sprays appeared to be most effective (27 July and 10 and 23 August) in reducing disease progress.

In 1985, the period May through July was wetter than 1984 and Cercospora blight developed earlier and was more severe than in the previous 3 yr. Greatest increase in percent disease on UC 157 F_2 occurred between 31 July and 28 August 1984 in mancozeb-treated (23–55%) and control blocks (20–70%) and between 14 and 28 August in chlorothalonil-treated blocks (8–42%). Temperatures recorded at the National Weather Bureau at Tulsa, OK, averaged 27.8 C (average daily range 21.4–34.1 C) for July and 28.1 C (21.7–34.6 C) for August. Rainfall recorded at the Bixby Research Station was 1.09 and 5.77 cm in July and August, respectively. In 1985, increases in percent disease on UC 157 F_2 occurred between 31 July and 14 August in control blocks (12–86%) and between 7 and 21 August in fungicide-treated blocks (8.3–70%). Disease development was similar in Mary Washington asparagus in 1985, with control blocks increasing from 16 to 92%, the mancozeb-treated block from 6 to 50%, and the chlorothalonil-treated block from 5.5 to 46.8%. Average temperatures and average daily ranges were 28.3 C (22.4–34.1 C) and 27.6 C (21.9–33.3 C) for July and August, respectively. Rainfall was 6.91 cm in July and 5.72 cm in August.

Comparisons of logistic and Gompertz transformations of disease development for Cercospora blight on asparagus in 1985 are presented in Table 1. Rate parameters for each model were obtained from slope values of simple linear regression of transformed disease proportions over time. In 1984 and 1985, slope values of disease progress in chlorothalonil-treated plots were significantly lower (P = 0.01) than those in control plots for both UC 157 F_2 and Mary Washington (1985 only). Mancozeb significantly (P = 0.01) reduced disease progress compared with controls in 1984 but not in 1985. The Gompertz model produced lower slope values and a better fit of y-values (disease proportions) to the regression lines as determined by the standard error of estimate values. Values for the coefficient of determination were more variable than the standard error of estimate values and indicated better fit for the Gompertz model in only four of 18 regression lines. Disease progress rates within blocks of UC 157 F_2 planted at normal and low density in-row crown spacing did not differ significantly.

During 1984, the average value for AUDPC for chlorothalonil-treated blocks of UC 157 F_2 was significantly lower than those for mancozeb-treated blocks (P= 0.05) and controls (P= 0.01) (Table 2). In 1985, chlorothalonil-treated blocks of UC 157 F_2 and Mary Washington had average AUDPC values significantly lower than those of the controls (P = 0.01). Average AUDPC values for mancozeb-treated blocks were significantly lower than those for control blocks of UC 157 F_2 (P= 0.05) and Mary Washington (P = 0.01). When AUDPC values for both cultivars were combined, fungicide treatments had values significantly lower than those of the controls (P = 0.01), indicating that both fungicides were effective in reducing Cercospora blight. There were no significant differences between AUDPC values in either 1984 or 1985 for blocks of UC 157 F_2 planted at different in-row crown spacings.

Yield data from UC 157 F_2 blocks for 1983–1985 are presented in Table 3. No yield data were recorded for 1982 because the crowns were too young to allow

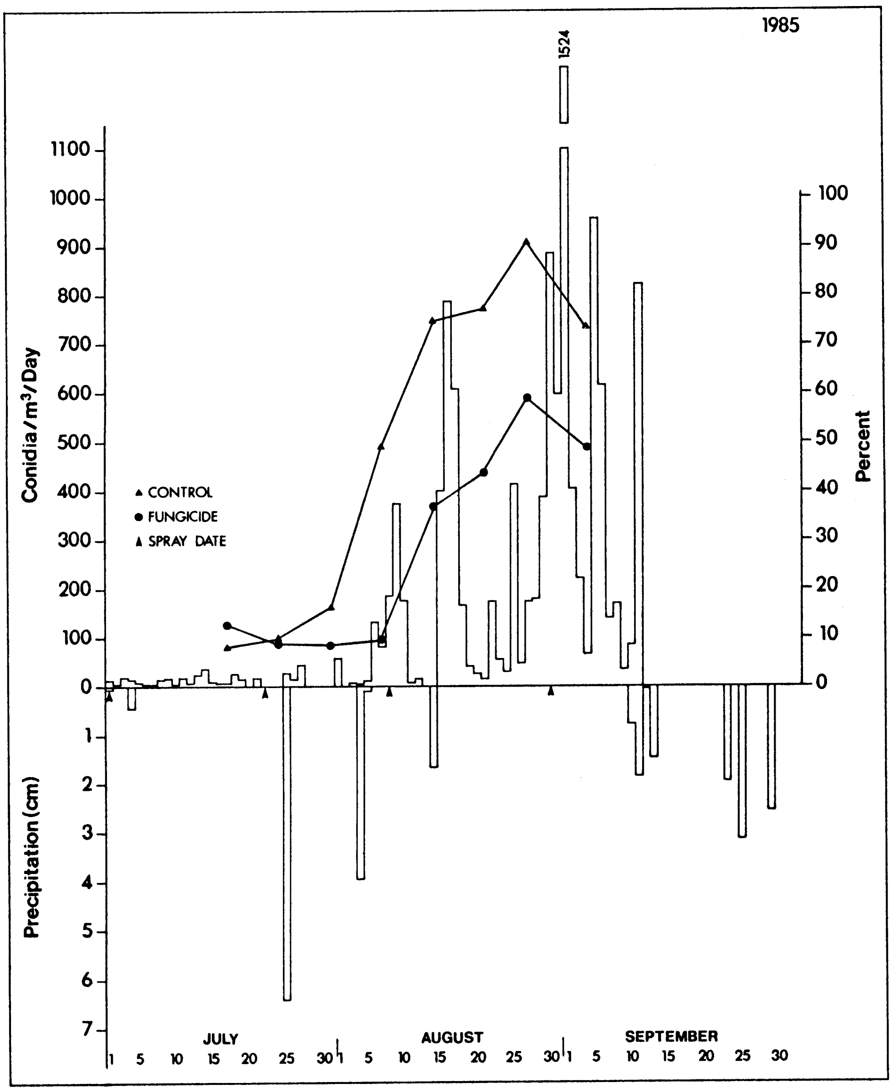

Fig. 2. Number of conidia of *Cercospora asparagi* per cubic meter trapped in the air each day from within asparagus plots at the Vegetable Research Station at Bixby, OK, and amounts (cm) and frequency of rainfall during July through September 1985. Densities of conidia were determined with a Kramer-Collins 7-day spore sampler calibrated to sample air hourly for 1 min. Untransformed percent disease severity is presented for block 1 (chlorothalonil-treated, 1.75 kg a.i./ha) and block 2 (unsprayed control) of cultivar UC 157 F_2. Arrows indicate dates of fungicide applications. Data were not available for 28–31 July and 13–14 August because of spore sampler malfunction.

Table 1. Comparison of logistic and Gompertz transformations of percent disease of Cercospora blight on two asparagus cultivars, UC 157 F_2 and Mary Washington, at Bixby, OK, in 1985

			Logistic model			Gompertz model		
Cultivar	**Treatment**[a]	**Density**[b]	**Rate**[c]	**SE**[d]	r^e	**Rate**	**SE**	r
UC 157 F_2	Chlorothalonil	N	0.107	0.867	0.766	0.060	0.505	0.754
		N	0.072	0.478	0.830	0.039	0.316	0.764
		L	0.098	0.549	0.873	0.051	0.324	0.840
		L	0.093	0.139	0.990	0.052	0.165	0.955
	Mancozeb	N	0.136	0.707	0.888	0.084	0.448	0.883
		N	0.103	0.297	0.963	0.061	0.181	0.961
	Control	N	0.137	0.437	0.955	0.097	0.314	0.953
		N	0.129	0.326	0.971	0.091	0.263	0.962
		L	0.112	0.800	0.809	0.083	0.633	0.785
		L	0.124	0.408	0.952	0.082	0.295	0.943
Mary Washington	Chlorothalonil	N	0.087	0.568	0.834	0.040	0.306	0.787
		N	0.068	0.281	0.927	0.030	0.117	0.932
	Mancozeb	N	0.108	0.359	0.951	0.054	0.243	0.914
		N	0.078	0.407	0.886	0.036	0.187	0.889
	Control	N	0.126	1.109	0.735	0.085	0.847	0.681
		N	0.119	0.909	0.787	0.071	0.485	0.822
		N	0.126	1.149	0.722	0.083	0.914	0.641
		N	0.098	0.898	0.718	0.051	0.462	0.746

[a] Fungicides applied to ferns on 1 and 22 July and 8 and 30 August at the following rates: chlorothalonil at 1.75 kg a.i./ha and mancozeb at 2.24 kg a.i./ha.
[b] Normal density (N) is 30 cm between crown in row; low density (L) is 46 cm.
[c] Rates for both models are the slope values of the simple linear regression of the transformed disease proportions over time.
[d] Standard error of estimate.
[e] Coefficient of determination.

harvesting of spears. Chlorothalonil applied to ferns at three rates during 1982 controlled Cercospora blight, and in 1983, yields of spears were 56.0–64.1% greater than those of control blocks. Chlorothalonil was applied to the ferns at the same rates during 1983, and yields in 1984 were 40.7–82.1% greater than those of control blocks. During the summers of 1984 and 1985, one rate of chlorothalonil (1.75 kg/ha) was applied to two of the blocks and mancozeb was applied to the other treated block. Yields in 1985 were 40.2–47.1% greater for chlorothalonil-treated ferns and 40.5% greater for mancozeb-treated than for control blocks.

Yield data for Mary Washington are also presented in Table 3. No fungicide treatment was applied to ferns in the four blocks during 1983. Yield of marketable asparagus spears was similar for the four blocks during 1984, establishing a baseline for yield. During the summer of 1984, ferns in two blocks were treated with either chlorothalonil or mancozeb. Yield of marketable spears in 1985 increased 65.8–68.4% in fungicide-treated blocks and 20.5–25.0% in control blocks compared with yields from the same blocks in 1984. Combined yields from fungicide-treated blocks in 1985 were significantly greater ($P = 0.05$) than those from control blocks when compared using a one-tailed t test.

Table 2. Mean area under the disease progress curve (AUDPC) for percent disease of Cercospora blight on two cultivars of asparagus from field tests conducted at Bixby, OK, in 1984–1985

		AUDPC[a]	
Cultivar	**Treatment**	**1984**	**1985**
UC 157 F_2	Chlorothalonil	676.8[b,c]	981.6[b]
	Mancozeb	1,085.5	1,383.7[d]
	Control	1,415.5	1,848.4
Mary Washington	Chlorothalonil	...	600.8[b]
	Mancozeb		737.6[b]
	Control		1,832.9
Both cultivars	Chlorothalonil	...	854.6[b]
	Mancozeb		1,060.7[b]
	Control		1,840.7

[a] AUDPC calculated according to Shaner and Finney (13) for percent disease of asparagus ferns determined on a weekly basis from 24 July to 28 August during both years.
[b] Significantly less than control ($P = 0.01$).
[c] Significantly less than mancozeb ($P = 0.05$).
[d] Significantly less than control ($P = 0.05$).

DISCUSSION

Conidia of *C. asparagi* have been trapped from the air over asparagus fields at Bixby, OK, as early as June; however, the greatest densities of conidia occur during mid-August and September. Cooperman et al (5) showed similar patterns for the aerobiology of *C. asparagi* in North Carolina. These large conidial releases occur when asparagus ferns are 60–90% infected and are not as important as earlier conidial releases that initiate and drive the epidemic. Control strategies should be directed at the ferns during July and August.

The average daily temperature range for July and August at Bixby during 1984 and 1985 was 21.4–34.6 C. Greatest increases in apparent disease development occurred during this period. According to Cooperman and Jenkins (4), optimal growth and conidial production and germination for *C. asparagi* under laboratory conditions occurred between 20 and 32 C. Symptom expression was expressed within 8 days at temperatures between 20 and 25 C and within 11 days at 30 C. They also reported that a red pigment, tentatively identified as cercosporin, was produced in culture at 16–28 C. Temperatures during July and August at Bixby appear to be in the range that optimizes growth, conidial production, and germination of *C. asparagi* and symptom development on asparagus.

The Cercospora blight rating system provided a rapid, easy to use system for estimating percent disease of asparagus ferns in the field. Asparagus has an indeterminant growth pattern, and new growth of ferns as well as production of new ferns can occur during the summer

Table 3. Yield of snapped asparagus spears of cultivars UC 157 F_2 and Mary Washington at Bixby, OK, in 1983–1985 from plots planted at two crown spacings and sprayed with various concentrations of fungicides to control Cercospora blight

Cultivar	Treatment[a]	Density[b]	Total yield (kg/ha) 1983	1984	1985	Increase (%)
UC 157 F_2	2C,2C,C	N	2,976.0 (56.0%)[c]	7,196.7 (56.6%)	8,950.3 (40.2%)	···
	0.5C,0.5C,M	N	3,009.0 (57.7%)	6,467.0 (40.7%)	8,965.9 (40.5%)	···
	Control	N	1,908.0	4,595.6	6,381.9	···
	C-C-C	L	2,535.0 (64.1%)	6,520.5 (82.1%)	9,061.2 (47.1%)	···
	Control	L	1,545.0	3,579.8	6,160.4	···
Mary Washington	O-M	N	···	4,778.6	8,045.1	68.4[d]
	O-C	N	···	5,626.8	9,330.5	65.8
	Control	N	···	5,091.2	6,365.4	25.0
	Control	N	···	5,144.8	6,199.2	20.5

[a] Numbers and letters refer to fungicides and rates: chlorothalonil, 2C = 3.5 kg a.i./ha, C = 1.75 kg/ha, 0.5C = 0.87 kg/ha; mancozeb, M = 2.24 kg/ha, 0 = no treatment. Fungicides were applied to UC 157 F_2 in 1982, 1983, and 1984 and to Mary Washington in 1984.
[b] Normal density (N) is 30 cm between crown in row; low denisty (L) is 46 cm.
[c] Percent increase in yield compared with controls from within the same crown spacing for each year.
[d] Percent increase in yield in 1985 from within each treatment compared with yield in 1984.

after periods of rain. This may have been responsible for decreases in percent disease ratings during the periods of 1984 and 1985 (Figs. 1 and 2).

Use of logistic and Gompertz transformations of proportions of disease is helpful in comparing disease development on different cultivars and under different treatments. However, neither transformation provided statistically significant fits to disease progress for all treatments (Table 1). Johnson et al (7) found similiar problems with model fitting for early leaf spot of peanuts. They suggested that AUDPC values avoid problems associated with transformations and linear regression and are easier to compute. AUDPC values for Cercospora blight on asparagus indicated that fungicide protection of the ferns significantly reduced disease on both cultivars during 1985 and on UC 157 F_2 in 1984. In 1985, AUDPC values for chlorothalonil- and mancozeb-treated ferns of UC 157 F_2 were greater than those for Mary Washington (Table 2). This difference can probably be attributed to the shorter height of Mary Washington ferns that allowed for better penetration of fungicides into the inner rows of the treated blocks.

Plaut and Berger (12) found with late leaf spot (*Cercosporidium personatum*) of peanut that fungicide treatments were more effective in reducing the initiation of the epidemic than in slowing the rate of the epidemic. In this study, chlorothalonil significantly reduced the apparent infection rate of the epidemic during 1984 and 1985. The difference in fungicide efficacy between the two studies may be due to a slower disease progress observed for Cercospora blight of asparagus.

Reduced density of plants within the row is not an effective cultural practice to limit severity of Cercospora blight. No difference in either disease progress or AUDPC was evident between blocks receiving the same treatment and planted at different crown densities during 1984 or 1985. Fewer spears were harvested in the low-density control for the 3-yr period than in blocks with normal crown spacing. An alternative that needs to be investigated is to increase distances between rows to delay canopy closure to reduce disease development.

Yield increases from large blocks of UC 157 F_2 asparagus have been correlated for 3 yr with fungicide treatment of the ferns compared with untreated controls. Increases have averaged 40–50% or more during this 3-yr period for UC 157 F_2. Yields of marketable asparagus from control blocks used in this study were similar to those from non-fungicide-treated replicated plots of UC 157 F_2 grown at the Bixby station (10), indicating that protection of ferns by fungicides was responsible for the apparent increased yields in treated blocks. Further evidence for efficacy is provided by the yield response in the Mary Washington blocks attributable to application of fungicides. Chlorothalonil may provide a more effective control of Cercospora blight than mancozeb based on AUDPC values; however, both fungicides were effective in reducing disease and were correlated to increased yields of both asparagus cultivars. Cercospora blight began to increase in severity during late July (Figs. 1 and 2), and rainfall in August was followed by large increases in conidial densities in the air over the ferns and disease severity. Percent disease of unprotected asparagus ferns may be 80–90% by early September. Based on these findings, under Oklahoma weather conditions, application of fungicides should begin in early to mid-July on a 10- to 14-day schedule until mid-August. This will allow for three or four fungicide applications, depending on rainfall frequency in July and August.

Although neither fungicide evaluated is specifically labeled for control of Cercospora blight on asparagus, mancozeb is cleared for application to asparagus. Both fungicides are effective in reducing disease on the ferns, which allows for greater yields of harvested spears during the following year. All three rates of chlorothalonil were effective in controlling Cercospora blight during 1982 and 1983 based on yield responses during the next year's harvest. Chlorothalonil was used in the earlier testing because it is highly effective in controlling diseases caused by *Cercospora* spp. Mancozeb was later included as a comparison and to provide growers with a more economical choice. Growers must realize that the health of ferns during summer and fall can affect yield of asparagus spears in the following year. To increase penetration of fungicide into the fern canopy, methods of applications using conventional spray equipment must be evaluated to optimize the effectiveness of fungicides.

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LITERATURE CITED

1. Averre, C. W. 1983. Evaluation of fungicides for control of Cercospora leaf spot on asparagus, 1982. Fungic. Nematic. Tests 38:89.
2. Berger, R. D. 1981. Comparison of the Gompertz and logistic equations to describe plant disease progress. Phytopathology 71:716-719.
3. Conway, K. E., and Motes, J. E. 1984. Cercospora blight of asparagus in Oklahoma. (Abstr.) Phytopathology 74:865.
4. Cooperman, C. J., and Jenkins, S. F. 1986. Conditions influencing growth and sporulation of *Cercospora asparagi* and Cercospora blight development in asparagus. Phytopathology 76:617-622.
5. Cooperman, C. J., Jenkins, S. F., and Averre, C. W. 1986. Overwintering and aerobiology of *Cercospora asparagi* in North Carolina. Plant Dis. 70:392-394.
6. Draper, N. R., and Smith, H. 1981. Applied Regression Analysis. John Wiley & Sons, New York. 709 pp.
7. Johnson, C. S., Beute, M. K., and Ricker, M. D. 1986. Relationship between components of resistance and disease progress of early leafspot on Virginia-type peanut. Phytopathology 76:495-499.
8. Kramer, C. L., and Pady, S. M. 1966. A new 24-hour spore sampler. Phytopathology 56:517-520.

9. Motes, J. E. 1983. Asparagus. OSU AG-FACTS 6018, Okla. State Univ., Stillwater. 4 pp.
10. Motes, J. E., and Conway, K. E. 1985. Asparagus. Variety evaluation. Page 1 in: 1985 Biennial Report of Vegetable Breeding in the Southern United States, Hawaii, and Puerto Rico. U.S. Veg. Lab. U.S. Dep. Agric., Charleston, SC. 59 pp.
11. Nigh, E. L., Jr. 1981. Influence of water and fertilizer rates delivered by sprinkler irrigation on foliar diseases of asparagus. (Abstr.) Phytopathology 71:1006.
12. Plaut, J. L., and Berger, R. D. 1980. Development of *Cercosporidium personatum* in three peanut canopy layers. Peanut Sci. 7:46-49.
13. Shaner, G., and Finney, R. E. 1977. The effect of nitrogen fertilization on the expression of slow-mildewing resistance in Knox wheat. Phytopathology 67:1051-1056.
14. Vanderplank, J. E. 1963. Plant Diseases: Epidemics and Control. Academic Press, New York. 349 pp.
15. Walker, J. C. 1952. Diseases of Vegetable Crops. McGraw-Hill, New York. 529 pp.