Effect of Three Tillage Practices on Development of Northern Corn Leaf Blight (*Exserohilum turcicum*) Under Continuous Corn

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ABSTRACT

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Corn hybrid A632 × A619 was planted in 1985 on 0.6 ha, and plants were inoculated 6 wk later with *Exserohilum turcicum* race 2. A severe epidemic of northern corn leaf blight developed. Three tillage treatments, ridge-till, mulch-till, and no-till, were established, and three corn hybrids, A632 × A619, B73 × Mo17, and B73 × LH38, were planted in the same field in 1986. The experiment was repeated by planting and inoculating A632 × A619 on 0.6 ha in 1986 and reevaluating the three tillage treatments and three corn hybrids in 1987. Northern corn leaf blight was more severe under no-till than mulch-till for the susceptible hybrid A632 × A619 in both years. Disease severity levels for ridge-till were similar to those for no-till in 1986 but were similar to those for mulch-till in 1987. Highest yields were obtained from ridge-till and mulch-till plots for both years, whereas no-till plot yields were consistently the lowest. A significant negative correlation occurred between area under disease progress curve (AUDPC) and yield and a significant positive correlation between AUDPC and lodging for A632 × A619. The more resistant hybrids, B73 × Mo17 and B73 × LH38, had significant negative correlations between lodging and yield for all tillage practices.

Crop rotation is an effective means of controlling foliar diseases on most crops. The normal crop rotation in Illinois alternates crops of corn (*Zea mays* L.) and soybeans (*Glycine max* (L.) Merr.). However, due to projected prices, potential herbicide carryover, or changes in government programs, growers often choose to grow continuous corn for two or more years.

A shift is underway to practice some form of conservation tillage to reduce soil erosion. By leaving plant residue on the soil surface, soil temperatures and water evaporation are reduced, water infiltration is increased, and water runoff is reduced (1,8,10). Price (14) indicated that plant diseases were not increased under reduced tillage; however, several reports indicate tillage practices do affect many corn diseases (7,11,12,17,19). Griffith et al (7) found earlier and more severe levels of northern leaf blight, southern leaf blight, and yellow leaf blight in Indiana when plant debris was retained on the soil surface. Payne et al (11) found higher levels of gray leaf spot with no-till than with any form of reduced tillage. They showed that tillage that brings soil in contact with infested plant debris will reduce initial inoculum. Generally, when moldboard plow tillage is compared with no-till, the greater the exposure of plant debris to soil (burying versus placing on the soil surface), the lower the survival of the pathogen (9,17,19).

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No information, to our knowledge, is available on the effect of ridge-till on foliar corn diseases. Our objective was to evaluate the effect of three tillage systems (mulch-till, ridge-till, and no-till) on the development of northern corn leaf blight caused by *Exserohilum turcicum* (Pass.) K.J. Leonard & E.G. Suggs.

MATERIALS AND METHODS

Spring 1985 to fall 1986. All research was done at the Agronomy/Plant Pathology South Farms, Urbana, Illinois, on a Drummer soil with an organic content of 4.5% and a pH of 7.0. The susceptible corn hybrid, A632 × A619, was planted at 55,000 seeds/ha on 0.6 ha in 1985. Row width was 0.76 m and planting depth was 5.0 cm. Six weeks after planting, every third plant in alternating rows was inoculated by placing 25 mg of ground dry leaf tissue infected with *E. turcicum* race 2 into the whorl. Disease severity levels were visually estimated 6 wk after midsilk.

Tillage treatments were established at cultivation, and each treatment was 9.1-m wide (12 rows) × 45-m long with 0.76-m row spacing. The three tillage treatments were no-till (no tillage before or after planting), ridge-till (planting on tillage ridges from the previous crop, but with no additional fall or spring tillage), and mulch-till (fall and spring cultivation, but no use of a moldboard plow). The only difference between no-till and ridge-till was the use of a ridge-till cultivator, which resulted in ridges approximately 20- to 25-cm high and 35- to 40-cm wide. Following harvest, stalks on all plots were mechanically chopped. Mulch-till plots were tilled with a chisel plow, whereas ridge-till and no-till plots received no tillage. Percent soil surface covered with plant debris was visually estimated for each plot following fall tillage and before spring planting.

In 1986, all plots received 224 kg/ha of nitrogen as ammonium nitrate and were treated with glyphosate (2.24 kg a.i./ha) and chlorpyrifos (2.3 kg a.i./ha) before planting. All plots were treated with atrazine (2.24 kg a.i./ha) and alachlor (2.24 kg a.i./ha) after planting.

A split-split-plot arrangement of a randomized complete block design with four replications was used for the study. Each main plot (tillage treatment) was divided into three subplots (hybrids) (four-rows wide × 45-m long) and two sub-subplots (four-rows wide × 22.5-m long), which were either inoculated or not inoculated with *E. turcicum*.

Three corn hybrids, A632 × A619, B73 × Mo17, and B73 × LH38, were planted at 55,000 seeds/ha on 7 May using a Case/International Early Riser planter, equipped with furrowing disks. Plant emergence was counted 4 wk after planting. Mulch-till and ridge-till plots were cultivated approximately 5 wk after planting with either a conventional row cultivator or a ridge-till cultivator, respectively. Six weeks after planting, sub-subplots were inoculated with *E. turcicum* race 2, as previously described. Visual disease severity ratings were recorded weekly, beginning 2 wk after inoculation and continuing for 7 wk, with the final rating on 15 August. The percentage of lodged plants was determined for the center two rows of each sub-subplot. The center two rows from each sub-subplot were hand-harvested, ears were shelled, and grain weights were converted to kilograms per hectare at 15.5% moisture.

Spring 1986 to fall 1987. In 1986, a 0.6-ha area adjacent to the 1985–1986 plots was planted to A632 × A619 at 55,000 seeds/ha. The three tillage treatments previously described were begun at cultivation. Six weeks after planting, every third plant in alternating rows was inoculated with ground dry leaf tissue infested with *E. turcicum* race 2 as previously described. Disease severity ratings were recorded 6 wk after midsilk. Following harvest, stalks were chopped, and the mulch-till plots were tilled with a chisel plow.

In 1987, all plots received the same rates of fertilizer, herbicides, and insecticides as used on the tillage plots in 1986. The three hybrids were planted at 55,000 seeds/ha on 27 May using a John Deere Maximerge planter equipped with fluted no-till coulters. Plant stands were determined 4 wk after planting. The mulch-till and ridge-till plots were cultivated 5 wk after planting with either a conventional row crop cultivator or a ridge-till cultivator. Six weeks after planting, half of the plots were inoculated with ground dry leaf tissue infested with *E. turcicum* race 2. Visual disease severity ratings were recorded weekly beginning 2 wk after inoculation, with the final rating on 6 September. Percent lodging and yield were determined as previously described.

Statistical analysis. All data were analyzed by ANOVA (16), and mean comparisons were done using the appropriate error term for a split-split-plot design (2). Disease severity estimates were used to determine area under disease progress curves (AUDPC) for individual plots (18).

RESULTS

Tillage tests 1985–1986. In 1985, the disease severity on A632 × A619 was 70% at physiological maturity, and lodging was 38% at harvest. All three tillage treatments resulted in plots with considerable plant debris on the surface prior to fall tillage. After chisel-plowing, the surface of mulch-till plots was approximately 30% covered with plant debris; the surfaces of no-till and ridge-till plots were approximately 70% covered with plant debris. Following 1986 spring tillage, which included tilling with a tandem disk, a field cultivator, and a Danish-tine cultivator, virtually no plant debris remained on the surface of mulch-till plots at planting. The surfaces of no-till and ridge-till plots were approximately 50–60% covered with plant debris at planting.

In 1986, no differences were observed among hybrids or tillage treatments for plant stands, which ranged from 51,000 to 52,400 plants per hectare. AUDPC values for A632 × A619 were significantly ($P = 0.05$) higher for inoculated than control plots for all tillage treatments (Table 1). Control plots of A632 × A619 had an AUDPC value of 397.5 for the no-till treatment, whereas the same hybrid with ridge-till or mulch-till treatments had respective AUDPC values of 80.0 and 30.0. Significantly higher lodging and lower yields occurred in A632 × A619 inoculated with *E. turcicum* under all tillage treatments. AUDPC values from inoculated plots were significantly higher than controls for B73 × Mo17 and B73 × LH38, except for B73 × Mo17 with the ridge-till treatment. Lodging and yield were not affected, except for an increase in lodging for B73 × Mo17 for the no-till treatment. The highest yields from control plots for B73 × Mo17 and B73 × LH38 were obtained from ridge-till and mulch-till plots. No-till plots, averaged over all hybrids, yielded 7% less than mulch-till plots, whereas ridge-till plots averaged 5% greater yields than mulch-till plots.

Table 1. Effect of three tillage methods on northern corn leaf blight, lodging, and yield of three corn hybrids in 1986 at Urbana, Illinois

Hybrid Tillage	Disease	AUDPC[a]	Lodging (%)	Yield (kg/ha)
A632 × A619				
Mulch-till	Inoculated	727.5	36	9,228
	Control	80.0	10	10,951
No-till	Inoculated	580.0	30	8,988
	Control	397.5	24	9,948
Ridge-till	Inoculated	825.0	33	9,353
	Control	30.0	10	11,735
B73 × Mo17				
Mulch-till	Inoculated	187.5	20	10,662
	Control	30.0	20	11,114
No-till	Inoculated	112.5	32	9,897
	Control	22.5	25	10,274
Ridge-till	Inoculated	95.0	25	11,843
	Control	35.0	20	11,735
B73 × LH38				
Mulch-till	Inoculated	117.5	30	12,136
	Control	7.5	30	12,393
No-till	Inoculated	102.5	25	11,202
	Control	20.0	20	11,270
Ridge-till	Inoculated	90.0	20	12,481
	Control	8.8	20	12,626
LSD ($P = 0.05$)		80.4	5.6	834

[a] Area under disease progress curve.

Tillage tests 1986–1987. Disease severity on A632 × A619 in 1986 was 62% at physiological maturity and lodging was 42% at harvest. After stalks had been chopped and mulch-till plots chisel-plowed, plant debris on the surface was similar to that on plots at the end of the 1985 season. The surface of mulch-till plots was 30% covered, whereas the ridge-till and no-till plot surfaces were 80% covered with plant debris. Following 1987 spring tillage, less than 10% of the mulch-till plots were covered with plant debris, and 50–60% of no-till and ridge-till plot surfaces were covered with plant debris.

No differences were observed among tillage or hybrid treatments in 1987 for plant stands, which ranged from 52,000 to 54,500 plants per hectare; however, stands were slightly higher than in 1986. AUDPC values were significantly higher for all inoculated plots than control plots for all hybrids and treatments (Table 2). Unlike 1986, AUDPC values from the control plots of ridge-till treatment for A632 × A619 were nearly as high as for the corresponding no-till treatment. AUDPC values for control plots of the mulch-till treatment were significantly lower than for the other two tillage treatments. Plots of A632 × A619 inoculated with *E. turcicum* race 2 had higher percentages of lodging and lower yields than control plots for all three tillage treatments. Inoculation with *E. turcicum* did not influence lodging or yield in B73 × Mo17 or B73 × LH38 for any tillage treatment. Highest yields from control plots of B73 × Mo17 and B73 × LH38 were obtained from mulch-till or ridge-till treatments. No-till plots for all hybrids had yields 11% lower than mulch-till plots, whereas ridge-till plots had yields 3% lower than mulch-till plots.

Correlation coefficients (Table 3) for control and inoculated treatments indicated a significant positive relationship between AUDPC and lodging and a significant negative relationship between AUDPC and yield for A632 × A619 for all tillage treatments. However, a significant negative correlation was found between lodging and yield for B73 × Mo17 and B73 × LH38 for all tillage treatments.

DISCUSSION

Inoculation with *E. turcicum* in 1985 resulted in a uniform infection across the entire field. Following harvest, approximately 70% of the soil surface was covered with residue. Although no-till reduces soil erosion, it also allows fungal pathogens to overwinter and serve as a source of inoculum the following season (9,17,19).

Despite planting dates that differed by 20 days, disease development and yields in 1986 and 1987 were similar. Inoculated plots of most hybrids and treatments had significantly more disease than control plots. However, only A632 × A619 had sufficient disease to influence both lodging and yield. The major difference between 1986 and 1987 was the response of control plots of A632 × A619 with the ridge-till treatment. In 1986, AUDPC values for ridge-till plots were similar to those for mulch-till, whereas in 1987 they were similar to those for no-till plots. Tillage treatments were identical in 1986 and 1987, with one exception. All plots in 1986 were planted with the Early Riser planter, equipped with furrowing disks. These disks are mounted in the front of the planter and are designed to move soil clods and plant debris from in front of the disk opener. When used on the ridge-till plots, approximately 5–6 cm of soil from the ridge top was spread over plant debris in the valley, i.e., the area between ridges. We believe this enhanced rapid breakdown of infected plant debris from 1985, which could have served as the initial inoculum in control plots in 1986. In 1987, we used the Maximerge planter equipped with fluted no-till coulters. These coulters are designed to cut through plant debris, rather than move the debris to the side like the furrowing disks. The no-till coulter didn't cover plant debris from 1986, thereby allowing it to remain on the soil surface. Therefore, infected plant debris could serve as a source of inoculum in control plots of no-till and ridge-till treatments.

There also were significant reductions in yield from no-till control plots for B73 × Mo17 and B73 × LH38 compared with ridge-till or mulch-till plot yields in both years. Lower yields were not due to a reduction in plant population, so they must have resulted from reductions in kernel number, kernel weight, or ears per plant. Additional research is needed to determine this reduction in yield associated with no-till versus ridge-till or mulch-till.

The correlation analysis indicated a significant positive relationship between AUDPC and lodging but a significant negative relationship between AUDPC and yield for A632 × A619. In this case, we believe lodging was increased as a result of foliar infection by *E. turcicum*. The relationship between foliar disease and stalk rot has been studied previously (3–6,15) and appears to be consistent for A632 × A619. However, the other two hybrids were different. Despite inoculation with *E. turcicum*, we were unable to establish enough disease on B73 × Mo17 or B73 × LH38 to cause a yield loss. Field evaluation of these two hybrids (Pedersen, *unpublished*) indicated they have moderate to high levels of quantitative resistance to *E. turcicum*. Although neither hybrid had a significant positive correlation between AUDPC and lodging or AUDPC and yield, they did have significant negative correlations between lodging and yield for all tillage treatments. This suggests that increased lodging resulted in a decrease in yield, but lodging was independent of northern corn leaf blight. Lodging generally was not affected by tillage in this study, and northern leaf blight was below the disease threshold of 126 AUDPC units (13) for both B73 × Mo17 and B73 × LH38.

In conclusion, this study demonstrated one potential problem associated with no-till when corn is not rotated with another crop, such as soybeans. Most of the yield reduction associated with no-till in this study could be attributed to severity of northern corn leaf blight. Whereas ridge-till left a similar amount

Table 2. Effect of three tillage methods on northern corn leaf blight, lodging, and yield of three corn hybrids on 1987 at Urbana, Illinois

Hybrid Tillage	Disease	AUDPC[a]	Lodging (%)	Yield (kg/ha)
A632 × A619				
Mulch-till	Inoculated	707.5	30	7,858
	Control	92.5	5	9,697
No-till	Inoculated	806.3	28	7,445
	Control	411.3	3	8,499
Ridge-till	Inoculated	650.0	34	7,771
	Control	386.3	5	8,894
B73 × Mo17				
Mulch-till	Inoculated	195.0	25	10,587
	Control	22.5	20	10,455
No-till	Inoculated	155.0	18	9,019
	Control	27.5	19	9,314
Ridge-till	Inoculated	140.0	15	10,405
	Control	25.0	16	10,512
B73 × LH38				
Mulch-till	Inoculated	122.5	18	11,196
	Control	25.0	20	11,127
No-till	Inoculated	120.0	17	9,759
	Control	6.3	15	9,941
Ridge-till	Inoculated	121.3	18	10,932
	Control	17.5	16	10,757
LSD ($P = 0.05$)		91.3	7.4	788

[a] Area under disease progress curve.

Table 3. Correlation coefficients for AUDPC,[a] lodging, and yield for three corn hybrids under three tillage methods in 1986 and 1987

Hybrid Tillage	Parameter	Lodging	Yield
A632 × A619			
Mulch-till	AUDPC	0.95**[b]	−0.64*
	Lodging	...	−0.48
No-till	AUDPC	0.69*	−0.86**
	Lodging	...	−0.42
Ridge-till	AUDPC	0.78**	−0.62*
	Lodging	...	−0.43
B73 × Mo17			
Mulch-till	AUDPC	−0.06	−0.15
	Lodging	...	−0.52*
No-till	AUDPC	0.03	−0.44
	Lodging	...	−0.53*
Ridge-till	AUDPC	−0.13	−0.21
	Lodging	...	−0.69**
B73 × LH38			
Mulch-till	AUDPC	−0.09	−0.19
	Lodging	...	−0.85**
No-till	AUDPC	0.27	−0.10
	Lodging	...	−0.67*
Ridge-till	AUDPC	−0.03	−0.19
	Lodging	...	−0.67*

[a] Area under disease progress curve.
[b] Correlation coefficients marked by * or ** are significant at the 0.05 and 0.01 probability levels, respectively.

of debris on the soil surface over winter, the use of furrow-openers on the planter in 1986 appeared to reduce initial inoculum and disease pressure on A632 × A619. The study also indicated that corn hybrids are commercially available with high levels of resistance to *E. turcicum*.

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