Use of an Action Threshold for Common Maize Rust to Reduce Crop Loss in Sweet Corn

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ABSTRACT

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An action threshold of 80% incidence, based on incidence and severity relationships for common maize rust on sweet corn caused by *Puccinia sorghi*, was evaluated in commercial plantings of sweet corn grown for processing in central and western New York. Three different plantings of the cultivar Jubilee were evaluated each year from 1986 through 1988. Applications of mancozeb made at or near the action threshold resulted in significantly reduced disease severity (measured as percent leaf area diseased) at harvest and a significant reduction in the area under the disease progress curve in most fields. The mean number of marketable ears harvested, green weight of the ears, and the husked ear weight were significantly greater in mancozeb-treated blocks in most fields. The 80% incidence action threshold can be used as a guideline for proper timing of the first fungicide application, which is critical for preventing development of damaging levels of disease.

Additional keywords: yield loss, *Zea mays*.

Common rust of sweet corn (*Zea mays* L.) is caused by the macrocyclic, heteroecious fungus *Puccinia sorghi* Schwein. Although infection of the alternate host (*Oxalis* L. spp.) has been reported (1), it does not occur in sufficient frequency to influence development of rust epidemics in temperate areas of the United States. The spore stage of most importance is the urediniospore, which represents the repeating stage of the fungus. Urediniospores are considered too fragile to overwinter in northern climates, thus, the urediniospores needed to initiate rust epidemics are believed to be windblown into northern areas following the sequential plantings of corn from southern areas.

Greater than 76,000 ha of sweet corn are grown annually for processing in central and western New York State. Prior to 1980, New York sweet corn processors had not experienced regular rust epidemics of sufficient magnitude to warrant consideration of a fungicide program to control the disease. An apparent increase in disease severity occurred after 1980; and in 1984, preliminary studies were conducted to demonstrate efficacy of the fungicide mancozeb for control of common maize rust (3). Because the primary inoculum for initiation of common maize rust epidemics comes from outside the immediate area, further research was conducted to improve timing of the fungicide applications to reduce the rate of epidemic development and subsequent crop loss without applying unnecessary sprays.

An action threshold based on incidence and severity relationships for common maize rust on sweet corn in New York was determined, and preliminary results were reported (4,5). The action threshold was developed for the sweet corn hybrid Jubilee, which is grown almost exclusively for processing in New York and is classified as moderately susceptible (7,14) to moderately resistant (9). This paper evaluates the efficacy of the proposed action threshold of 80% incidence of common maize rust prior to tasseling in reducing crop loss due to common maize rust.

MATERIALS AND METH0DS

In 1986, 1987, and 1988 the sweet corn hybrid Jubilee was evaluated for common maize rust incidence, severity, and yield. Descriptions of planting and evaluation dates for each field have been reported previously (6).

Each year three commercial fields were used in this study and varied from 6 to 12 ha. Each field was arbitrarily divided in half to establish two treatments: treated, or not treated with the fungicide mancozeb. The half-field design was used for the convenience of the commercial pesticide applicator. The half-field portions were divided into 10 blocks. Within each block, 10 plants were randomly selected for evaluation. All living leaves on a plant were evaluated for incidence and severity of common maize rust as described previously (6). Descriptions of growth stages of the plant follow the method of James (10). Area under the disease progress curve (AUDPC) for percent leaf area diseased was computed in the manner of Shaner and Finney (15). All time events were recorded as climatological day where day 1 = 1 March.

Fungicide application dates and harvest dates for each field from 1986 through 1988 were recorded (Table 1). In 1986 and 1987, the treated portion of the fields located in LeRoy, NY, received aerial applications of mancozeb from a Cessna Ag-truck equipped with D8-45 nozzles aimed straight back, traveling at an air speed of 193 km/hr. Mancozeb was applied at the rate of 1.4 kg a.i./ha in 11 L of water at 207–241 kPa. The treated portion of the field at the Corning location (1987) received ground applications of mancozeb at the rate of 1.1 kg a.i./ha in 76 L of water at 207 kPa. The applications were made using a John Deere Hi-Cycle 6,000 traveling at a ground speed of 11 km/hr and equipped with flat fan nozzles aimed over the top of the rows. Fungicide applications were not made to fields in 1988.

In 1986, yield was obtained by harvesting ears from 25 randomly selected plants per block from the treated and control areas from each field. In 1987 and 1988, yield was obtained by harvesting the marketable ears from 10 randomly selected plants per block from the threshold treatment and control areas from each field. Green and husked weights were recorded, and data were analyzed with t-tests.

RESULTS

In 1986, common maize rust was first detected at the mid whorl growth stage (climatological day 159, Fig. 1A). Favorable environmental conditions apparently promoted rapid disease development. At the 80% incidence action threshold, the plants were approximately at the late whorl growth stage. The first application of mancozeb was made on day 173, prior to the third sampling date. Disease severity increased from less than 1% to greater than 5% from the second sampling date (late whorl) to the third sampling date (silk) in the sprayed and unsprayed blocks (Fig. 2A). An apparent decrease in disease severity was detected at the final evaluation. The percent leaf area diseased at harvest for upper and all leaves was significantly reduced in the mancozeb-treated blocks in Fields A and B (Table 2). The percent leaf area diseased at harvest on the lower leaves was significantly reduced in the mancozeb-treated blocks in Field A. Mancozeb did not reduce disease severity on upper and all leaves in Field C. An anomalous result was that percent leaf area diseased at harvest on the lower leaves was greater in the mancozeb-treated blocks in Field C. AUDPC was significantly less in the mancozeb-treated blocks in all of the fields. Yield components measured as the mean number of harvestable ears, the green weight of the ears, and the husked weight of the ears were significantly greater in the mancozeb-treated blocks in Fields A and B (Table 3).

Common maize rust was detected at the mid whorl growth stage (second evaluation date) in 1987 (Fig. 1B). However, disease severity increased slowly (Fig. 2B). The first application of mancozeb was made on climatological day 156 when the plants were at the mid whorl growth stage and incidence was about 60%. At the 80% incidence action threshold, the plants were at the late whorl growth stage. At harvest, disease severity levels were less than 2% in treated and control blocks in all of the fields. The percent leaf area diseased at harvest for all leaves was significantly reduced in the mancozeb-treated blocks in Field D (Table 2). Disease severity was reduced on the upper leaves (leaves superior to the ear) in Fields D and E. AUDPC was greater in the unsprayed blocks in Field D. An anomalous result was that AUDPC was greater in the sprayed blocks in Field E. The mean number of harvestable ears, the green weight of the ears, and the husked weight of the ears were significantly greater in the mancozeb-treated blocks in Fields D and F (Table 3).

In 1988, common maize rust was detected at tassel (third evaluation date, Fig. 1C). Disease severity increased slowly (Fig. 2C), and the plants were approaching maturity before the 80% incidence action threshold was reached. Because the 80% incidence action threshold was not reached prior to tasseling, fungicides were not applied to any of the fields in 1988. Final disease severity levels were low, and there were no significant differences in percent leaf area diseased at harvest between paired blocks (Table 2). An anomalous result was that the AUDPC was greater in the threshold treatment blocks in Field G. There were no significant differences in yield between treatments in any of the fields (Table 3).

DISCUSSION

Late-season control of common maize rust is needed in New York because of two production activities. First, processing sweet corn is planted in New York from May to June to allow processing facilities to operate over an extended period of time. The staggered planting schedules result in a significant build-up of inoculum that originally enters from southern states. Second, processors continue to use the cultivar Jubilee because of its horticultural qualities in spite of the fact that cultivars with Rp resistance genes or partial resistance to common maize rust are available (7,11).

An action threshold was needed to enable growers and processors to apply a control measure at the proper time to reduce the rate of epidemic development and prevent damaging levels of disease from being reached prior to harvest. Similar thresholds have been developed for stripe rust of wheat in Australia (2) and in the Netherlands (16). We have developed an action threshold of 80% incidence prior to tasseling for initiation of fungicide sprays to avoid crop loss in processing sweet corn (5,6). The threshold was developed for growth stages prior to tasseling

TABLE 1. Year, location in New York, planting date, fungicide application dates, and harvest date for trials conducted in 1986 through 1988 with the sweet corn cultivar Jubilee

Year	Field	Location	Planting date (climatological day)[a]	Spray dates (climatological day)			Harvest date (climatological day)
1986	A	LeRoy[b]	119	173	181	191	220
1986	B	LeRoy	119	173	181	191	220
1986	C	LeRoy	119	173	181	191	220
1987	D	Corning[c]	113	156	163	171	198
1987	E	LeRoy	112	171	179	185	199
1987	F	LeRoy	110	171	179	185	199
1988	G	Corning	107	N/A[d]	N/A	N/A	190
1988	H	LeRoy	110	N/A	N/A	N/A	197
1988	I	LeRoy	114	N/A	N/A	N/A	204

[a]Day 1 = 1 March.
[b]Fields located in LeRoy in 1986 and 1987 received aerial applications of mancozeb (1.4 kg a.i./ha).
[c]The field located in Corning received ground applications of mancozeb (1.1 kg a.i./ha).
[d]N/A = No fungicide sprays.

because Headrick and Pataky (9) demonstrated that susceptible and resistant hybrids became more resistant to *P. sorghi* as the plants approached anthesis.

Fungicide applications were initiated in this study when plants were at or near the proposed 80% incidence action threshold (Fig. 1). Some flexibility was allowed in the first application date to accommodate scheduling of aerial applications, weather-related delays, and scouting time. Subsequent sprays were timed from 7 to 10 days after the first application or timed to coincide with needed insecticide sprays as determined in an integrated pest management program. When the action threshold was used and fungicide sprays were warranted, applications of mancozeb significantly reduced disease severity in most fields. In 1986, common maize rust severity levels were high, and fungicide applications significantly reduced AUDPC in all fields. Disease severity levels were not as great in 1987. Threshold levels were achieved late in the growth stage of the plant (late whorl), and environmental conditions were not conducive for rapid development of common maize rust. Applications of mancozeb resulted in minimal reductions in disease severity in one field. However, two fields exhibited increases in yield in the mancozeb-treated blocks in 1987. The increase in yield in the treated blocks of Field D (Corning location) may be due in part to control of northern leaf blight (*Exserohilum turcium* (Pass.) Leonard and Suggs) achieved with mancozeb applications. In 1988, rainfall was significantly below normal, and disease levels did not reach the action threshold until after tassel. Thus, fungicides were not warranted and there was no difference, as expected, between paired plots.

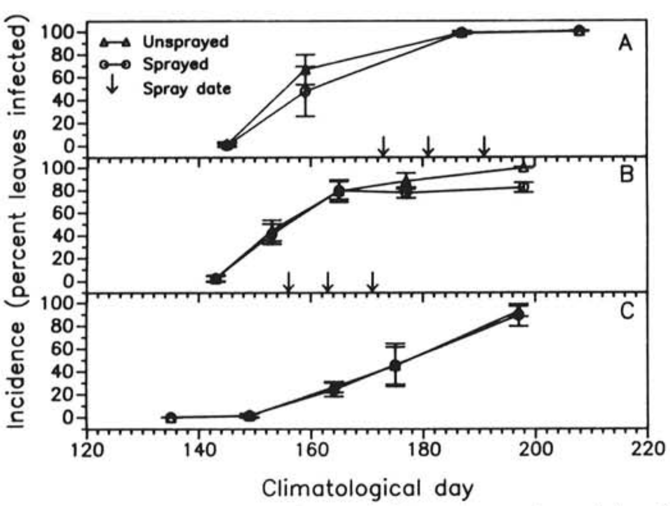

Fig. 1. Progress of common maize rust incidence (percent leaves infected) in time for sprayed and unsprayed plots. Bars represent the standard error of the mean. Day one of the climatological year starts on 1 March. **A,** Data are for Field B, 1986. **B,** Data are for Field D, 1987. **C,** Data are for Field H, 1988. No fungicides were applied in 1988.

In fields where anomalous results were obtained or the action threshold was reached and fungicides were applied but had no effect on disease severity, the lack of measured response may be attributable to the experimental design. Because the treatments could not be randomized throughout the field, nutritional or environmental factors may have contributed to the uncontrolled lack of uniformity. In this study, crop loss was assessed in terms of yield only, and common maize rust may also have an effect on quality of the sweet corn. Previous research has shown that common maize rust can result in reduced ear length, ear diameter, percentage of moisture in the kernels, and the percentage of sugar in the kernels (8,14).

An apparent decrease in percent leaf area diseased (all leaves) was detected at the final evaluation in two fields in 1986 (Fig. 2A). Further study showed that disease severity on the upper leaves (leaves above the ear) had not changed from the silk to mature growth stage, but disease severity on the lower leaves (leaves subtending the ear) had decreased significantly from silking to maturation (6). The apparent decrease in disease severity was due to the presence of fewer lower leaves to rate because of their senescence.

In Fields C, E, and G, the final percent leaf area diseased (all leaves) was not significantly different in the sprayed and control blocks. However, the AUDPC in these fields was significantly different in the sprayed and control blocks. This is because the AUDPC measurement is more sensitive to fluctuations in the disease progress curve than a final disease severity rating.

At this point, the 80% action threshold is valid only for the cultivar Jubilee and cultivars in the moderately resistant category. Highly susceptible cultivars will require a lower action threshold to avoid yield and quality reductions (12,13). The threshold can be readily incorporated into existing integrated pest management scouting procedures because incidence can be easily measured. Although the first fungicide spray is dictated by the action thresh-

TABLE 2. Effect of mancozeb applications on disease severity of common maize rust on the sweet corn cultivar Jubilee

			% Leaf area diseased at harvest			
Year	Field	Treatment	Lower[a] leaves	Upper[b] leaves	All leaves	AUDPC[c]
1986	A	Threshold treatment	3.9[e]	5.3[e]	5.3[e]	1081.6[e]
		No fungicide applications	4.7	8.3	7.6	1608.1
1986	B	Threshold treatment	4.7	5.7[e]	5.9[e]	1209.1[e]
		No fungicide applications	5.2	7.7	7.4	1660.3
1986	C	Threshold treatment	16.5[e]	11.7	12.8	1645.4[e]
		No fungicide applications	13.4	11.8	13.0	2271.4
1987	D	Threshold treatment	1.5	1.1[e]	1.2[e]	55.2[e]
		No fungicide applications	1.5	1.5	1.5	60.2
1987	E	Threshold treatment	1.5	1.3[e]	1.4	39.7[e]
		No fungicide applications	1.5	1.4	1.4	35.2
1987	F	Threshold treatment	1.5	1.5	1.5	50.4
		No fungicide applications	1.5	1.5	1.5	46.9
1988	G	Threshold treatment[d]	0.8	1.0	0.9	16.5[e]
		No fungicide applications	0.7	1.1	1.0	12.8
1988	H	Threshold treatment[d]	1.4	1.8	1.6	9.0
		No fungicide applications	1.4	1.7	1.6	9.3
1988	I	Threshold treatment[d]	1.6	2.2	2.0	10.7
		No fungicide applications	1.6	2.1	1.9	9.8

[a] Lower leaves = leaves subtending the ear.
[b] Upper leaves = leaves above the ear.
[c] Area under the disease progress curve (AUDPC) expressed as units of percent disease-days.
[d] Fungicides were not applied to fields in 1988 because 80% incidence was not reached prior to tassel.
[e] Means are significantly different statistically ($P = 0.05$) based on a t-test.

TABLE 3. Effect of mancozeb applications for control of common maize rust on yield components of the sweet corn cultivar Jubilee

Year	Field	Treatment	Ears per block[a] (mean no.)	Green weight (kg)	Husked weight (kg)
1986	A	Threshold treatment	27.3[c]	7.6[c]	4.9[c]
		No fungicide applications	25.8	6.8	4.4
	B	Threshold treatment	27.9[c]	8.6[c]	5.6[c]
		No fungicide applications	25.7	7.3	4.7
	C	Threshold treatment	25.1	6.2	4.0
		No fungicide applications	25.1	6.3	4.1
1987	D	Threshold treatment	16.8[c]	5.1[c]	3.4[c]
		No fungicide applications	13.5	4.1	2.6
	E	Threshold treatment	13.0	4.2	2.7
		No fungicide applications	12.9	4.1	2.8
	F	Threshold treatment	14.2[c]	4.4[c]	3.2[c]
		No fungicide applications	12.8	3.9	2.8
1988	G	Threshold treatment[b]	12.6	4.7	3.1
		No fungicide applications	11.6	4.4	2.9
	H	Threshold treatment[b]	12.1	4.4	2.8
		No fungicide applications	12.2	4.5	2.8
	I	Threshold treatment[b]	11.6	4.5	2.9
		No fungicide applications	12.4	4.8	3.1

[a] Results from 25 plants per block in 1986 and 10 plants per block in 1987 and 1988.
[b] Fungicides were not applied to fields in 1988 because 80% incidence was not reached prior to tassel.
[c] Means are significantly different statistically ($P = 0.05$) based on a t-test.

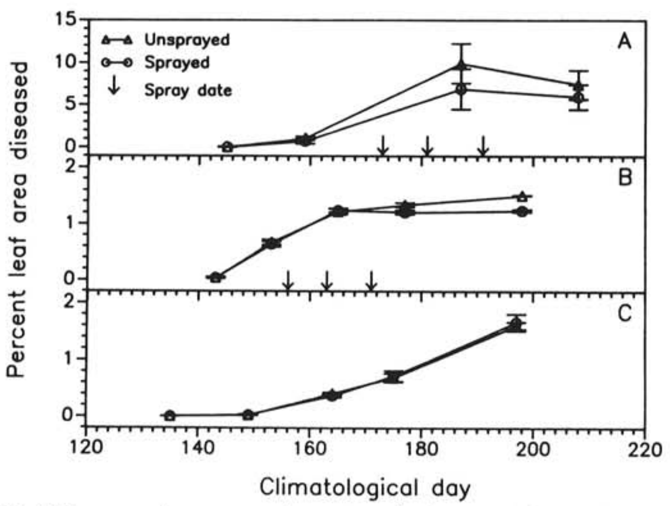

Fig. 2. Progress of common maize rust severity (percent leaf area diseased) in time for sprayed and unsprayed plots. Bars represent the standard error of the mean. Day one of the climatological year starts on 1 March. **A,** Data are for Field B, 1986. **B,** Data are for Field D, 1987. **C,** Data are for Field H, 1988. No fungicides were applied in 1988.

old, subsequent sprays can be included with insecticide sprays. Use of the action threshold provides proper timing of the first fungicide application and prevents unnecessary fungicide applications when the threshold is not reached prior to tassel.

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