Survival of *Colletotrichum graminicola* in Infested Corn Residues in Ohio

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ABSTRACT

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In the spring, the number of acervuli of *Colletotrichum graminicola* developing on corn (*Zea mays*) residues buried by fall plowing was significantly less than on residues left on the soil surface. Although a relatively low level of sporulation occurred on rind sections of buried stalks, acervuli developed on 30% of the stalks that were buried and left to overwinter. *C. graminicola* was eliminated from infested corn stalks buried 1–2 cm below the soil surface from 10 December to 18 August.

Anthracnose, caused by *Colletotrichum graminicola* (Ces.) G. W. Wils., has become one of the most important diseases of corn (*Zea mays* L.) in Ohio. From the initial report in 1963 (8) to the present, the incidence and severity of anthracnose leaf blight and stalk rot has increased significantly within the state, especially during the past decade. In 1979, the disease was observed in more than 50% of the corn fields surveyed and the incidence of plants with stalk rot in individual fields ranged from 10 to 90%, with 50 to 80% lodging in some fields. A considerable level of inoculum must have overwintered throughout the state for this amount of disease to occur.

Naylor and Leonard (5), in North Carolina, reported that *C. graminicola* survived poorly in infested corn stalks left on the soil surface from November to March and the fungus could not be recovered from residues that were buried from November to February. *C. graminicola* survived the winter and following growing season (10 mo), however, on residues suspended 60 cm above the soil surface (5). Vizvary and Warren (6) reported that burial of infested residues from fall to spring reduced sporulation of *C. graminicola* 10-fold, whereas sporulation on surface residues doubled. Both of these studies (5,6) indicate that long-term survival of *C. graminicola* depends on residues being left on the soil surface.

Increased incidence of anthracnose diseases of corn may possibly be linked to the relatively recent change in tillage practices that leave corn residues on the soil surface (3,4). Before 1970, essentially all corn acreage in Ohio was moldboard plowed and most corn residues were buried. By 1979, 28% of the corn acreage in the state (with acreage of individual counties ranging from 1–77%) was managed by using some type of conservation tillage method that left most residues on the soil surface (2). Although it is impossible to prove that reduced tillage techniques favored the anthracnose epidemic of 1979, it is interesting that the increased prevalence of anthracnose in the state coincided with the relatively widespread use of reduced tillage

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systems, which may have led to greater overwinter survival.

The purpose of this study was to determine the level of *C. graminicola* in commercial fields before planting in the spring and to determine if burial of residues for a single growing season would eliminate *C. graminicola* from infested corn stalks under Ohio's climatic conditions.

MATERIALS AND METHODS

On 14 April 1981, corn stalks were collected from six commercial fields that had been moldboard plowed the previous fall in Champaign, Crawford, Delaware, Pickaway, Ross, and Union counties. Twenty stalk sections (30–40 cm long) lying on the soil surface (surface residues) and 20 stalk sections buried 5–15 cm deep by plowing (buried residues) were collected from each field. Only stalks that exhibited the black-streak symptoms of anthracnose stalk rot were collected (3). Three 1.5 × 2 cm sections of the surface stem tissue (rind) and 15 2–3 cm long vascular bundles were excised from every stalk. These tissues were washed free of adhering soil with tap water, surface sterilized in 1:9 (v/v) 5.25% sodium hypochlorite-distilled water for 15 sec, and rinsed in sterile distilled water. Tissues were pressed between paper towels to remove excess moisture and plated on 2% water agar plus 300 μg/ml streptomycin sulfate. After 3–5 days at 23–26 C under continuous light (1,400 lux), tissues were examined for development of acervuli with pink masses of conidia characteristic of *C. graminicola*. Sporulation on rind sections was visually estimated on a 0–5 scale, where 0 = no sporulation, 1 = 1–5%, 2 = 6–10%, 3 = 11–25%, 4 = 26–50%, and 5 = 51–100% of the surface of the rind section covered with sporulating acervuli. Sporulation on vascular bundles was estimated by determining the number of vascular bundles with sporulating acervuli from a total of 15 bundles per stalk. Data presented are means or percentages based on means of stalks producing sporulating acervuli.

To determine the ability of *C. graminicola* to survive a single growing season on buried residues, severely infected stalks were collected on 7 December 1980 from a commercial field of hybrid corn (Pioneer Brand 3780). Twenty-three stalk sections, 30–40 cm long, containing an internode and two nodes each, were secured between layers of hardware cloth screen (150 cm long × 30 cm wide with 1.2-cm holes). Three sets of 23 stalk sections were placed in a corn field at Wooster, OH, on 10 December 1980. One set of stalk sections was buried 10–14 cm deep to simulate plowing. A second set was placed on the soil surface and covered with a 1–2 cm layer of soil. Stalk sections of the third set were placed upright on the soil surface and attached to metal stakes to simulate standing corn stubble. On 18 August 1981, the 69 stalk sections were retrieved from the field and assayed for development of sporulating acervuli of *C. graminicola*, as described above.

RESULTS AND DISCUSSION

Significantly ($P = 0.05$) fewer sporulating acervuli of *C. graminicola* developed on corn residues that had been buried than on residues that overwintered on the soil surface (Tables 1 and 2). Visual ratings for sporulation on rind sections ranged from 1.2 to 4.2 on a 0–5 scale for the residues left on the soil surface to 0.0–1.1 for residues buried 5–15 cm deep (Table 1). There was considerable variation in the percentage of stalks with acervuli developing on rind sections from different fields (surface stalks = 55–100% and buried stalks = 0–60%) (Table 1). This variation may be a reflection of the different genotypes of corn grown, the level of disease present within each field, or differences in environmental conditions associated with each site.

The fungus was reduced to undetectable

Table 1. Overwinter survival of *Colletotrichum graminicola* on rind tissue of corn stalks left on the soil surface or buried 5–15 cm deep by plowing in commercial fields

Location (county)	Percent stalks with acervuli on rind sections[a]		Sporulation on rind[b]	
	Surface	Buried	Surface	Buried
Champaign	80	40*[c]	2.3	0.4*
Crawford	100	60*	2.9	1.1*
Pickaway	55	25*	1.2	0.2*
Ross	60	0*	1.5	0.0*
Union	100	30*	4.2	0.5*
Delaware	90	25*	3.0	0.1*
Mean	81	30*	2.5	0.4*

[a] Percent based on a total of 20 stalks collected on 14 April 1981 from the soil surface or buried per field.
[b] Visual sporulation rating where: 0 = no sporulation, 1 = 1–5%, 2 = 6–10%, 3 = 11–25%, 4 = 26–50%, and 5 = 51–100% of the rind section surface covered with sporulating acervuli.
[c] * Indicates that means of buried residue were significantly different ($P = 0.05$) from means of surface residues at the same location.

Table 2. Overwinter survival of *Colletotrichum graminicola* on vascular bundles within corn stalks left on the soil surface or buried 5–15 cm deep by plowing in commercial fields

Location (county)	Percent stalks with acervuli on vascular bundles[a]		Percent vascular bundles in a stalk with acervuli[b]	
	Surface	Buried	Surface	Buried
Champaign	65	35*[c]	27	7*
Crawford	90	70*	60	39*
Pickaway	65	25*	26	9*
Ross	45	15*	16	1*
Union	100	60*	79	19*
Delaware	90	85	59	17*
Mean	76	48*	45	15*

[a] Percent based on a total of 20 stalks collected on 14 April 1981 from the soil surface or buried in a field.
[b] Percent based on the number of vascular bundles with sporulating acervuli from a total of 15 in a stalk with 20 stalks examined per location.
[c] * Indicates that means of buried residues were significantly different ($P = 0.05$) from means of surface residues at the same location.

Table 3. Survival from 10 December 1980 to 18 August 1981 of *Colletotrichum graminicola* on corn residues buried at two depths and left on the soil surface

Residue position	Percent stalks with acervuli on rind[w]	Sporulation on stalk rind[x]	Percent stalks with acervuli on vascular bundles[w]	Percent vascular bundles in a stalk with acervuli[y]
Surface	100 a[z]	2.43 a	78 a	10 a
Buried 1–2 cm	4 b	0.04 b	0 b	0 b
Buried 10–14 cm	0 b	0.00 b	0 b	0 b

[w] Percentage based on a total of 23 stalks collected from the soil surface or each depth.
[x] Visual sporulation rating where: 0 = no sporulation, 1 = 1–5%, 2 = 6–10%, 3 = 11–25%, 4 = 26–50%, and 5 = 51–100% of the rind section covered with sporulating acervuli.
[y] Percent based on the number of vascular bundles with sporulating acervuli from a total of 15 in a stalk with 23 stalks examined per residue position.
[z] Column means followed by the same letter are not statistically different ($P = 0.05$) according to Duncan's new multiple range test.

levels on rind tissues of buried stalks in only one of the six fields in which stalks were buried (Table 1). Across all fields, the sporulation level on buried residues was low (mean, 0.4), but the fungus was recovered from a relatively large number of buried stalks (range, 0–60%; mean, 30%) (Table 1). Because the fungus survived in buried residues from five of six fields, it is possible that buried stalks could serve as a source of inoculum if residues were moved to the soil surface by tillage operations.

C. graminicola was essentially eliminated from heavily infested residues buried 1–2 or 10–14 cm below the soil surface from 10 December to 18 August (Table 3). Of the 46 buried stalks examined, only a few acervuli developed on one rind section (mean sporulation rating on a scale of 0–5 for three rind sections per stalk = 0.3). All of the stalks placed upright on the soil surface developed numerous acervuli on rind sections (mean sporulation rating, 2.43) (Table 3). Acervuli also developed on vascular bundles from 78% of the stalks on the soil surface and on 10% of the vascular bundles in a stalk (Table 3). These results indicate that *C. graminicola* would be eliminated from infested residues buried for one growing season, but inoculum would be produced on stalk residues left on the soil surface. *C. graminicola* may have been eliminated from buried residues by competition from other microorganisms because the stalk surface was in immediate contact with the soil (1,6,7).

Naylor and Leonard (5) stated that plowing or disking corn stalks into the soil in the fall would effectively reduce inoculum for the succeeding corn crop in North Carolina. Because of Ohio's different climatic conditions, this system of residue management may not reduce the level of inoculum sufficiently by planting time (late April and May) to avoid early infection of emerging seedlings. In the present study, a mean of 30% of the stalks buried by plowing in the fall and collected in mid-April produced some acervuli (Table 1). A considerable amount of corn residue was left on the soil surface after plowing in the fields sampled. These residues would probably be a major source of inoculum for initial infections if futher tillage did not incorporate them into the soil before planting.

Results reported here and elsewhere (5,6) indicate that *C. graminicola* readily overwinters above the ground on residues and infested residues left on the soil surface produce inoculum throughout the growing season. Tillage systems that leave residues on the soil surface probably have the greatest potential for losses from anthracnose (3,4). Because *C. graminicola* survived on buried residues until planting time but was eliminated in residues buried 1–2 cm deep by mid-August, the most effective combination of cultural practices for control of anthracnose in Ohio would probably be clean plowdown of corn residues in the fall plus a 1-yr rotation away from corn.

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