Influence of Tillage on Development of Gray Leaf Spot and Number of Airborne Conidia of *Cercospora zeae-maydis*

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ABSTRACT

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Four tillage treatments (fall plow, spring disk; fall disk, spring plow, spring disk; spring plow, spring disk; and no-till) were compared for their influence on development of gray leaf spot and numbers of airborne conidia of *Cercospora zeae-maydis*. The effects of tillage were similar for 1983 and 1984, but 1983 was a hot, dry season in which little disease developed. In 1984, conidia were first trapped on 23 May, 5 days after planting, but collection was erratic. Levels of airborne conidia increased beginning on 27 July in all the plots, with the greatest number of conidia collected in the no-till plots. Lesions appeared earlier (2 wk before silking) and disease was greater at each evaluation date in the no-till plots than in the other plots. By 12 September, the numbers of lesions on the fifth leaf above the ear averaged 72 for the no-till plots and 36 for the other tillage plots. There were no differences in disease severity among the other treatments. Yield was significantly less in the no-till plots than in the other plots.

Gray leaf spot is a foliar disease of corn (*Zea mays* L.) caused by the fungus *Cercospora zeae-maydis* Tehon & Daniels. The disease is most severe in regions that have long periods of high humidity that are favorable for infection by the fungus and lesion development (3,4,11). Before 1970, gray leaf spot was of little consequence to corn production in the United States. Serious outbreaks of the disease first appeared in river bottom fields in the mountainous regions of Virginia, Kentucky, and Tennessee (7), and by 1973, gray leaf spot was the most destructive disease of corn in the mountainous regions of North Carolina (8). The disease has now spread to Delaware (5), Maryland, and Pennsylvania and has been reported in Iowa, Missouri, and Illinois (7). Gray leaf spot also has been reported in Mexico, Central and South America, and Trinidad (7).

The recent increase in the distribution and severity of the disease has been associated with an increase in the use of reduced-tillage practices. Roane et al (10) first reported an association between increased severity of gray leaf spot and continuous production of corn by minimum-tillage practices. Likewise, Hilty et al (6) observed the disease to be most severe in fields with minimum tillage. No-till production of corn is predicted to increase in the United States from the present 10 to 26% and reduced tillage will increase from 28 to 48% (12). The wide acceptance and potential increase of reduced-tillage farming in the United States is likely to result in a further increase in the severity of this disease.

Currently, no genotypes of corn are available with a high level of resistance to *C. zeae-maydis*, and management of this disease must be achieved by cultural practices. Given the potential importance of this disease and the likelihood of increased reduced-tillage practices, we designed this study to compare several tillage practices for their influence on severity of gray leaf spot and on the numbers of airborne conidia of *C. zeae-maydis*.

MATERIALS AND METHODS

Tillage treatments and experimental design. Four tillage practices were examined: 1) fall plowing, spring disking; 2) fall disking, spring plowing, spring disking; 3) spring plowing, spring disking; and 4) no-till planting into corn residue. Plowing was done with a moldboard plow. Plots were established in 1982 near Asheville, NC, in a field that had been planted to corn and harvested for silage. Only a small amount of residue was left in the field after harvest in 1982. Thus, residue was brought in from an adjacent cornfield that also had a history of gray leaf spot but had been harvested for grain. The corn residue was baled immediately after harvest, and on the same day, 1 November 1982, three bales (40 kg each of residue) were scattered in each plot and treatments 1 and 2 were plowed and disked, respectively. Treatments 2 and 3 were plowed and treatments 1, 2, and 3 were disked on 17 May 1983. Corn was planted in all treatments on 18 May 1983. Tillage treatments were imposed on the same plots in 1984 as in 1983. No residue was brought into the plots in 1984 because the plots had been harvested for grain in 1983 and plant residue was plentiful on the soil surface. For 1984, treatments 1 and 2 were plowed and disked, respectively, on 26 October 1983; treatments 2 and 3 were plowed and treatments 1, 2, and 3 were disked on 16 May 1984. The corn was planted the next day.

Before planting, 101 kg/ha of 5-15-30 fertilizer was broadcast over the field and all plots except the no-till plots were disked. Corn was planted with a no-till planter. Carbofuran was applied at 0.4 kg/ha for insect control. Weeds were controlled by spraying alachlor and atrazine on all plots; glyphosate was used on the no-till plots. Plants were side-dressed with 26.6 kg/ha ammonium nitrate on 29 June 1983 and 28 June 1984.

The experimental design was a randomized complete block with four replicates. Each plot consisted of six rows 12.2 m long and 1 m apart and was planted to a corn hybrid classified as intermediate in susceptibility in hybrid evaluations in North Carolina. The plots were bordered on the sides with four rows and on the ends with 12.2 m of a taller growing hybrid that was among the more resistant hybrids to gray leaf spot in tests in North Carolina in 1980–1982. Disease was rated and yield was taken in the center two rows of each plot. Data were subjected to analysis of variance, and means were compared using a least significant difference multiple comparison test.

Spore collection. A Rotorod spore sampler (Ted Brown Associates, Los Altos Hills, CA) was placed in the center of each of the 16 plots 61 cm above the soil surface. The sampler was programmed to operate for 180 sec during each 30-min period in 1983 and for 30 sec during each 10-min period in 1984. Each sampler

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Table 1. Monthly rainfall and temperature for 1983 and 1984 and for a 25-yr period at Fletcher, NC

Month	1983 Rainfall (mm)	1983 Temperature (C) Maximum	1983 Temperature (C) Minimum	1984 Rainfall (mm)	1984 Temperature (C) Maximum	1984 Temperature (C) Minimum	24-yr Average Rainfall (mm)	24-yr Average Temperature (C) Maximum	24-yr Average Temperature (C) Minimum
May	95.25	22.6	8.6	172.21	22.6	7.8	126.49	24.0	9.4
June	91.95	22.9	10.1	120.90	24.1	11.2	112.27	26.8	13.5
July	47.50	30.0	15.6	160.53	26.4	15.9	127.51	28.6	16.0
August	23.62	30.6	15.9	158.50	26.9	16.1	142.00	28.1	15.8
September	154.43	21.4	8.9	2.03	21.3	6.6	103.63	25.0	12.3

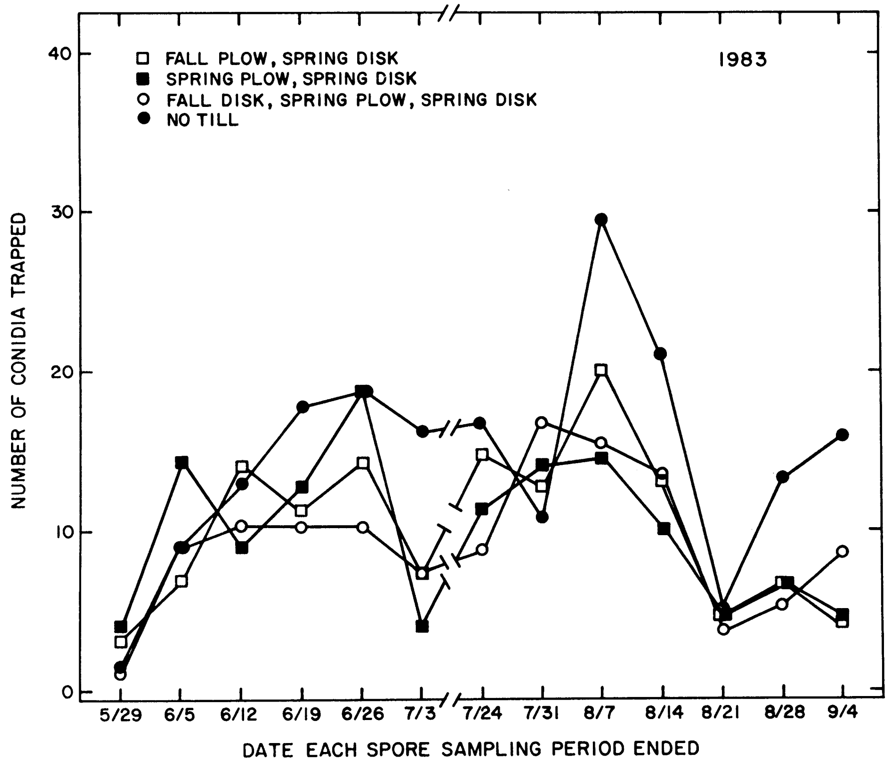

Fig. 1. Number of conidia of *Cercospora zeae-maydis* trapped per 120 m^3 of air per day above four tillage treatments in 1983.

Table 2. Total and per-plant yield of corn grown in four tillage treatments in 1983 and 1984

Treatment	1983[x] Total (Mg/ha)	1983[x] Per plant (g)	1984[y] Total (Mg/ha)	1984[y] Per plant (g)
Fall plow	11.7 a[z]	256 a	10.1 a	230 b
Spring plow	11.5 a	254 a	10.4 a	248 ab
Fall disk, spring plow	11.5 a	242 a	10.7 a	255 a
No-till	10.8 a	254 a	7.9 b	219 b

[x] Machine-harvested.
[y] Hand-harvested.
[z] Values in each column followed by common letters are not significantly different ($P \leq 0.05$) according to LSD test on means.

sampled 120 and 60 m^3 of air each day in 1983 and 1984, respectively. Conidia were collected on transparent rods (4 × 64 mm) coated with silicon grease, stained with cotton blue, and conidia were counted at 400× with a compound microscope. In 1983, rods were collected every day from 23 May to 4 September. In 1984, rods were collected on Monday, Wednesday, and Friday from 18 May to 31 August. Because of electrical problems in 1984, not all spore samplers were operating until 10 June.

Disease evaluation. In 1983, disease was evaluated on a scale of 0–5 (6), where 0 = no symptoms; 1 = trace of lesions below the ear, none above; 2 = many lesions below the ear, trace above; 3 = severe lesion development below the ear, all leaves above the ear with lesions; 4 = all leaves with severe lesion development but green tissue visible, and 5 = all leaves dry and dead. Disease developed slowly in 1983 and was rated only once, on 20 September 1983.

In 1984, plots were examined three times per week and disease development was quantitated five times during the growing season by counting lesions on designated leaves. Lesions were counted on the sixth leaf below the ear leaf on 3 August, on the fifth leaf below on 11 and 16 August, on the ear leaf on 30 August, and on the fifth leaf above the ear leaf on 12 September. On the first three evaluation dates, every 10th plant in the two center rows of each plot was rated (about 14 plants). On the last two evaluation dates, every fifth plant was evaluated. Weather data were obtained from the Mountain Horticultural Crops Research Station, Fletcher, NC, located about 4 km from the plots.

Yield evaluation. Plots were machine-harvested on 26 October 1983 and hand-harvested on 3 October 1984. Yield was determined on the basis of a moisture content of 15.5%. Yield also was calculated on a per-plant basis because the plant stand was reduced in the no-till plots.

RESULTS

The 1983 growing season was characterized by a cool spring and a dry summer with above-average temperatures (Table 1). Airborne conidia of *C. zeae-maydis* were trapped throughout the sampling period (Fig. 1). Levels of airborne conidia were never high and fluctuated between weeks; however, the number of conidia trapped was generally higher in the no-till plots, with a broad peak from 19 June to 24 July and later peaks on 7 August and 4 September. The mean number of conidia collected over the entire sampling period was significantly greater in the no-till treatment than in the other tillage treatments; the other treatments did not differ significantly from one another.

Gray leaf spot developed slowly in 1983, and few lesions were present even by 2 September. Plants were rated for disease on 20 September, but still, little disease was present and there was no significant difference in disease severity among the tillage treatments. Mean disease ratings were 2.3 for fall plow, spring disk; 2.5 for fall disk, spring plow, spring disk; 2.6 for spring plow, spring disk; and 2.9 for no-till. Yield was not significantly affected by the tillage treatments (Table 2).

Rainfall was more frequent in 1984 than in 1983 (Table 1). Conidia were trapped on 23 May, 5 days after planting, but airborne levels of the spores were quite variable. From 29 June until 17 August, levels of airborne conidia were the highest at each sampling date in the no-till plots (Fig. 2). Over this period, the mean number of conidia trapped was significantly greater in the no-till treatment than in any other treatment and the other treatments did not differ significantly from one another.

Lesions of gray leaf spot appeared on 11 July, 2 wk before silking. Lesions appeared first, and the mean number of lesions per leaf was greatest at each evaluation date in the no-till plots (Fig. 3). The other tillage treatments did not differ significantly from one another in number of lesions present. Total yield and yield per plant were less in the no-till plots (Table 2).

DISCUSSION

The number of airborne conidia and the severity of gray leaf spot were greater in the no-till treatment than in the other three tillage treatments in both years of the study. Lesions appeared earlier in the no-till treatment, which allowed for more secondary cycles of the fungus. With the greater number and earlier appearance of lesions, there was a rapid buildup of inoculum in the no-till treatment. By the last rating date, there were twice as many lesions in the no-till treatment as in any other tillage treatment.

Increased disease severity in the no-till treatment was due to corn residue on the soil surface, which provided an earlier and more extensive source of inoculum than in the tillage treatments. This is supported by the fact that *C. zeae-maydis* survives better in debris on or above the soil surface than in buried debris (9).

Extensive blighting occurred in the no-till plots by the end of the 1984 growing season, and total yield in these plots was reduced significantly. Yield reduction was due in part to fewer plants in these plots; however, because per-plant yield in the no-till treatment was 10% less than the average yield of the other tillage treatments, part of the yield loss was probably attributable to gray leaf spot. Yield losses of 20% have been reported for this disease in Pennsylvania (1) and Tennessee (6). Gray leaf spot occurs frequently in the mountainous regions of North Carolina. Disease severity greater than that observed in this study has been reported in several locations in the state. Differences between locations in severity of the disease are probably related to environmental conditions and culture practices. There is, however, evidence that isolates of the fungus differ in virulence (2), and differences in disease

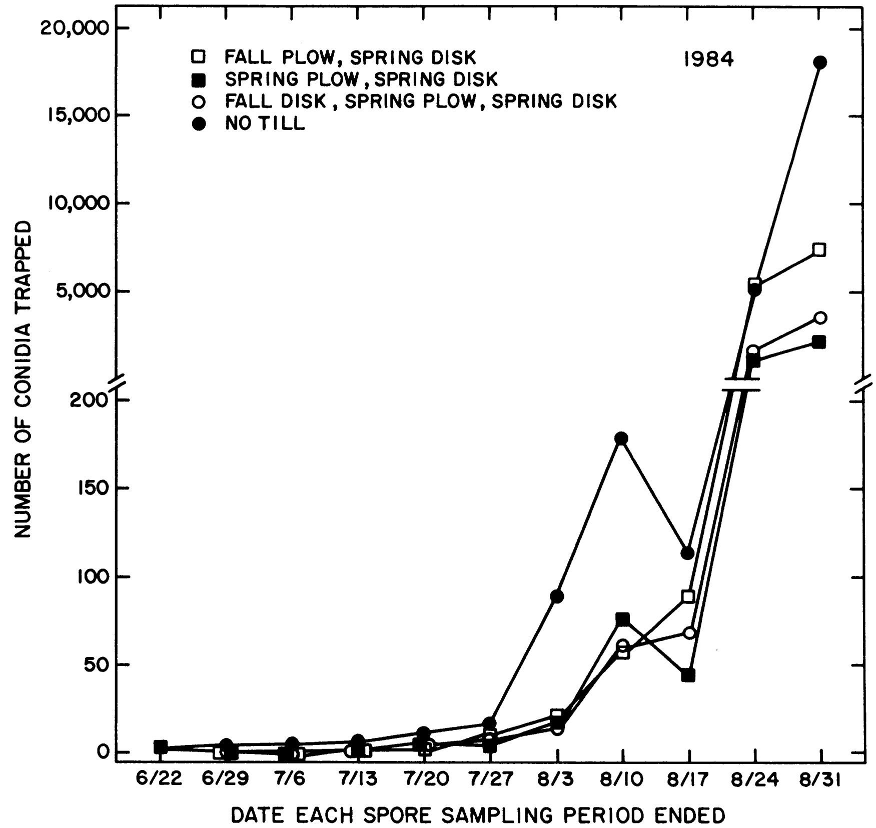

Fig. 2. Number of conidia of *Cercospora zeae-maydis* trapped per 60 m^3 of air per day above four tillage treatments in 1984.

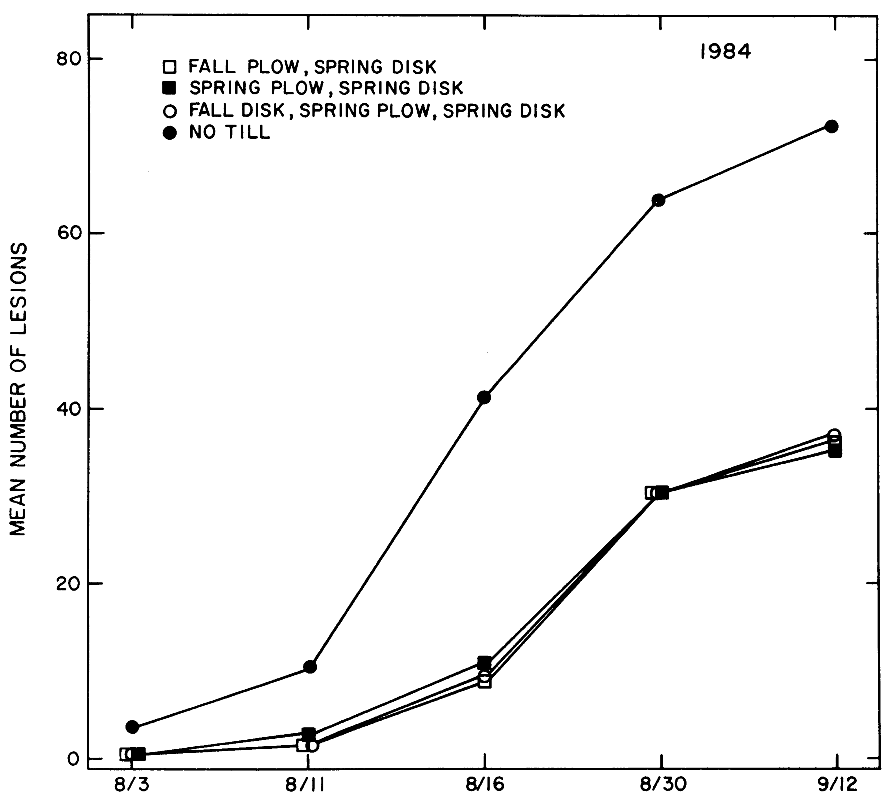

Fig. 3. Mean number of lesions per leaf produced by *Cercospora zeae-maydis* on corn grown in four tillage treatments in 1984. Lesions were counted on the sixth leaf below the ear leaf on 3 August, on the fifth leaf below the ear leaf on 11 and 16 August, on the ear leaf on 30 August, and on the fifth leaf above the ear leaf on 12 September.

severity among locations may be related, in part, to the virulence of the pathogen.

The number of airborne conidia and the severity of gray leaf spot differed in 1983 and 1984. Few airborne conidia were present and little disease developed in 1983, which was drier and warmer than average. The 1984 season was cooler and wetter. Infection and lesion development by the fungus are favored by long periods of high humidity and leaf wetness (3,11), conditions that were more prevalent in 1984 than in 1983.

The results of this study are consistent with observations by other investigators (1,6,7,10) that disease severity of gray leaf spot is greater under minimum-tillage practices. An important finding of this study is that all tillage practices that destroyed the corn residue reduced the level of inoculum and disease severity; spring plowing was as effective as fall plowing in reducing disease severity. Because no resistant genotypes are currently available, cultural practices are an important means of control for this disease. Rotation is not an economical solution to this problem in many mountainous areas of North Carolina. Spring plowing is a preferable alternative to fall plowing because it does not promote as much erosion of soil. Because much of the corn is grown by dairy farmers and is used for silage, an alternative control, where possible, may be for farmers to plant no-till in cornfields previously harvested for silage and where little residue is present, and plow those fields that were harvested for grain. Because no-till farming is predicted to increase (12), more studies are needed to learn how to manage diseases such as gray leaf spot under these conditions.

LITERATURE CITED

1. Ayers, J. E., Johnson, M. W., Jr., and Hill, R. R., Jr. 1984. Identifying resistance to gray leaf spot. Proc. Annu. Corn Sorghum Ind. Res. Conf. 39:157-175.
2. Bair, W., and Ayers, J. E. 1986. Variability in isolates of *Cercospora zeae-maydis*. Phytopathology 76:129-132.
3. Beckman, P. M., and Payne, G. A. 1982. External growth, penetration, and development of *Cercospora zeae-maydis* in corn leaves. Phytopathology 72:810-815.
4. Beckman, P. M., and Payne, G. A. 1983. Cultural techniques and conditions influencing growth and sporulation of *Cercospora zeae-maydis* and lesion development in corn. Phytopathology 73:286-289.
5. Hawk, J. A., Carroll, R. B., and Latterell, F. M. 1985. First report of gray leaf spot (*Cercospora zeae-maydis*) of corn in Delaware. Plant Dis. 69:361.
6. Hilty, J. W., Hadden, C. H., and Garden, F. T. 1979. Response of maize hybrids and inbred lines to gray leaf spot disease and the effects on yield in Tennessee. Plant Dis. Rep. 63:515-518.
7. Latterell, F. M., and Rossi, A. E. 1983. Gray leaf spot of corn: A disease on the move. Plant Dis. 67:842-847.
8. Leonard, K. J. 1974. Foliar pathogens of corn in North Carolina. Plant Dis. Rep. 58:532-534.
9. Payne, G. A., and Waldron, J. K. 1983. Overwintering and spore release of *Cercospora zeae-maydis* in corn debris in North Carolina. Plant Dis. 67:87-89.
10. Roane, C. W., Harrison, R. L., and Genter, C. F. 1974. Observations on gray leaf spot of maize in Virginia. Plant Dis. Rep. 58:456-459.
11. Rupe, J. C., Siegel, M. R., and Hartman, J. R. 1982. Influence of environment and plant maturity on gray leaf spot of corn caused by *Cercospora zeae-maydis*. Phytopathology 72:1587-1591.
12. Worsham, A. D. 1980. No-till corn: Its outlook for the 80's. Proc. Annu. Corn Sorghum Conf. 35:146-163.