Relationships Between Yield of Sweet Corn and Northern Leaf Blight Caused by *Exserohilum turcicum*

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ABSTRACT

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Relationships between yield of six sweet corn hybrids that differed in resistance to northern leaf blight (NLB) and severity of NLB were examined in field experiments done in 1988, 1989, and 1990. Severity of NLB was assessed on an individual leaf basis and was weighted by the proportion of the total leaf area accounted for by each leaf. Three leaves (the primary ear leaf and the leaves immediately above and below the primary ear) accounted for about 33–40% of the total leaf area. When a stepwise regression procedure was done, models with two independent variables were not significantly different from one variable models, and percentage of yield usually was explained by severity of NLB on the ear leaf or the leaves immediately above or below the ear. The effect of NLB on yield (based on weight of ears) was dependent on the resistance or susceptibility of the hybrid. Yields of susceptible hybrids were reduced in all three years. Yields of moderately resistant and resistant hybrids were not affected substantially. When severity in the upper 75% of the canopy was less than 8%, yield was not affected by NLB. Slope coefficients from regressions of percentage of yield on severity of NLB in the entire leaf canopy ranged from about −0.44 to −0.75. Lesions on husk leaves were detrimental to the appearance of ears of all hybrids.

Additional keywords: crop loss assessment, *Helminthosporium turcicum*, maize.

Northern leaf blight (NLB), caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs, is an endemic disease in many of the areas of the United States where sweet corn (*Zea mays* L.) is grown. Severe epidemics of NLB are particularly prevalent in the spring in southern and central Florida. Epidemics of NLB also have occurred on late season, summer crops in the northern corn belt (Illinois, Wisconsin, and Minnesota) and in upstate New York.

Reactions of commercially grown sweet corn hybrids to NLB vary from highly resistant to highly susceptible (8–11). NLB-resistant hybrids may have major gene resistance (*Ht* genes) and/or partial resistance adequate to prevent severe NLB. Conversely, NLB can be quite severe on highly susceptible hybrids, some of which are grown extensively, such as Jubilee. Fungicides can be used to reduce severity of NLB on susceptible hybrids (1,19).

Reductions in yield due to NLB have been associated with susceptibility (2,4,11,12,14,18), although most studies have evaluated dent corn rather than sweet corn. Ullstrup and Miles (18) observed reductions in yield of susceptible hybrids ranging from 40 to 70% when disease onset occurred 2–3 wk after silking, whereas reductions in yield of resistant hybrids ranged from 2 to 18%. Fisher et al (4) reported reductions in yield of 20 hybrids ranging from 0 to 30% when severity of NLB ranged from 4 to 87% 3–4 wk after mid-silk. Equivalent yield as a percentage and severity of NLB were correlated negatively ($r = -0.47$; $b = -0.23$). Raymundo and Hooker (14) observed a 63% reduction in yield of an early maturing, susceptible hybrid on which severity of NLB was 97% 6 wk after silking. Yield reductions were 43 and 17%, and severities of NLB were 89 and 27%, respectively, for a hybrid with polygenic resistance and a hybrid with *Ht*-gene and polygenic resistance. Perkins and Pedersen (12) observed reductions in yield of a susceptible hybrid ranging from 0 to 18% when severity of NLB ranged from 1 to 38% 3 wk after mid-silk. Yield was not affected by NLB for hybrids with intermediate or high levels of polygenic resistance. Likewise, Bowen and Pedersen (2) observed reductions in yield of a susceptible inbred ranging from 5 to 44% when severity of NLB at the full dent stage ranged from 52 to 100%. Yields of moderately and highly resistant inbreds were not affected by NLB.

Yields of susceptible sweet corn hybrids were reduced 12–20% by NLB severities ranging from 15 to 58% (11). Moderately susceptible hybrids with NLB severities from 5 to 30% had yield reductions of 2–14%. Slope coefficients from the regressions of percentage of yield on severity of NLB ranged from −0.30 to −0.53, although the regressions were not particularly close fits (r^2 ranging from 0.08 to 0.29).

In each of the aforementioned studies, severity of NLB was based on visual estimates of leaf area affected, with little or no regard to the distribution of NLB within the canopy. Typically, NLB is more severe on leaves in the lower and middle thirds of the plant than on leaves in the upper third, as illustrated in a scale for rating NLB developed by Elliott and Jenkins (3). However, in at least three studies in which plants were defoliated to simulate the effects of NLB (7,13,16), loss of leaf tissue from the lower third of the plant had little effect on yield.

Hooker (5) proposed an index of photosynthesis based on the percentage of healthy leaf tissue at various reproductive growth stages. Hooker assigned values of 10, 5, and 1 to the photosynthetic contributions to grain yield made by the top, middle, and bottom thirds of the leaf canopy. The index explained 97% of the variation in yield from the defoliation studies of Raymundo (13) and 93% of the variation in yield of plants inoculated with *E. turcicum*. Hooker and Perkins (6) proposed that economic losses could be avoided if 75% or more of the upper leaf canopy remained uninfected through three-fourths of the grain filling period. They suggested that blight on lower leaves early in the season had a greater effect on the appearance of hybrids than on the performance of hybrids.

Many of the sweet corn hybrids that Pataky et al (8–11) have classified as resistant or moderately resistant to NLB can prevent this disease from developing substantially in the upper leaf canopy. A more accurate determination of the effect of NLB on yield of sweet corn, in which the distribution of NLB in the leaf canopy is considered, would be useful in determining the economic impact of NLB on sweet corn and in evaluating levels of resistance necessary to prevent economic damage. This paper reports on relationships between yield of sweet corn and severity of NLB.

MATERIALS AND METHODS

Experiments were done at the University of Illinois, Agronomy-Plant Pathology South Farm, Urbana, IL, in 1988, 1989, and 1990. Soil types were a Flannigan silt loam in 1988 and 1989 and a Drummer silt loam in 1990. Planting dates were 17 May 1988, 17 May 1989, and 8 May 1990.

Five sweet corn hybrids were grown in 1988 and 1989. Six hybrids were grown in 1990. Hybrids were selected based on their resistance to NLB (11). Jubilee and Platinum Lady are susceptible. The resistance of Kandy Korn EH and Seneca Sentry is moderate. Miracle and Honey n Frost have high levels of partial resistance relative to other sweet corn hybrids. None of the hybrids have *Ht* genes for resistance to NLB.

In each year, hybrids were grown as separate experiments to minimize random variation among experimental units within each experiment (hybrid). Therefore, statistical comparisions of yield and NLB severity could not be made among hybrids, but comparisons among treatments within hybrids were less subject to field variation. In 1988, there were four replicates of six treatments in each of five experiments. In 1989 and 1990, there were three replicates of eight treatments in each of five or six experiments. The experimental designs were randomized complete blocks for all experiments. Treatments consisted of inoculation of plants at various growth stages to create different levels of NLB in the lower, middle, and upper parts of the canopy (Table 1). Also, some treatments were sprayed with 0.29 L ha^{-1} of propiconazole (Tilt 3.6E, Ciba-Geigy Corp., Greensboro, NC) to prevent the development of NLB. In each experiment, the treatment intended to cause the most severe NLB consisted of inoculation of plants twice a week from about the three- to five-leaf stage until tassels began to emerge. All experiments also included a control treatment that was not inoculated or sprayed with fungicides. Plants were inoculated by spraying about 15 ml of a conidial suspension (approximately 10^3 conidia ml^{-1}) directly into whorls. Inoculum was prepared as described previously (11).

Each experimental unit consisted of a six-row plot with the middle two rows treated; the outer four rows served as borders. Each row was approximately 3.5 m long with about 15 plants per row. Rows were spaced about 0.76 m apart.

Severity of NLB was rated on an individual leaf basis within 1 wk of harvest. All leaves from five plants that were representative of each experimental unit were rated separately. A disease assessment diagram for rating individual leaves was prepared (Fig. 1), and the net blotch program of DISTRAIN (17), which resembles a computer simulation of NLB on individual leaves, was used to improve assessments of NLB. Leaf area was measured within 1 wk of harvest on an individual leaf basis from five healthy plants in the border rows of control plots. Leaves were removed from plants, labeled for position from the primary ear, and measured on a Li-Cor leaf area meter. The percentage of the total leaf area that was accounted for by each leaf was calculated each year for each hybrid. Severity of NLB was then calculated as a weighted sum:

$$\sum_{i=1}^{n} (NLB_i \times LA_i)$$

in which, NLB_i = the severity of NLB on the *i*th leaf; LA_i = the proportion of the total leaf area accounted for by the *i*th leaf; and n = the total number of leaves. When severity of NLB was determined for only a portion of the leaf canopy (e.g., the upper 75%), percentage of leaf area of each leaf was calculated from the total leaf area being considered (e.g., LA_i = the proportion of the upper 75% of the leaf area accounted for by the *i*th leaf), and severity of NLB was adjusted accordingly.

Primary ears were harvested by hand at fresh market maturity (about 20 days after mid-silk) from 10 consecutive plants in each of the middle two rows of each plot. Weight of ears with and without husk leaves and total number of marketable ears were measured. Harvest began 3 August 1988, 2 August 1989, and 4 August 1990 and continued for about 1 wk, based on the maturity of each hybrid. Yield based on weight of ears with husk leaves removed was converted to a percentage of the control treatments and a percentage of the intercept of the regression of yield on total severity of NLB for each hybrid.

Treatments were compared by analysis of variance (ANOVA) and mean separation tests to determine if severity of NLB and yield differed within hybrids. Various regression models then were used to relate percentage of yield with severity of NLB. Stepwise multiple regression (MAXR selection of SAS) was used to determine which combination of leaves best explained the variability in yield. Also, the leaf canopy was divided into various portions (i.e., bottom, middle, and top thirds, and total), and the stepwise procedure was repeated. Regressions of percentage of yield on severity of NLB in the upper 75% of the canopy and in the entire leaf canopy also were done. All regressions were done for treatment means within hybrids and years. Regressions were evaluated by F tests for significance of the model, r^2 for variation explained, and analysis of residuals for lack of fit and outliers.

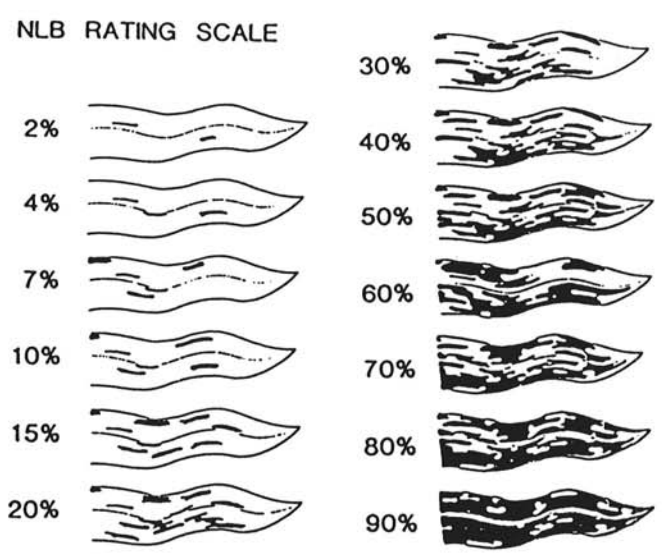

Fig. 1. A disease assessment diagram used to rate the severity of northern leaf blight (NLB) on individual leaves of sweet corn plants.

RESULTS

Leaf area. The percentage of the total leaf area 1 wk before harvest, which was accounted for by each leaf, varied slightly

TABLE 1. Treatments used in 1988, 1989, and 1990 to generate different levels of northern leaf blight in the bottom, middle, and top thirds of the canopy of sweet corn hybrids

	Growth stages at which plants were treated[b]				
Treatment[a]	Three- to four-leaf	Five- to six-leaf	Seven- to eight-leaf	Nine- to ten-leaf	Early tassel
1	N	N	N	N	N
2	I	I	I	I	I
3	I	I	I	F	N
4	I	I	F	F	N
5	N	I	I	F	N
6	N	N	N	N	I
7	N	N	N	I	I
8	N	N	I	I	I
9	I	F	F	F	N
10	N	I	I	I	N

[a]Treatments 1–6 used in 1988; 1–8 were used in 1989; and 1–4 and 7–10 were used in 1990.
[b]N = no treatmet; I = inoculation (see text); and F = fungicide spray (see text).

among years probably due to growing conditions, but was relatively consistent among hybrids averaged over years (Table 2). Three leaves (the primary ear leaf and the leaves immediately above and below the primary ear) accounted for 33–41% of the total leaf area. Five leaves (the primary ear leaf and the two leaves above and below the primary ear) accounted for 54–65% of the total leaf area. The upper 75% of the plant canopy included all leaves above the primary ear, the primary ear leaf, and one or two leaves below the primary ear depending on the hybrid and year.

Severity of NLB. Although inoculation and fungicide treatments were similar among years, NLB was more severe in 1989 and 1990 than in 1988 when a drought occurred. Severity of NLB in the entire leaf canopy of all hybrids ranged from 0 to 17%, 0 to 69%, and 0 to 56% in 1988, 1989, and 1990, respectively (Table 3). Severity of NLB differed significantly ($P < 0.01$) among treatments for all hybrids in all years.

Various amounts of NLB occurred in the bottom, middle, and top portions of the canopy as a result of the six or eight inoculation and fungicide treatments (Table 3). In general, NLB was more severe in the bottom third and least severe in the upper third of all hybrids in spite of an attempt to create various amounts of disease in all three portions of the canopy. As expected, NLB was most severe on Jubilee and Platinum Lady and least severe on Miracle and Honey n Frost. The range of severity of NLB in the upper 75% of the canopy was greatest, 18–49%, for Platinum Lady in 1989; and least, 0–5%, for Honey n Frost in 1990, Miracle in 1988 and 1990, and Seneca Sentry in 1988 (Fig. 2). Severity of NLB in control treatments (treatment 1) was less than 5% in each experiment except for Platinum Lady in 1989 (Fig. 2).

Lesions of NLB were observed on husk leaves of all hybrids (Fig. 3) but number or size of lesions was not measured. In some instances, several lesions coalesced resulting in large, necrotic areas that gave ears an appearance of being old and dehydrated (Fig. 3B).

Yield of sweet corn. Yield ranged from about 2.69 kg plot^{-1} for Platinum Lady in 1988 to 5.88 kg plot^{-1} for Miracle in 1989 (Table 4). Yield of all hybrids was about 15–25% lower in the drought of 1988 than in 1989 and 1990. Yield differed significantly ($P < 0.10$) among treatments except for Seneca Sentry and Miracle in 1988 and Honey n Frost in 1990. Severity of NLB ranged from 0 to 7% among treatments for these three exceptions. Yield of Jubilee and Platinum Lady was slightly lower than normal each year due to about 25% incidence of systemic infection of naturally occurring Stewart's wilt (*Erwinia stewartii*), which was relatively uniform in all experimental units of these two hybrids. Incidence of Stewart's wilt in plots of the other hybrids was less than 5%, and those plants were removed immediately before

TABLE 2. Percentage of the total leaf area within 1 wk of harvest accounted for by each leaf of sweet corn hybrids evaluated in 1988, 1989, and 1990[a]

	Leaves below the primary ear							Leaves above the primary ear						
Hybrid	B6	B5	B4	B3	B2	B1	E[b]	T1	T2	T3	T4	T5	T6	T7
Jubilee	<1	<1	2	6	10	13	13	14	14	12	9	6	1	<1
Platinum Lady	<1	2	5	8	11	14	14	13	13	10	6	3	1	<1
Kandy Korn EH	<1	2	4	8	10	11	11	12	13	10	8	7	3	1
Seneca Sentry	1	3	6	8	10	11	11	11	11	10	8	7	4	<1
Miracle	<1	1	3	7	10	13	14	14	14	12	8	3	1	<1
Honey n Frost	<1	<1	2	7	9	12	14	15	14	12	10	5	1	<1

[a] Percentage of the total leaf area based on means of five plants per control plot for each hybrid in each year.
[b] E = leaf at the primary ear; B1 = first leaf below the primary ear; T1 = first leaf above the primary ear, etc.

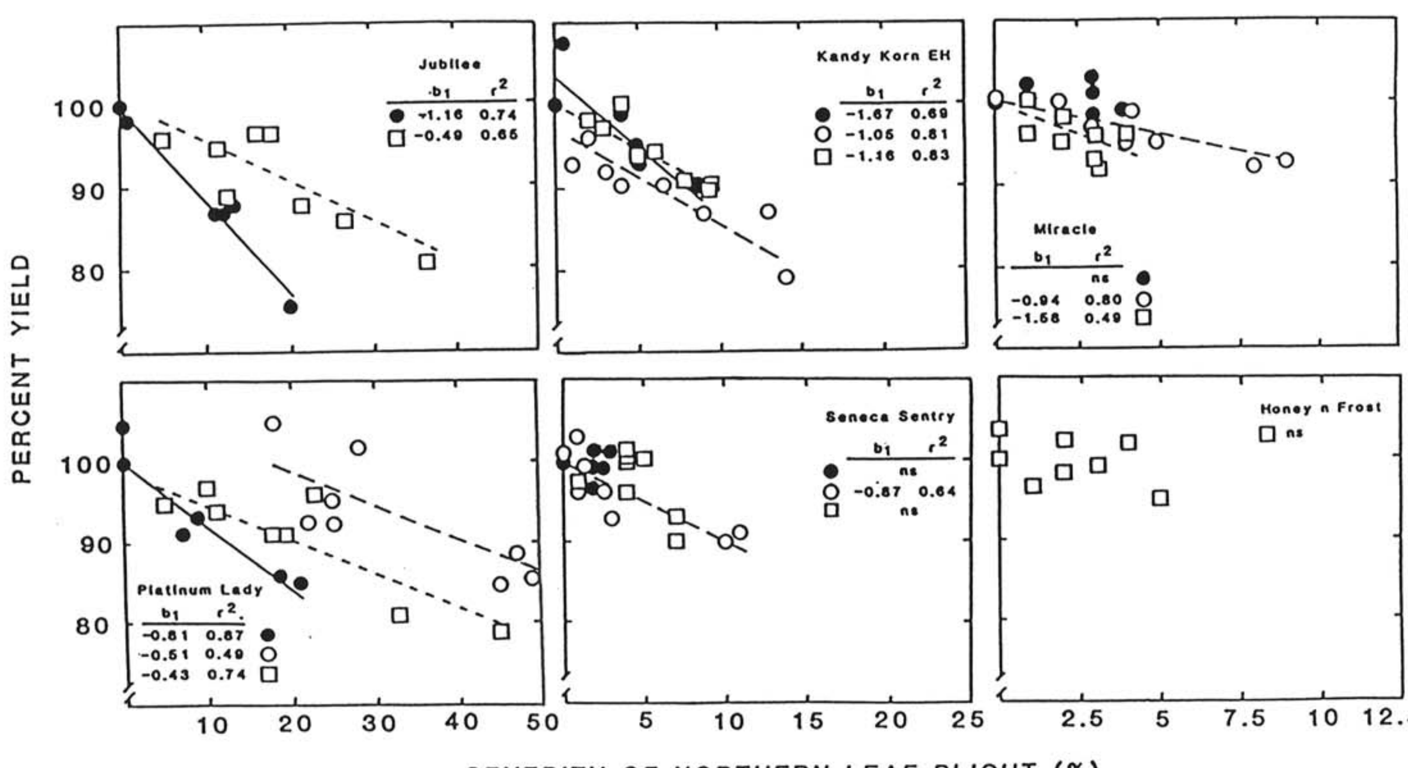

Fig. 2. Relationships between percentage of yield of six sweet corn hybrids and severity of northern leaf blight in the upper 75% of the leaf canopy. All hybrids were evaluated as separate experiments in 1988 (●), 1989 (○), and 1990 (□).

harvest.

Reductions in yield varied among hybrids. Maximum yield reductions were about 20–25% for Jubilee, Platinum Lady, and Kandy Korn EH in 1989; about 10% for Kandy Korn EH in 1988 and 1990, Seneca Sentry in 1989 and 1990, and Miracle in 1989; and less than 10% for Seneca Sentry in 1988, Miracle in 1988 and 1990, and Honey n Frost in 1990 (Table 4, Fig. 2).

Relationships between yield and severity of NLB. Regression models with two independent variables were not significantly different than one variable models except for Platinum Lady in 1989 (Table 5). When the stepwise procedure was done with severity of NLB on individual leaves as the independent variables, the variation in percentage of yield usually was explained best by the severity of NLB on the ear leaf (E) or on the leaf immediately above (T1) or below (B1) the ear leaf. When the stepwise procedure was done with severity of NLB in the top, middle, and bottom thirds of the canopy and in the entire canopy (total) as the independent variables, the variation in percentage of yield was explained best by severity of NLB in the entire canopy or in the middle third of the canopy. Regression coefficients varied considerably among hybrids and years partly because of differences in ranges of the independent variables. Coefficients of determination ranged from 0.42 to 0.90.

The effects of NLB on yield were dependent on the resistance or susceptibility of the hybrid, and subsequently, the severity of NLB. Regressions of percentage of yield on severity of NLB in the upper 75% of the plant were significant in all years for the susceptible hybrids, Jubilee and Platinum Lady (Fig. 2). Severity of NLB in the upper 75% of these two susceptible hybrids ranged from about 20 to 50% in the most severely diseased treatments. For the moderately resistant hybrids, Kandy Korn EH and Seneca Sentry, regressions were significant when severity ranged from 0 to 10% or more, but regressions were not significant for Seneca Sentry in 1988 and 1990 when severity was less than 7% for all treatments. Similarly, for the partially resistant hybrids, Miracle and Honey n Frost, the range of severity was about 0–5% except for Miracle in 1989, which ranged from 0 to 8%. Regressions of percentage of yield on severity were significant only for Miracle in 1989 and 1990. Slope coefficients varied among hybrids and years and ranged from about −0.4 to −1.7. For the susceptible hybrids and Kandy Korn EH, slope coefficients were more negative in 1988 when the drought occurred. Coefficients of determination ranged from 0.49 to 0.87.

Regressions of percentage of yield and severity in the entire canopy were significant for the same sets of data as those for percentage of yield and severity in the upper 75% of the canopy except for Miracle in 1990 (Table 6). Regressions of percentage of yield and severity in the entire canopy also were significant for the same sets of data as those for percentage of yield and severity on individual leaves except for Seneca Sentry in 1990. Slope coefficients ranged from −1.01 to −1.35 in the drought year of 1988 and from −0.44 to −0.75 in 1989 and 1990 (Table 5). Coefficients of determination ranged from 0.49 to 0.86 and were similar to those from the other regression models.

Fig. 3. Lesions of northern leaf blight on husk leaves of sweet corn hybrids. **A,** a typical cigar-shaped lesion. **B,** several lesions that have coalesced, resulting in a large, necrotic area.

TABLE 3. Range of severity (%) of northern leaf blight (NLB) in the bottom, middle, and top thirds of the canopy of six sweet corn hybrids that received six (1988) or eight (1989, 1990) inoculation and fungicide treatments[a]

Hybrid and year	Bottom	Middle	Top	Total[b]
Jubilee				
1988	0–21	0–19	0–13	0–17
1990	13–68	8–57	4–36	7–47
Platinum Lady				
1988	0–19	0–13	0–9	0–11
1989	23–76	18–67	17–56	18–69
1990	12–72	6–57	5–45	6–56
Kandy Korn EH				
1988	0–6	0–8	0–6	0–6
1989	0–52	0–23	0–14	0–29
1990	1–25	1–17	1–9	1–13
Seneca Sentry				
1988	0–8	0–6	0–3	0–3
1989	0–32	0–17	0–12	0–14
1990	1–13	1–10	1–7	1–7
Miracle				
1988	0–8	1–5	1–4	0–4
1989	0–35	0–12	0–9	0–13
1990	0–9	0–8	0–8	0–8
Honey n Frost				
1990	0–11	0–6	0–5	0–7

[a]Severity of NLB in the bottom, middle, or top third of the leaf canopy as determined from the proportion of the total leaf area accounted for by individual leaves (see text and Table 2).
[b]Severity of NLB for the total leaf area.

TABLE 4. Range of yield of six sweet corn hybrids that received six (1988) or eight (1989, 1990) inoculation and fungicide treatments that resulted in various amounts of northern leaf blight, and level of significance at which treatments differed

Hybrid and year	Range of yield (kg $plot^{-1}$)	Level of significance
Jubilee		
1988	2.91–3.94	0.01
1990	4.08–5.01	0.05
Platinum Lady		
1988	2.69–3.37	0.01
1989	2.91–4.02	0.10
1990	3.81–4.72	0.01
Kandy Korn EH		
1988	3.60–4.12	0.01
1989	3.81–4.86	0.10
1990	4.17–4.61	0.05
Seneca Sentry		
1988	4.00–4.15	NS[a]
1989	4.84–5.45	0.10
1990	4.49–4.99	0.10
Miracle		
1988	4.19–4.42	NS
1989	5.45–5.88	0.10
1990	4.63–5.06	0.10
Honey n Frost		
1990	4.09–4.54	NS

[a]Not significant.

DISCUSSION

Northern leaf blight reduced the yield of susceptible sweet corn hybrids but had little effect on the yield of partially resistant hybrids. This is similar to the effects of NLB on the yield of dent corn for which substantial reductions in yield have been observed frequently in susceptible hybrids but infrequently in resistant hybrids (2,4,12,14,18). Slope coefficients from regressions of percentage of yield on severity of NLB in the entire plant canopy ranged from −0.44 to −0.75 in the 2 yr without drought. Slope coefficients ranged from about −0.3 to −0.5 in our sweet corn hybrid disease nurseries (11). When severity of NLB on susceptible dent corn hybrids was measured about 3–4 wk after mid-silk, percentage of yield was decreased about 0.2–0.5% for each 1% severity of NLB (4,12). The slightly more adverse effects of NLB in this study (i.e., more negative slope coefficients) as compared to previous studies (4,11,12) may have resulted from a greater amount of NLB in the middle and upper thirds of the leaf canopy or from the calculation of severity of NLB based on measurements of individual leaves.

TABLE 5. Significant independent variables and coefficients of determination from regression of yield of six sweet corn hybrids or severity of northern leaf blight on individual leaves or in portions of the leaf canopy[a]

	Individual leaves[b]		Leaf canopy[c]	
Hybrid and year	Variable	r^2	Variable	r^2
Jubilee				
1988	B1	0.68	Total	0.70
1990	E	0.66	Total	0.67
Platinum Lady				
1988	T1	0.90	Total	0.86
1989	T4, T5	0.44	Total	0.61
1990	B1	0.79	Total	0.77
Kandy Korn EH				
1988	B2	0.75	Middle	0.61
1989	B1	0.86	Middle	0.80
1990	T1	0.77	Total	0.80
Seneca Sentry				
1988		NS[d]		NS
1989	E	0.57	Middle	0.61
1990	B1	0.44	Middle	0.42
Miracle				
1988		NS		NS
1989	B1	0.49	Middle	0.57
1990		NS		NS
Honey n Frost				
1990		NS		NS

[a] Regression models selected as the best models to explain yield (maximum r^2) with the fewest number of significant independent variables.

[b] Leaf position determined from the primary ear leaf (E); B1 = the leaf immediately below the primary ear; T1 = the leaf immediately above the primary ear.

[c] Canopy = total leaf area, or bottom, middle, and top thirds of the leaf canopy as determined from percentage of the total leaf area accounted for by individual leaves.

[d] Not significant.

TABLE 6. Slope coefficients and coefficients of determination (r^2) from regressions of percentage of yield of six sweet corn hybrids on severity of northern leaf blight in the total leaf canopy

Hybrid and year	Slope coefficient	r^2
Jubilee		
1988	−1.01	0.70
1990	−0.43	0.67
Platinum Lady		
1988	−1.35	0.86
1989	−0.49	0.61
1990	−0.46	0.77
Kandy Korn EH		
1988	−1.04	0.55
1989	−0.70	0.66
1990	−0.75	0.80
Seneca Sentry		
1988	...	NS[a]
1989	−0.47	0.58
1990	...	NS
Miracle		
1988	...	NS
1989	−0.44	0.49
1990	...	NS
Honey n Frost		
1990	...	NS

[a] Not significant.

In this study, random variation in yield among experimental units usually was greater than the effects of NLB on yield when severity in the upper 75% of the canopy was less than 8%. The maximum severity of NLB in the upper 75% of the leaf canopy usually was less than 8% for the partially resistant hybrids and greater than 20% for the susceptible hybrids. Percentage of yield was related to severity of NLB on susceptible hybrids and usually was unrelated to the low levels of NLB on resistant hybrids. When maximum severity of NLB in the upper 75% of the canopy ranged from about 10 to 15% for the moderately resistant hybrids, regression models were significant, but when severity was less than 8% on these hybrids, regressions were not significant. Thus, the proposal of Hooker and Perkins (6) seems to be applicable to sweet corn if yield and economic return are based on ear weight. Reductions in yield based on ear weight are minimal if 75% or more of the upper leaf canopy remains relatively healthy (i.e., less than 8% severity). Nevertheless, for sweet corn that is shipped and/or sold in fresh markets, appearance of ears may be diminished by lesions on husk leaves. If lesions on husk leaves substantially affect economic returns, then additional control may be warranted. In this study, lesions were observed on husk leaves of all hybrids, including hybrids with relatively high levels of partial resistance and relatively low severity of NLB in the middle third of the leaf canopy.

In this study, the relatively low levels of NLB on upper leaves as compared to lower leaves may have been related to secondary infection and rates of lesion expansion. The incubation and latent periods for NLB are about 10–14 days, beyond which lesions expand for at least 2–3 wk. Sigulas et al (15) measured expanding lesions up to 30 days after inoculation. Lesions on leaves in the lower canopy had sufficient time to expand and produce secondary inoculum. In fact, severity was above 50% for many of the lowest leaves (B6, B5, etc.), because lesions coalesced and caused necrosis of large areas of the leaf beyond the infections. Conversely, lesions resulting from secondary infection in the upper canopy had relatively little time to expand before harvest, which occurred 3 wk after mid-silk.

Although severity of NLB was as high as 50% in this study, it was considerably less than what occurs in severe epidemics, such as those in the Belle Glade area of Florida. Thus, although yield of the partially resistant hybrids was not substantially affected by NLB in this study, it would be unwise to extrapolate these results to environments that are exceptionally more conducive to the development of NLB. Severity of NLB is likely to be greater in those environments even on partially resistant hybrids. Instead, it would be more appropriate to expect that yields of partially resistant hybrids grown in conducive environments would be related to severity of NLB and that if severity in the upper 75% of the leaf canopy is below 8%, yield reductions would be minimal. If severity of NLB in the upper 75% of the canopy is greater than 8%, reductions in yield of susceptible or resistant hybrids are likely to be about 0.4–1% for each 1% severity in the upper 75% of the leaf canopy or about 0.3–0.75% for each 1% severity of the total leaf area.

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