Comparison of Chemical and Cultural Controls for Cercospora Blight on Asparagus and Correlations Between Disease Levels and Yield

Kenneth E. Conway, James E. Motes, and Carol J. Foor

First and third authors, professor and senior agriculturist, Department of Plant Pathology; second author, professor, Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater 74078-9947.

Journal Series 5719, Oklahoma Agriculture Experiment Station, Oklahoma State University, Stillwater.

We appreciate the assistance of Bruce Bostian and Nancy Maness, Department of Horticulture and Landscape Architecture for collection and analysis of yield data and Dr. P. L. Claypool for discussions on statistical procedures.

Accepted for publication 23 April 1990 (submitted for electronic processing).

ABSTRACT

Conway, K. E., Motes, J. E., and Foor, C. J. 1990. Comparison of chemical and cultural controls for Cercospora blight on asparagus and correlations between disease levels and yield. Phytopathology 80:1103-1108.

The relationship between disease levels of Cercospora blight on ferns of four cultivars of asparagus during the summer and yield of asparagus during the following spring was investigated for a 3-yr period (1986–1989). The area under the disease progress curve (AUDPC) was used to describe overall disease levels. Five treatments: residue management before spear production in the spring either through tillage or burning, application of mancozeb or chlorothalonil fungicides to ferns during summer, and an untreated control were followed to attain different disease levels. Disease progress curves showed that fungicides were most effective in delaying and reducing the levels of disease; however, burning of the residue also delayed disease for approximately 7 days and reduced total levels of disease compared to the control and tillage treatments. Applications of mancozeb or chlorothalonil fungicides to ferns during the summer resulted in greater yields than other treatments ($P \leq 0.05$). Burning of fern residue increased yield compared to tillage and control treatments ($P \leq 0.05$). Tillage treatments had similar (AUDPC) values as the control but resulted in increase yields ($P \leq 0.05$). Linear regression analysis was used to determine the relationship between the amount of disease on asparagus ferns during the summer and the yield of marketable spears produced in the following spring. Coefficients of determination (R^2) varied among the cultivars and years but accounted for 38–99% of the variation in yield. The amount of disease on the ferns was inversely correlated with yield. Slopes and intercepts varied within and among years. UC 157 cultivars had higher intercept and slope values than either Mary Washington or Viking, indicating a greater yield response from disease management practices. Residue management or the use of fungicides should be included in any integrated pest management system developed to reduce disease and maximize yield of asparagus.

Cercospora blight, incited by *Cercospora asparagi* Sacc., is an important disease of asparagus (*Asparagus officinalis* L.) in the more southern production areas in the United States (4–7). It is also considered one of the most serious diseases of asparagus in Malaysia (14). The pathogen overwinters in the fern residue. Ferns are normally mowed during early March to prepare for spear production and their residues are left on the soil surface to retain moisture and to lessen blowing sand during the harvest period (7,13). In Oklahoma, harvest of spears ceases during the last week of May and the spears are allowed to produce fern. During June, the ferns will attain a height of 1.2–1.5 m and row closure will occur in the first weeks of July. The disease is initiated by conidia from the fern residue (7) and is first noticed as small lesions on the cladophylls (small needlelike branches) located at the base of the ferns during the latter part of June. Lesion development progresses upward in the fern, eventually causing a blighting of the entire fern by mid- to late August (5,7). Conway et al (5) studied the epidemiology of the disease and developed a system to assess disease progress on the ferns. Application of fungicides to the ferns during the summer growing season provided adequate control of the disease and increased yields during harvest of the following year (5,6).

Although sources of resistance to rust, caused by *Puccinia asparagi* DC in Lam. & DC, were identified in asparagus (9,10), there are no known sources of resistance to Cercospora blight (14). Both diseases occur on the fern portion of the plant and the pathogens overwinter in the fern residue. Because asparagus is a perennial plant with an indeterminate growth pattern, evaluation of disease control and its effect on yield is more difficult. The results of control strategies applied to the ferns during the summer must be evaluated during harvest in the following spring. The objective of this study was to evaluate disease control strategies and to determine their effect on yield. Preliminary reports have been published (4,6).

MATERIALS AND METHODS

Experiments were conducted at the Oklahoma State University Vegetable Research Station located at Bixby, OK, during 1986–1989. Four cultivars of asparagus, UC 157 F_1, UC 157 F_2, Mary Washington, and Viking were used in this study. Plantings for each cultivar consisted of five blocks, each containing four rows 25 m long with 1.5 m between rows. Blocks were separated from each other by 5-m alleys. Assessments of yield and disease were determined from the inner two rows of each block.

Control strategies included two cultural techniques related to residue management, two fungicides, and an untreated control. Residue was removed from the soil surface before spear production each year by burning residue in one block and by rototilling residue into the soil to a depth of 10 cm in the other block. Fern residue in the three other blocks was left in place. Harvest period extended from early April until the last of May when the spears were allowed to produce fern. Dates for the last harvest were 22 May 1986, 29 May 1987, and 26 May 1988. Ferns in two blocks of each cultivar received an application of either mancozeb (Dithane M-45, 2.24 kg a.i./ha plus Triton CS-7, 1.25 ml/L) or chlorothalonil (Bravo 720, 1.75 kg a.i./ha). The mancozeb treatment was not included during 1986. Fungicides were applied to the ferns three times using an overhead sprayer with nozzles directed down into the fern. Two hollow cone nozzles were directed at each row of fern and were calibrated to deliver 280.6 L/ha at 206.8 kPa. Chlorothalonil was applied during 1986 at 48, 63, and 82 days after the last harvest. In 1987 both fungicides were applied at 52, 77, and 102 days after harvest and an additional application of chlorothalonil was applied to UC 157 F_1 and Mary Washington at 118 days. During 1988, both fungicides were applied at 34, 57, and 73 days and additional applications of chlorothalonil were made to UC 157 F_1 and Mary Washington at 92 and 111 days after the last harvest. The experimental design was a split-plot with cultivars assigned to main plots, treatments to subplots and years as replications.

Disease progress was assessed as described previously (5). The rating 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 in each third of the canopy. A rating of 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. Four assessments were made at three locations in each block of ferns and values were averaged. These numbers were inserted into the formula

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

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 are weighted values for severity of disease based on symptom expression and location. For instance, complete defoliation of the lower third of the fern (rating = 1,1,1) would equal a total disease of 33%.

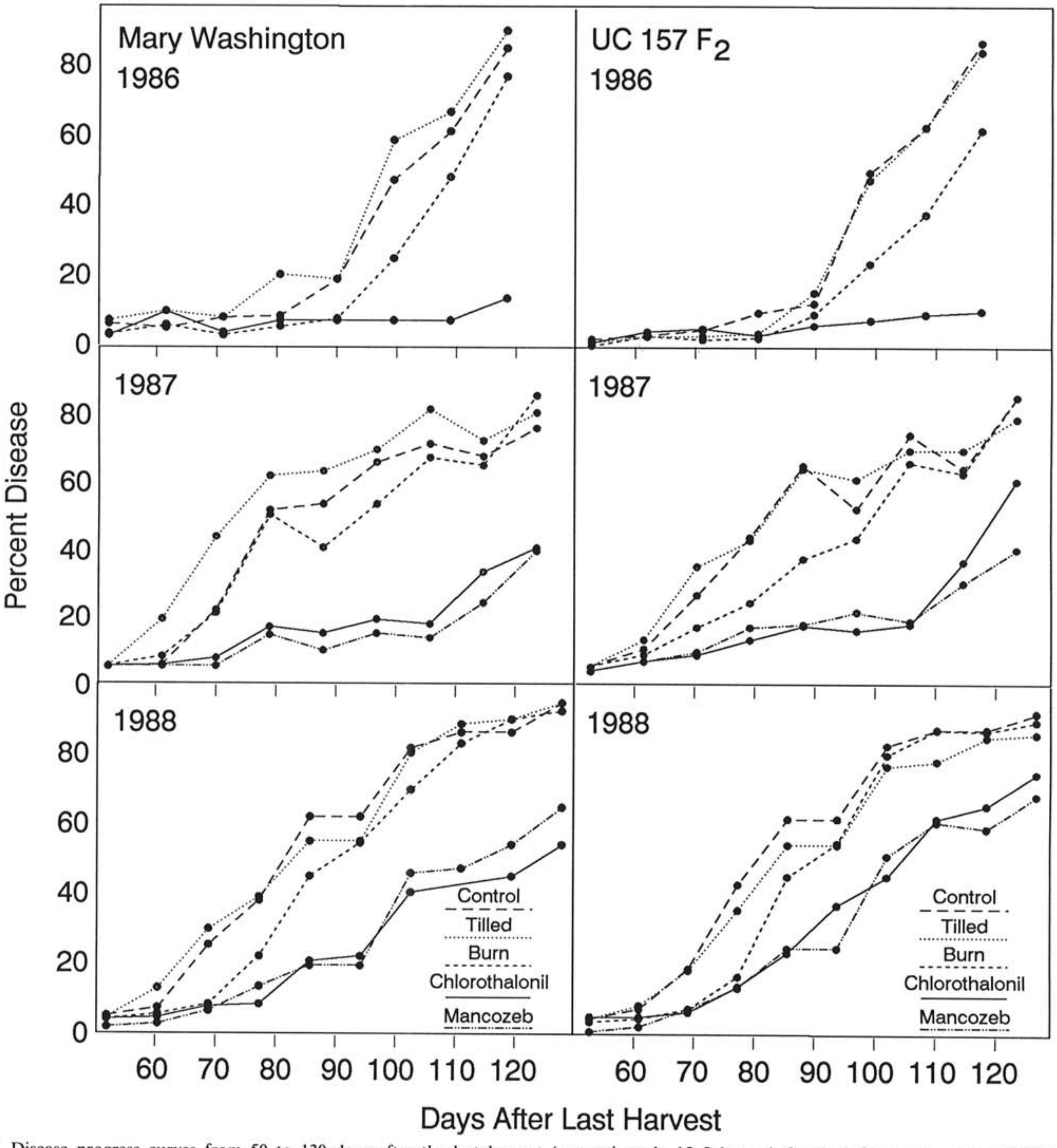

Fig. 1. Disease progress curves from 50 to 130 days after the last harvest (approximately 15 July to 1 October) for a 3-yr period (1986–1988) for development of Cercospora blight on ferns of asparagus cultivars UC 157 F_2 and Mary Washington, comparing residue management techniques of burning or tillage before spear production in the spring, application of chlorothalonil or mancozeb fungicides to the ferns during the summer (mancozeb not applied during 1986), and a untreated control.

TABLE 1. Effect of various treatments on the area under disease progress curve (AUDPC) for Cercospora blight and yield of four cultivars of asparagus for three growing seasons, 1986–1989

Cultivar	Treatment[a]	AUDPC[b]			Yield (kg/ha)[c]		
		1986	1987	1988	1987	1988	1989
UC 157 F_1	Chlorothalonil	1.73	5.69	16.01	6,076.2	7,523.9	7,155.8
	Mancozeb	...[d]	6.34	18.96	...	7,985.1	7,268.2
	Burn	10.27	24.52	27.86	5,246.1	6,904.7	5,760.4
	Till	13.79	24.18	29.26	4,323.7	5,662.3	4,395.2
	Control	12.65	23.95	32.17	3,839.5	5,182.6	4,565.7
UC 157 F_2	Chlorothalonil	2.38	8.02	17.71	7,073.6	7,042.0	6,954.8
	Mancozeb	...	7.63	18.96	...	7,773.3	6,852.8
	Burn	8.17	17.90	27.86	4,169.1	5,797.3	4,856.5
	Till	12.31	24.32	29.26	4,509.9	5,294.1	4,815.7
	Control	12.84	23.28	32.17	3,233.1	4,304.0	4,110.6
Mary Washington	Chlorothalonil	2.33	6.60	12.83	5,851.7	6,026.5	6,475.8
	Mancozeb	...	4.69	15.77	...	6,052.3	6,699.0
	Burn	9.13	21.21	27.26	3,851.8	4,720.8	4,907.9
	Till	14.24	28.12	32.37	4,919.8	5,418.5	4,845.5
	Control	12.67	23.00	31.76	2,973.6	3,793.3	3,814.8
Viking	Chlorothalonil	1.90	8.63	21.14	5,431.8	6,069.7	6,523.9
	Mancozeb	...	5.78	15.28	...	5,177.0	5,465.1
	Burn	13.25	27.69	32.57	3,845.0	5,271.7	4,974.1
	Till	14.30	24.78	32.87	3,068.1	4,121.2	3,863.0
	Control	13.44	25.40	32.82	3,158.8	4,001.3	3,778.2
	LSD (0.05)	1.79	3.54	3.31	880.3	767.7	555.7

[a]Treatments: chlorothalonil (1.75 kg a.i./ha) applied to ferns, mancozeb (2.24 kg a.i./ha) applied to ferns, burned residue prior to harvest, residue rototilled into soil prior to harvest, and an untreated control.
[b]Area under the disease progress curve calculated by the method of Shaner and Finney (15). A total of eight, nine, and 10 observations were made in 1986, 1987, and 1988, respectively.
[c]Hand snapped asparagus spears trimmed to 22.5 cm.
[d]Mancozeb not used in 1986.

Disease progress curves were prepared by plotting proportions of disease over time. Area under the disease progress curve (AUDPC) values were calculated (15) from the proportions of disease on the ferns determined on a weekly basis during the summer (mid-July to mid-September) for a 3-yr period (1986–1988). Assessment of disease began approximately 55 days after the last harvest and allowed for 8, 9, and 10 observations during 1986, 1987, and 1988, respectively. Yield (as weight per block) was recorded, each spring, from each block by hand-harvesting spears, which were snapped and trimmed to a length of 22.5 cm. Analysis of variance was performed using the CoStat program (CoHort Software, Berkeley, CA) and means were separated with a Student-Newman-Keuls multiple range test. Linear regression lines were determined using the SAS procedure (SAS Institute Inc., Cary, NC) from AUDPC values of the previous year and yield data from the current year.

RESULTS

Although the severity of disease varied each year, disease progress was similar each year among cultivars and treatments. The effect of treatments on disease progress for UC 157 F_2 and Mary Washington during the 3-yr year period was typical of other cultivars (Fig. 1). Fungicide treatments effectively controlled Cercospora blight through September. Additional applications of chlorothalonil during 1987 and 1988, which were made for a residue study, reduced the level of disease on ferns of Mary Washington, especially during 1988 (Fig. 1). The effect of the additional application during 1987 is not shown in Figure 1. Burning of the fern residue, which reduced the initial inoculum on the fern residue, delayed disease development on the ferns approximately 1 wk during the first half of the growing season compared to the tillage and control treatments (Fig. 1). Final disease levels in these three treatments were similar at the end of the season, reaching levels of 80–95%. At that time, ferns were defoliated into the top third of the fern canopy and the entire fern appeared brown. Disease levels on ferns treated with either fungicide varied among the 3 yr, ranging from 10 to 75%. Fungicide-protected ferns were visibly green compared to the other treatments. Disease development in the tillage treatments was as great as the control (Fig. 1).

TABLE 2. Mean area under disease progress curve (AUDPC) values and yield of snapped asparagus spears for four cultivars of asparagus and four treatments used to control Cercospora blight incited by *Cercospora asparagi* at Bixby, OK, during 1986–1989

	AUDPC[a]	Yield (kg/ha)[b]
Cultivar		
UC 157 F_1	18.51 a[c]	5,553.01 a
UC 157 F_2	18.02 a	5,180.06 ab
Mary Washington	18.45 a	4,800.00 bc
Viking	20.73 b	4,508.90 c
Treatment[d]		
Fungicide	8.75 a	6,517.14 a
Burn	20.63 b	5,025.45 b
Tillage	23.32 c	4,603.08 c
Control	23.01 c	3,896.29 d

[a]Area under the disease progress curve calculated by the method of Shaner and Finney (15).
[b]Hand snapped asparagus spears trimmed to 22.5 cm.
[c]Values in columns followed by the same letter are not significantly different at $P \leq 0.05$ according to Student-Newman-Keuls test.
[d]Treatments included tillage into soil or burning of asparagus fern residue before harvest in the spring, application of chlorothalonil fungicide (1.75 kg a.i./ha) to ferns during the summer, and an untreated control.

Total disease level, as measured by AUDPC, increased in all cultivars and in all treatments over the 3 yr (Table 1). The same trend for increase in total disease was also apparent over this period when data from only the first eight assessment dates were used to calculate AUDPC. Yield of asparagus for each cultivar increased, regardless of treatment, through 1988 but generally declined in 1989. Greatest yields occurred in the fungicide treated blocks for each cultivar. Yields also tended to be greater from blocks where residue had been burned compared to tillage or control blocks.

When AUDPC values were averaged over treatments (mancozeb not included), Viking had the highest AUDPC compared to the other three cultivars (Table 2). Tillage and control treatments had greater amounts of disease compared to the burn and fungicide treatments ($P \leq 0.05$). Application of fungicides to the ferns reduced disease and resulted in greater yields of asparagus ($P \leq 0.05$) compared to the other treatments (Table 2). Burning the fern residue also reduced disease and increased yield compared to the control and tillage treatments ($P \leq 0.05$). Yield of asparagus from tillage blocks was greater than the control ($P \leq 0.05$) even though both had similar AUDPC values (Table 2).

Equations were determined from linear regression of yield on AUDPC for all treatments of each cultivar (Table 3). Over the 3-yr period there was generally an inverse correlation between yield and disease levels (Fig. 2). AUDPC of each cultivar explained 38–99% of the variation in yield (Table 3). Regression equations reflect the variability among years for the amount of disease developing on the ferns and its effect on yield. Relatively high R^2 values were recorded for 9 of 12 of these linear calculations (values of 0.56–0.99) (Table 3). Lowest R^2 values were estimated for 1988 for three of the four cultivars. Mean square error (MSE) terms generally were greater during 1988, indicating high variability in the yield data; however, regression statistics for two of the four cultivars also had high MSE values during 1987 (Table 3). Estimated slope values were less in 1988 than in 1987 or 1989, indicating less yield reduction during the harvest in 1988 in response to Cercospora blight during the summer of 1987. Cultivars varied greatly in slopes within a year, with the UC 157 cultivars generally having greater slope values than Viking or Mary Washington. In 1989 UC 157 F_2 and UC 157 F_1 had slopes representing a loss of 200.45 and 184.59 kg per AUDPC unit, respectively, compared to Mary Washington and Viking, with slopes representing losses of 123.74 and 104.55 kg per AUDPC unit. The rankings of cultivars according to slope values were generally consistent across the years except for 1987 when Viking was greater than Mary Washington.

The intercepts (a) from the linear regression equations represented the theoretical maximum yield of each cultivar in the absence of disease (Table 3). Intercept values were always greater for the UC 157 cultivars compared to either Mary Washington or Viking. The rankings for intercept values were consistent for each year with UC 157 F_2 having the highest values and Viking the lowest.

Temperatures and rainfall data from the Bixby Research Station showed that less rain was received during 1988 than in 1986 or 1987 (86.6 vs. 110.5 or 107.6 cm, respectively). However, total rainfall during the harvest period was greatest in 1987 compared to 1988 or 1989 (42.0 cm vs. 27.2 or 30.3 cm, respectively). Average monthly temperatures and heating degree days (base 18.3 C) were similar for all years.

DISCUSSION

The use of fungicides, either mancozeb or chlorothalonil, to protect ferns of asparagus during the summer reduced the amount of disease on the ferns. This allowed for an increase in spear production during harvest of the following year compared to the cultural treatments and controls. Increase in the amount of disease (AUDPC) during this 3-yr period was probably due to the location of these tests within a larger untreated asparagus production area at the Bixby Research Station. Infected fern residue in this area may have provided an inoculum reservoir that contributed to the amplification of disease severity. Fluctuations in disease intensity (Fig. 1) were attributed to the indeterminate growth habit of asparagus. The number of ferns per crown and height of each fern increased throughout the summer following rainfall. This addition of new host material resulted in lower assessment values for disease.

Yield of asparagus increased in all cultivars until 1988, with greatest increases occurring in fungicide treatments (Table 1). However, yields generally declined in 1989. According to Falloon and Nikoloff (8) both male and female crowns of Mary Washington 500W declined in yield during the ninth and tenth harvest periods when the crowns were 10–12 yr old. Crowns of Mary Washington and Viking had been planted in 1978 and the UC 157 cultivars in 1981. Therefore all cultivars were reaching a maximum for spear production by 1988.

Management of fern residue before harvest in the spring can affect disease development and yield. Since Cercospora blight is initiated from the residue and does not develop on the lower portion of the ferns until row closure, substantial interplot interference would not be expected until the later stages of the epidemic, when the disease reaches the upper portions of the ferns. Therefore, removal or burial of fern residue within the blocks would affect the amount of inoculum available to initiate disease. It has been suggested that tillage of fern residue was a possible means of inoculum reduction for *C. asparagi* (6,7). However, data from this study indicated that removing the residue by burning is a better management technique than tillage. Yield of asparagus from plots where residue had been burned was greater and ferns had less disease than the tillage and control treatments. The amount of disease on ferns in the tillage plot was not different from the control but the yield of asparagus from the tillage plots was greater than the control. The reason for this increase in yield in the tillage plots compared to the control is not readily apparent from the

TABLE 3. Linear regression statistics for yield (kilograms per hectare) in relation to area under the disease progress curve of Cercospora blight for four cultivars of asparagus during the years 1986–1989[a]

		Regression coefficients[c]					
Cultivar	Year[b]	a	$s(a)$	b	$s(b)$	R^2	MSE ($\times 10^4$)
UC 157 F_2	1987	7,482.8	1,018.1	−306.6	103.3	0.82	74.8
	1988	8,659.1	602.4	−161.2	33.9	0.88	29.8
	1989	10,567.9	231.5	−200.5	9.0	0.99	1.3
UC 157 F_1	1987	6,451.7	591.3	−164.4	55.2	0.82	27.2
	1988	8,332.4	747.6	−99.2	39.1	0.68	60.7
	1989	10,416.6	974.6	−184.6	38.0	0.89	28.2
Mary Washington	1987	5,799.2	1,402.1	−145.9	131.9	0.38	146.1
	1988	6,239.7	745.6	−62.1	39.0	0.46	66.2
	1989	8,318.1	712.1	−123.7	28.1	0.87	26.3
Viking	1987	5,790.6	418.7	−178.6	35.3	0.93	13.0
	1988	5,902.5	769.5	−52.8	37.3	0.40	59.8
	1989	7,737.0	1,495.2	−104.6	53.5	0.56	77.7

[a]Cercospora blight severity was assessed using a previously described scale (5) and AUDPC was calculated according to Shaner and Finney (15). AUDPC values varied due to cultural treatments (residue tillage and burning), application of fungicides (chlorothalonil and mancozeb, except mancozeb not applied during summer 1986) to ferns and an untreated control.

[b]Year refers to date of harvest.

[c]a and b are the intercept and the slope, respectively; $s(a)$ and $s(b)$ are their standard errors; R^2 is the coefficient of determination; MSE is the mean square error. There were five data points (four points for 1987), each a mean of 12 observations, in each regression analysis (3 df).

data. AUDPC values did not indicate any advantage for tillage vs. control. It is possible that sufficient residue may be left on the surface after tillage to initiate Cercospora blight epidemics without a lag period. Tillage, with its incorporation of organic matter into the soil, may provide moisture and nutrients, or reduce soil crusting that could provide conditions more conducive for spear production compared to the control. In addition, the assessments system used to calculate disease on the ferns may not have been adequate in the early stages of the disease epidemic to differentiate between these two treatments. Similarly, Carson (3) could not consistently correlate seed yields, oil content, and seed weights of sunflower with his assessments of percent disease or AUDPC values of infection by *Alternaria zinniae* M. B. Ellis and *Septoria helianthi* Ellis & Kellerm.

Linear regression equations using disease (AUDPC) as a single predictor variable accounted for a great amount of the variation within the data. Variation among years also could be documented by R^2 values with the lowest values occurring during 1988. Burleigh et al (2) used combinations of locations and fungicide applications to create epidemics of *Pyrenophora teres* Dreschs. on barley in Morocco. They used R^2 values to account for variation in yield caused by either disease (AUDPC) or the presence of weeds (AUWGC). AUWGC values helped to explain variation in yield not accounted for by AUDPC. Bailey et al (1) attributed differences in AUDPC values of *Puccinia polysora* Underw. on maize from 1 yr to the next to environmental conditions. Although total rainfall and average temperatures from the Bixby Research Station were similar during the harvest period of asparagus, the distribution and amounts of moisture and occurrence of cooler temperatures during this period may be critical yield-limiting factors. Development of Cercospora blight on ferns also is influenced by the amount and distribution of rain and dew during the summer months.

Lipps and Madden (11) studied the relationship of powdery mildew severity and yield of winter wheat cultivars and concluded that cultivars with the greatest yield loss in relation to disease severity may provide economic returns when expensive control measures, such as fungicides, are used. Variability in slope values each year also implies that yield response from disease management will vary due to other environmental factors. Greater slope values estimated for the UC 157 cultivars during the 3-yr period indicated that the use of fungicides to protect ferns from Cercospora blight would result in greater yield response than for Viking or Mary Washington. Overall, Viking had greater amounts of disease than the other three cultivars. Saadaoui (14) screened more than 43 asparagus cultivars and experimental lines for resistance to Cercospora blight but found that all were susceptible. His evaluations were under artificial conditions and his method for evaluation of resistance was not stated. In this investigation, although similar levels of disease occurred on the UC 157 cultivars and Mary Washington, UC 157 F_1 had greater yields of asparagus than Mary Washington (Table 2). This ranking of cultivars for yield has been reported (12) and is attributed to genetic potential of the cultivars rather than tolerance to Cercospora blight. However, lower slope values for Viking and Mary Washington also may indicate that they are more tolerant of Cercospora blight than the UC cultivars.

Yield of harvested asparagus in the spring can be increased by management of fern residue before the harvest period in the spring or by protection of the fern with fungicides during the summer. Reductions in yield are correlated to the amount of Cercospora blight developing on the fern during the summer.

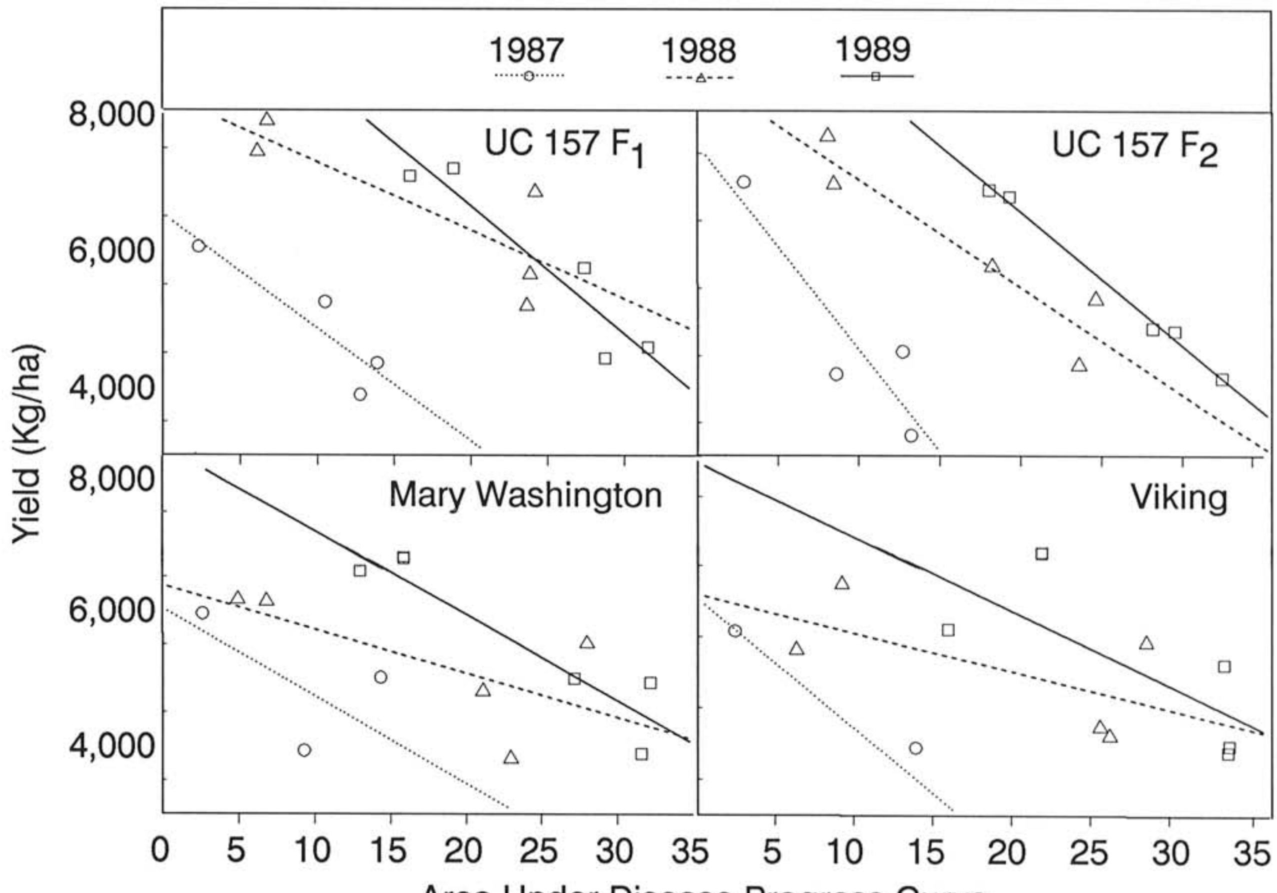

Fig. 2. Linear regression lines for yield in relation to area under the disease progress curve for Cercospora blight on four cultivars of asparagus during three seasons, 1987–1989. AUDPC values varied due to cultural treatments (residue tillage and burning before harvest in the spring), application of fungicides (chlorothalonil and mancozeb, except mancozeb not applied during the 1986–1987 season) to ferns during the summer, and an untreated control.

Management of fern residue also may reduce inoculum of other foliar pathogens such as *Puccinia asparagi* (rust) and *Pleospora herbarum* (Pers.:Fr.) Rabenh. (purple spot). Some form of residue management or protection of the fern with fungicides should be included in any integrated pest management system developed to reduce pest populations and maximize yield of asparagus.

LITERATURE CITED

1. Bailey, B. A., Schuh, W., Fredericksen, R. A., Bockholt, A. J., and Smith, J. D. 1987. Identification of slow-rusting resistance to *Puccinia polysora* in maize inbreds and single crosses. Plant Dis. 71:518-521.
2. Burleigh, J. R., Tajani, M., and Seck, M. 1988. Effects of *Pyrenophora teres* and weeds on barley yield and yield components. Phytopathology 78:295-299.
3. Carson, M. L. 1987. Effect of two foliar pathogens on seed yield of sunflower. Plant Dis. 71:549-551.
4. Conway, K. E. 1988. Effects of Cercospora blight on asparagus yield. (Abstr.) Phytopathology 78:1530.
5. Conway, K. E., Motes, J. E., Bostian, B., Fisher, C. G., and Claypool, P. L. 1987. Cercospora blight development on asparagus fern and effects of fungicides on disease severity and yield. Plant Dis. 71:254-259.
6. Conway, K. E., Motes, J. E., Bostian, B., and Foor, C. J. 1987. Comparison of cultural and fungicidal controls for Cercospora blight of asparagus. (Abstr.) Phytopathology 77:640.
7. 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.
8. Falloon, P. G., and Nikoloff, A. S. 1986. Asparagus: Value of individual plant yield and fern characteristics as selection criteria. N. Z. J. Exp. Agric. 14:417-420.
9. Johnson, D. A. 1986. Two components of slow-rusting in asparagus infected with *Puccinia asparagi*. Phytopathology 76:208-211.
10. Johnson, D. A. 1989. Variation for rust resistance within asparagus cultivars. Plant Dis. 73:309-312.
11. Lipps, P. E., and Madden, L. V. 1989. Assessment of methods of determining powdery mildew severity in relation to grain yield of winter wheat cultivars in Ohio. Phytopathology 79:462-470.
12. Motes, J. E. 1987. Asparagus. Variety evaluation. Page 3-4 in: 1987 Biennial Report of Vegetable Breeding in the Southern United States, Hawaii, and Puerto Rico. U.S. Veg. Lab., U.S. Dep. Agric., Charleston, SC. 79 pp.
13. Price, H. 1986. Growing asparagus in Michigan. Page 11-19 in: Proc. 1986 Illinois Asparagus School. Hortic. Ser. 60. University of Illinois at Urbana Champaign. 44 pp.
14. Saadaoui, E. M. 1987. Cercospora blight of asparagus in Malaysia. Plant Dis. 71:1146.
15. 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.