Leaf Infection and Yield Loss Caused by Four Helminthosporium Leaf Diseases of Corn

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ABSTRACT

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Disease reactions and effects on yield caused by Helminthosporium leaf spot (HLS), northern corn leaf blight (NCLB), southern corn leaf blight (SCLB-T) and (SCLB-O) on 20 corn hybrids were determined in the field. Overall yields were reduced least by HLS and most by SCLB-T. Mean equivalent yield had a significant negative correlation with percentage leaf area blighted by NCLB, SCLB-T, and SCLB-O, but not by HLS.

Additional key words: Zea mays, Helminthosporium maydis race O, *H. maydis* race T, *H. turcicum, H. carbonum*, normal and Texas male-sterile cytoplasms, Helminthosporium leaf spot, southern corn leaf blight, northern corn leaf blight.

In 1972, a pathogen was isolated from corn (*Zea mays* L.) leaves in several parts of the Corn Belt (3). The pathogen is a biotype of *Helminthosporium carbonum* Ullstrup, similar to race II (5), and causes the disease referred to as Helminthosporium leaf spot (HLS) (2, 7). The disease was locally damaging on certain susceptible inbred lines in seed production fields and caused an ear rot in addition to leaf blight. The damage potential of this disease to commercial hybrids was unknown.

There have been few previous reports comparing the effects on grain yield by Helminthosporium leaf diseases of corn. Ullstrup and Miles (6) studied grain yield loss on hybrids that were resistant or susceptible to *H. carbonum* race I, *H. maydis* Nisikado and Miyake, and *H. turcicum* Pass. They used a different set of hybrids for each disease and compared the yield of susceptible hybrids to that of resistant hybrids in the absence of disease. Then they examined the effect of disease resistance on grain yield in the presence of disease. Comparing the two situations they found significant differences between yields of resistant and susceptible hybrids for each disease. Lim et al. (4) studied the effect of *H. maydis* race T on grain yield of corn hybrids using isogenic hybrids in normal and in Texas male-sterile (*cms*-T) cytoplasm. The yield reduction of *cms*-T hybrids compared to their normal cytoplasm counterparts ranged from 23 to 60%.

To assess the potential effect of HLS on grain yield of corn, a field experiment was made in 1973 comparing HLS to northern corn leaf blight (NCLB) caused by *H. turcicum*, southern corn leaf blight (SCLB-T) caused by *H. maydis* race T and (SCLB-O) caused by *H. maydis* race O. The comparison was based on percentage of leaf area blighted and on equivalent grain yield.

MATERIALS AND METHODS

Eighteen corn hybrids were chosen that ranged from resistant to susceptible to NCLB, SCLB-T and SCLB-O and, based on greenhouse tests (2), were expected to range from resistant to susceptible to HLS. In addition, two commercial hybrids with unknown reaction to disease were included.

The field experiment was conducted at the Illinois Agricultural Experiment Station Agronomy South Farm, Urbana, Illinois, in a randomized complete block design with a split plot arrangement of treatments. The four diseases were whole plots, and hybrids were split plots. One additional whole plot was left noninoculated as a control intended to provide a means of determining the yield of the hybrids in the absence of leaf blight. Some infection, however, did occur in the control plot. Because of the need for isolation and the limitations of available space, diseases were not replicated within blocks. Whole plots consisted of three blocks of 20 subplots each. Subplots consisted of two rows 76 cm apart with 12 plants per row spaced 38 cm apart.

The plants were artificially inoculated at the 7- to 9-leaf stage. Inoculations of corn plants with all pathogens except *H. carbonum* were by the ground leaf method (1). For HLS, plants were inoculated by dropping into the whorl 15-20 grains of sorghum on which fungus isolate 72:44-6 (ATCC 24962) had been grown.

Visual ratings of percent leaf area infected (0-100%) were taken 3-4 weeks after mid-silk. Ratings were made by two observers, and a mean of their ratings was used in the analyses.

Total grain yields at 15.5% moisture were determined for each plot and converted to kilograms per hectare. The yield of each of the artificially inoculated plots then was compared to the noninoculated control and an equivalent

yield value was calculated. The equivalent yield was the yield of an inoculated plot divided by the mean yield of three replications of the same hybrid in the control plot and that value (quotient) multiplied by 100. The equivalent yield values removed from the analyses genetic differences among hybrids for yielding ability, but did not compensate for differences among blocks due to soil fertility, planting date, and other factors.

Data analyses were based on disease ratings and equivalent yields. Disease ratings were arc sin transformed prior to analysis. A simple linear regression model was applied to study relationships between mean equivalent yield and mean disease rating for each disease.

RESULTS

Disease development was extensive on inoculated plants in all plots. Infection on the different hybrids ranged from 3.0 to 91.7% for SCLB-T, 5.0 to 89.2% for SCLB-O, 4.0 to 86.7% for NCLB, and 3.0 to 46.3% for HLS (Table 1). Natural infection in the control plot by all diseases was noted but consisted mostly of SCLB-O, HLS, and on the *cms*-T entries SCLB-T. This infection occurred late in the season, and it ranged from 1.0 to 23.8%.

An analysis of variance for disease reaction showed a significant hybrid effect and a significant hybrid × disease interaction (Table 2). This indicates that hybrids differed in their overall reaction to leaf blights and that specific hybrids did not react the same to each blight.

Significant differences also were found in equivalent yields among hybrids (Table 2). The interaction of hybrid by disease components also was significant. This indicates that losses in grain yield due to disease varied from hybrid to hybrid, and that a specific hybrid showed different amounts of yield depression due to the various diseases.

Since diseases were confounded with blocks, it was not possible to test mean equivalent yields among the whole plots (diseases) for significance. However, the overall mean equivalent yield including all hybrids did differ

TABLE 2. Analyses of variance for Helminthosporium leaf disease rating and for equivalent corn yields

		Mean squares	
	df	Disease rating[a]	Equivalent yield[b]
Hybrid	19	1,568.81**	465.10**
Hybrid × Disease	57	116.21**	256.23**
Error	152	8.03	55.31

[a]Percent leaf area infected (0-100%) 2-3 weeks after mid-silk. Each value is the mean of three replications.

[b]Equivalent yield. This value is the mean yield in kilograms per hectare of three replications of the inoculated block divided by the mean yield of three replications of the noninoculated block and the quotient multiplied by 100.

[c]Asterisks (**) indicate significance, $P = 0.01$.

TABLE 1. Mean disease ratings and mean equivalent yields for 20 corn hybrids infected with four Helminthosporium leaf pathogens, *Helminthosporium maydis* race T (SCLB-T), *H. maydis* race O (SCLB-O), *H. turcicum* (NCLB), and *H. carbonum* (HLS)

		Disease							
		SCLB-T		SCLB-O		NCLB		HLS	
Corn hybrids	Check plot yield[a]	Inf.[b] (%)	Eq. Y[c]	Inf. (%)	Eq. Y	Inf. (%)	Eq. Y	Inf. (%)	Eq. Y
Commercial A[d]	11,139.2	5.5	87.16	8.3	95.83	19.2	100.56	8.4	97.17
RC103Ht × RH55Ht	10,546.6	3.0	83.47	18.3	101.59	4.0	105.71	4.3	93.28
C103 × H55	10,306.2	3.2	85.12	19.2	96.18	6.7	92.76	3.0	88.42
Mo17 × N28	9,947.2	24.6	77.01	25.0	87.43	39.6	81.10	15.0	98.19
B57 × B14A	9,918.9	23.8	80.35	34.2	94.00	35.4	79.80	4.2	99.11
Commercial B[d]	9,397.3	17.1	85.80	15.8	91.88	35.0	80.85	11.3	94.62
Oh43 × B37	9,313.8	18.3	83.58	7.5	91.91	40.0	79.82	12.8	93.48
ROh43Ht × RB37Ht	9,055.2	4.7	92.67	5.0	87.32	8.3	87.46	8.3	85.17
C123 × A632	9,051.4	20.9	86.18	32.5	87.14	42.1	89.66	21.7	94.65
A619 × A632	9,022.6	22.5	89.83	25.0	91.53	26.7	90.84	25.0	94.46
(FR14A^{T} × Mo17) Pa884P	8,651.0	24.2	79.90	7.5	92.77	28.4	85.55	13.3	110.29
Oh43 × R177	8,582.5	15.0	84.83	10.8	100.40	33.8	79.62	12.9	105.04
C103 × B14	8,484.0	6.7	81.37	10.0	114.61	20.0	95.96	5.8	83.98
(W64A^{T} × B14A) MS137	8,151.9	51.7	55.15	52.1	74.40	59.6	71.09	28.3	92.12
C123 × W64A	8,151.3	25.0	89.30	50.4	77.79	30.9	88.92	37.1	76.76
FR37^{TRf} × Mo17^{TRf}	8,010.7	29.2	95.50	10.8	83.29	37.1	87.48	13.3	99.42
C123 × A619	7,934.1	22.1	87.32	35.8	93.77	29.6	97.50	35.0	87.36
R181B × Oh51A	7,789.1	30.0	83.26	45.8	74.68	47.1	80.88	20.0	87.63
C103D^{T} × B14A	7,484.7	33.8	71.93	25.8	72.65	14.0	83.75	16.3	95.74
W64A^{T} × BCW[e]	5,621.7	91.7	54.81	89.2	54.14	86.7	86.27	46.3	105.40

LSD for equivalent yield of hybrids within diseases ($P = 0.05$) = 12.53
($P = 0.01$) = 16.98

[a]Mean yield in kilograms per hectare of three replications of the noninoculated plot.

[b]Percent leaf area infected 2-3 weeks after mid-silk. Each value is the mean of three replications.

[c]Equivalent yield. This value is the mean yield in kilograms/hectare of three replications of the inoculated block divided by the mean yield of three replications of the uninoculated block and the quotient multiplied by 100.

[d]Commercial hybrids widely grown in 1972.

[e]BCW is selection out of the open pollinated cultivar Boone County White.

among diseases with the hybrids inoculated with SCLB-T having the lowest mean equivalent yield (81.83) and those inoculated with HLS having the greatest (94.11) (Table 1). Similarly, percent infection was most highly correlated with equivalent yield for SCLB-T ($r = -0.68$; $P \leq 0.05$) followed by SCLB-O ($r = -0.62$; $P \leq 0.05$) and NCLB ($r = -0.47$; $P \leq 0.05$). For HLS, however, the correlation of percent infection with equivalent yield was not significant ($r = -0.03$).

The regression coefficients (b) for SCLB-T ($b = -0.40$) and SCLB-O ($b = -0.44$) were the most negative which indicated that these diseases were the most damaging diseases per given amount of leaf area infected. Northern corn leaf blight had a more negative regression coefficient ($b = -0.23$) than HLS ($b = -0.02$). However, due to the confounding of blocks and diseases it was not possible to make a test for significance among regression lines for diseases.

DISCUSSION

The destructive potential of the HLS pathogen probably is not as great as that of either *H. turcicum* or *H. maydis* races O and T. However, the HLS pathogen (isolate 72:44-6) can cause significant yield loss on susceptible hybrids, as is evidenced by the C123 × W64A entry that showed a mean equivalent yield of only 76.76 in the HLS-inoculated plot. Inbreds C123 and W64A are both HLS-susceptible. This hybrid had the second highest mean percent plant infection in the HLS plot (37.1%) and was exceeded only by the $W64A^T \times$ Boone County White selection. This latter hybrid was susceptible to all diseases and had the highest percentage of leaf area blighted in the control plot (23.8%) making it a poor indicator of damage associated with any one disease. This also partially accounts for its high equivalent yield in the NCLB and HLS blocks in spite of a high percentage of infection.

The lack of any significant correlation of HLS percent plant infection with equivalent yield is probably because hybrids were relatively resistant to HLS. Thus, although a specific entry may have been reduced in yield by HLS infection, there were not enough of these hybrids to give a significant correlation.

A sufficient level of resistance to HLS probably is present in Corn Belt germplasm to prevent serious yield losses. Even though HLS seems to have less potential than NCLB and SCLB grain yield reduction, the use of hybrids involving parental inbreds all of which are susceptible to HLS should be avoided.

LITERATURE CITED

1. HOOKER, A. L. 1963. Monogenic resistance in Zea mays L. to Helminthosporium turcicum. Crop. Sci. 3:381-383.
2. HOOKER, A. L. 1974. Reaction of corn inbreds to Helminthosporium leaf spot in the greenhouse. Plant Dis. Rep. 58:399-400.
3. HOOKER, A. L., A. MESTERHAZY, D. R. SMITH, and S. M. LIM. 1973. A new Helminthosporium leaf blight of corn in the Northern Corn Belt. Plant Dis. Rep. 57:195-198.
4. LIM, S. M., A. L. HOOKER, J. G. KINSEY, and D. R. SMITH. 1974. Comparative grain yields of corn hybrids in normal and in Texas male-sterile cytoplasm (cms-T) infected with Helminthosporium maydis race T and disease components of cms-T corn hybrids. Crop Sci. 14:190-195.
5. ULLSTRUP, A. J. 1944. Further studies on a species of Helminthosporium parasitizing corn. Phytopathology 34:214-222.
6. ULLSTRUP, A. J., and S. R. MILES. 1957. The effects of some leaf blights of corn on grain yield. Phytopathology 47:331-336.
7. WALLIN, J. R., and D. V. LOONAN. 1973. A different Helminthosporium disease of corn in the Corn Belt. Plant Dis. Rep. 57:780-784.