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An Evaluation of Foliar Fungicides for Control of Southern Corn Leaf Blight (Helminthosporium maydis) in Indiana in 1971

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Larry Greulach
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Helminthosporium maydis

in Indiana in 1971
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AN EVALUATION OF FOLIAR FUNGICIDES
FOR CONTROL OF SOUTHERN CORN LEAF BLIGHT
(Helminthosporium maydis) IN INDIANA IN 1971

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Department of Botany and Plant Pathology

Introduction

At various times in the history of man's eternal struggle for survival, plant diseases have attracted attention and created concern as potential saboteurs of food and fiber for survival. The Irish potato famine of 1830-1840 caused by the late blight disease, the wheat stem rust outbreak in the U.S.A. in 1916, the Dutch Elm disease, chestnut blight and Victoria blight of oats are dramatic examples of near catastrophic consequences of destructive plant diseases.

In 1970 the Southern Corn Leaf Blight disease struck with electrifying impact in corn fields of the southern states, the corn production belt and the central provinces of the Dominion of Canada. A problem which in one growing season destroyed 1 billion bushels of our national corn crop inevitably resulted in a wave of national concern by farmers, complacent lay citizenry, commodity brokers, agribusiness interests and others. Southern Corn Leaf Blight became a dramatic subject for journalistic license -- the first time in a decade that a plant disease had aroused public interest.

During the winter of 1970-71 farmer interest in Indiana over Southern Corn Leaf Blight dominated Extension meetings and educational programs. In excess of 40 large regional meetings were conducted between January 1 and March 15, 1971 in cooperation with county area crops agents and Extension specialists in the Department of Agronomy. On these occasions the nature of the problem was explained in depth, the relationship of weather to epidemic blight development was discussed and suggestions for insurance against severe losses were offered as summarized below:

1. Plant N-cytoplasm hybrids
2. Reduce planting rate of N-cytoplasm corn
3. Plant susceptible hybrids first
4. Fertilize as usual based on soil tests
5. If disease severity justifies, protect susceptible hybrids with fungicides.

During these sessions there was no basis for providing positive answers to the following most generally asked questions:

1. Will SCLB overwinter in 1970-71?
2. What is the forecast for blight prospects in 1971?
3. What emergency measures could be used if SCLB should pose an economic threat to susceptible Indiana corn in 1971?

The farmers of Indiana were fully aware that a repeat of 1970, with 60 to 80 bushel corn yields and another state loss of 100 million bushels of corn would have meant disaster for many individual corn producers. As a result of considerable farmer interest, combined with promises of cooperation from area Extension specialists, chemical distributors, aerial applicators, related agribusiness interests, the Extension plant pathologist agreed to implement a program of evaluation of foliar fungicides for SCLB control at the applied level.

The purposes of this project were:

1. To serve as a guideline for practical usage if SCLB should constitute an economic threat to corn production in 1971.
2. To provide some practical basis of understanding of the potential of foliar fungicides for emergency usage in future years.

The results of the 1971 "on the farm" evaluation of foliar fungicides for the control of *H. maydis* are presented herewith.

Winter Investigations of Foliar Fungicides for SCLB Control in Florida 1970 - 1971

During the winter months of 1970-71 Purdue personnel maintained close contact with experimental field trials of foliar fungicides for SCLB control conducted by the Rohm and Haas Co., Philadelphia, PA. An opportunity was also provided to personally observe the results of these Florida trials.

Experimental corn plots were established in October 1970 by the Rohm and Haas Co. on the Purdue Ag Alumni Experiment Station at Homestead, Florida under the direction of Dr. Norman Gerhold of the Rohm and Haas Florida Experimental Station. Replicated plots of blight susceptible inbreds with Normal and TMS cytoplasm were planted with buffer rows of blight susceptible inbreds between plots. These plots were under continuous irrigation from October throughout the winter growing season. Dithane M-45 at various dosages and concentrations with and without adjuvants were established. Fungicides were applied with a Hi-Boy ground applicator calibrated to deliver 30 gallons per acre at 3-day and 7-day intervals. Natural blight infection was induced by susceptible inbred buffer strips.

By January 8, 1971 SCLB was well-established in these plots and had destroyed the inbred buffer strips at this time. Detailed observations of these plots were made by the Rohm and Haas personnel and Purdue and Illinois pathologists on January 8, 9 and 10, 1971.

The purpose of the Homestead trial was "an all or nothing" test of Dithane M-45 for *H. maydis* control. It was concluded that zinc-ion-manganese coordinated carbamate fungicides did control SCLB under conditions favorable for the pathogen. Equally good control was obtained with 13 applications as was obtained with 26 sprays. The dosage of 1.5 pounds per acre of Dithane M-45 was established as the effective fungicide rate, and control was improved with the addition of Triton CS-7 as an adjuvant.
Following the Homestead trials an additional large-scale demonstration was established by the Rohm and Haas Co. at Lakeland, Florida. A large scale planting of an early commercial hybrid of T-cytoplasm corn was established in April 1971. Replicated applications of Dithane M-45 at 1.5 pounds per acre were applied by fixed wing Pawnee aircraft (3.1 gpa) in combination with Triton CS 7 or Sun 11 E Oil. The trial was conducted in a field that had been heavily infected with SCLB in 1970. There were several hundred acres of commercial field corn in the immediate vicinity of N-cytoplasm hybrids. Several hybrids of different maturities were included in the trial with both T-cytoplasm and N-cytoplasm hybrids.

The Pawnee aircraft was equipped with a standard boom with 24 hollow cone nozzles and was flown at an altitude of 5 to 8 feet above the top of the corn at a speed of 115 to 120 mph.

The experimental plots were rated for disease severity using the standard Ullstrup Disease Severity Index (0.5-5.0). The data were recorded by T. J. Stelter (Rohm and Haas Co.) in cooperation with N. C. Schenck (University of Florida, Gainesville).

The disease severity ratings for the various plots in the early variety in the early dough stage are summarized in Table 1.

Table 1. Corn leaf blight aerial sprays, Lakeland, Florida; early variety, early dough stage, June 17, 1971

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Treatment (3) (4)</th>
<th>gpa</th>
<th>No. applications</th>
<th>Mean disease rating (1)(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SCLB</td>
</tr>
<tr>
<td>E</td>
<td>Control (no spray)</td>
<td>-</td>
<td>-</td>
<td>0.04</td>
</tr>
<tr>
<td>B</td>
<td>Dithane M-45 (alone)</td>
<td>3.1</td>
<td>5</td>
<td>0.02</td>
</tr>
<tr>
<td>G</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>1</td>
<td>0.00</td>
</tr>
<tr>
<td>D</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>5</td>
<td>0.00</td>
</tr>
<tr>
<td>C</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>7</td>
<td>0.04</td>
</tr>
<tr>
<td>A</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>6.2</td>
<td>5</td>
<td>0.02</td>
</tr>
<tr>
<td>F</td>
<td>Dithane M-45 + Sun 11 E oil</td>
<td>3.1</td>
<td>5</td>
<td>0.00</td>
</tr>
</tbody>
</table>

(1) Ratings by N. C. Schenck and T. J. Stelter.
(2) Average of 60 T and 40 N-cytoplasm plants in each of 3 replicates per treatment. Rated separately for SCLB and NCLB by Ullstrup Scale 0.5-5.0 (see Plant Disease Reporter 54:12,1135).
(3) Treatment Rates: Dithane M-45 1.5 pounds per acre. Triton CS-7 spreader-sticker 2 pints per 100 gallons. Sun 11 E oil 1 quart per acre - 8 gallons per 100 gallons of spray.
(5) N = Normal cytoplasm. T = Texas Male Sterile cytoplasm.

The same plots of the early variety corn were rated again for SCLB severity in the firm dough stage on June 24, 1971. The results are summarized in Table 2.
Table 2. Corn leaf blight aerial sprays, Lakeland, Florida; early variety, firm dough stage, June 24, 1971

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Treatment</th>
<th>gpa</th>
<th>No. applications</th>
<th>SCLB on T-cytoplasm (Barratt-Horsfall index)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Control (no spray)</td>
<td>-</td>
<td>-</td>
<td>4.34</td>
</tr>
<tr>
<td>B</td>
<td>Dithane M-45 alone</td>
<td>3.1</td>
<td>6</td>
<td>2.43</td>
</tr>
<tr>
<td>G</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>2</td>
<td>3.69</td>
</tr>
<tr>
<td>D</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>6</td>
<td>1.94</td>
</tr>
<tr>
<td>C</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>8</td>
<td>1.00</td>
</tr>
<tr>
<td>A</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>6.2</td>
<td>6</td>
<td>1.73</td>
</tr>
<tr>
<td>F</td>
<td>Dithane M-45 + Sun 11 E oil</td>
<td>3.1</td>
<td>6</td>
<td>1.71</td>
</tr>
</tbody>
</table>

(1) Average of 40 plants in each of 3 replicates.
(2) Data recorded by N.C. Schenck and T. J. Stelter.

The early hybrid plots were again rated for disease severity on July 1 in the late dough stage. At this time the unsprayed T-cytoplasm plots showed complete blighting to the top of the plants as did those plots receiving only late sprays. At this time N-cytoplasm plants were moderately infected with SCLB indicating the disease will build up on N-cytoplasm corn in the presence of sufficient *H. maydis* inoculum. The increase in severity of SCLB on Dithane sprayed plots from light to moderately heavy at this stage of late maturity was not considered to significantly reduce yield. The results of these late disease ratings are summarized in Table 3.

Table 3. Corn leaf blight aerial sprays, Lakeland, Florida; early variety, late dough stage, July 1, 1971

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Treatment</th>
<th>gpa</th>
<th>No. sprays</th>
<th>SCLB disease rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T-cytoplasm</td>
</tr>
<tr>
<td>E</td>
<td>Control (no spray)</td>
<td>-</td>
<td>-</td>
<td>4.88</td>
</tr>
<tr>
<td>B</td>
<td>Dithane M-45 alone</td>
<td>3.1</td>
<td>6</td>
<td>3.48</td>
</tr>
<tr>
<td>G</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>2 (1)</td>
<td>4.33</td>
</tr>
<tr>
<td>D</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>6</td>
<td>3.63</td>
</tr>
<tr>
<td>C</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>8</td>
<td>2.75</td>
</tr>
<tr>
<td>A</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>6.2</td>
<td>6</td>
<td>3.59</td>
</tr>
<tr>
<td>F</td>
<td>Dithane M-45 + Sun 11 E oil</td>
<td>3.1</td>
<td>6</td>
<td>3.37</td>
</tr>
</tbody>
</table>

(1) Late sprays only.

A similar plot of a mid-season hybrid on T-cytoplasm corn also received the same spray treatments as the early hybrid plot and was rated for SCLB severity as described for the preceding plots. The results obtained are summarized in Table 4.
Table 4. Corn leaf blight aerial sprays, Lakeland, Florida; mid-season hybrid T-cytoplasm

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Treatment</th>
<th>gpa</th>
<th>No. sprays</th>
<th>Disease severity index (1) 6/24/71</th>
<th>7/1/71</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Control (no spray)</td>
<td>-</td>
<td>-</td>
<td>3.73</td>
<td>4.12</td>
</tr>
<tr>
<td>B</td>
<td>Dithane M-45 alone</td>
<td>3.1</td>
<td>6</td>
<td>0.71</td>
<td>2.38</td>
</tr>
<tr>
<td>G (2)</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>2</td>
<td>2.43</td>
<td>3.81</td>
</tr>
<tr>
<td>D</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>6</td>
<td>0.49</td>
<td>2.16</td>
</tr>
<tr>
<td>C (3)</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>3.1</td>
<td>8</td>
<td>0.78</td>
<td>1.45</td>
</tr>
<tr>
<td>A</td>
<td>Dithane M-45 + Triton CS-7</td>
<td>6.2</td>
<td>6</td>
<td>0.81</td>
<td>2.22</td>
</tr>
<tr>
<td>F</td>
<td>Dithane M-45 + Sun 11 E oil</td>
<td>3.1</td>
<td>6</td>
<td>0.35</td>
<td>1.64</td>
</tr>
</tbody>
</table>

(1) Average of 40 plants in each of 3 replicates.
(2) Late sprays only starting at milk stage.
(3) Two extra early sprays.

The Lakeland, Florida field trials of the potential of Dithane M-45 for the control of Southern Corn Leaf Blight provided the basis for future field trials in Indiana.

The Rohm and Haas Co. Florida trials provided the following information:

1. Properly-timed applications of Dithane M-45 at 1.5 pounds per acre did significantly reduce the severity of SCLB in replicated trials.
2. Aerial application of fungicide by fixed-wing aircraft were practical. Aerial volumes of 3.1 gpa were just as effective as 6.2 gpa.
3. Late applications of fungicide starting in the milk stage after SCLB was well established were not effective.
4. Five applications of fungicide were necessary for SCLB control under Florida conditions.
5. Addition of sticker-spreaders to the fungicide improved disease control.
6. SCLB would develop on N-cytoplasm corn to moderately-severe levels.
7. Fungicide applications suppressed development of Northern Corn Leaf Blight.

While the results of the Rohm and Haas fungicide trials in Florida for SCLB control were not published in professional journals, they were available to Experiment Station and Extension personnel in late June 1971.

The Rohm and Haas Florida fungicide trials were conducted in cooperation with professional personnel from the Florida Agricultural Experiment Station, Gainesville.

Observation of these Florida trials and continuing communication with Rohm and Haas Co. officials during the early summer provided the Purdue Extension Plant Pathologist with a reliable basis and confidence to establish the Indiana field trials summarized in this report.
Weather and Corn Blight in 1971

Hoosier weather during 1971 was abnormally favorable for corn production and less favorable for Southern Corn Leaf Blight (H. maydis) than it was in 1970.

The winter was colder and drier than usual with little build-up of soil moisture until late in the winter. Soils were deeply frozen over a longer than usual period. Overwintering studies of winter survival of H. maydis in infected leaf samples were conducted in 13 locations in Indiana by Dr. A. J. Ullstrup. Periodic tests of spores produced from these samples were conducted on susceptible corn seedlings in the greenhouse at intervals during the winter months. Viable spores of H. maydis capable of inducing symptoms of SCLB on greenhouse seedlings were obtained from overwintered leaf samples from all locations as late as March 1971.

Spring field work started early, with seedbeds in all areas of the state prepared by late April. Unusual coolness continued through April and May. May precipitation also lagged behind normal except for small surpluses in the east, northeast, and southeast. Germination and emergence of corn during the first half of May was slow because of the low soil temperatures and dryness. Some replanting was necessary. By late May improved moisture levels and warmer temperatures boosted growth. At this time unfounded blight rumors were circulating in southern Indiana which were identified as flea beetle injury.

During June and early summer, rainfall was excellent in all areas except the northeast and south central. This good rainfall together with ideal temperatures (mid 60's to mid 70's at night, 80's to lower 90's during the day) produced very rapid growth. By late June or early July, corn was already starting to tassel. These conditions were ideal for the development of SCLB on susceptible volunteer corn seedlings.

By the second week of July, cool weather arrived and continued for the rest of the month. Precipitation was abundant in all areas except the northeast and extreme northern portions of north central Indiana where a mild drought period occurred. The July coolness (3 to 4 degrees below normal) slowed growth rates but provided excellent tasselling, silking, and filling conditions and helped conserve soil moisture. Heavy dew was also common during July. Despite the coolness, Southern Corn Leaf Blight increased sharply on susceptible corn by the end of the month (July) because moisture conditions were excellent for disease development.

Coolness continued during August, with temperatures 3 to 4 degrees below normal. Night-time dew also continued heavy, frequently lasting 9 to 12 hours. August rainfall was a little subnormal in all areas except in the northeast, central and eastern Indiana where it was moderately short.

A warming trend developed in late August and continued through mid-September followed by a cool subnormal period. Rainfall was abundant during September, totaling 4 to 6 inches across the state. By late September soil moisture was ideal for plowing, wheat seeding, pasture growth and late crops.

October began with temperatures in the upper 80's to lower 90's, which rapidly matured corn and soybeans and permitted early harvest. By October 12 the growing season was continuing, with only scattered light frost affecting bottom-land crops.
1971 growing degree day accumulations were subnormal through May in all of Indiana except the southwest. Departures were -100 or more. By the beginning of July, accumulations surged ahead of normal as a result of warm June temperatures, with totals near 1000 in the north and over 1500 in the southwest. The rate of accumulation slowed sharply during July and August and by September 1 lagged from normal by as much as 100 to 200 in all areas except the southwest and south central.

With respect to Southern Corn Leaf Blight, the growing season showed both favorable and unfavorable periods. Winter and early spring dryness combined with summer coolness apparently was effective in reducing spore viability in the 1970 corn crop residue. Early planting in late April and May plus very rapid growth in June pushed corn to its advanced stage earlier than usual by July 1. Below normal temperatures, especially at night-time, in July and August retarded blight fungus development. During July and August, the predominance of northwest through northeast winds at the surface and aloft (in contrast to the usual southerly flow of air) may have contributed to the lack of spore influx from the south. This, plus factors such as reduced acreage of susceptible corn in Southern corn-producing states were among the reasons for Indiana's improved leaf blight picture.

(The above summary was prepared with the cooperation of W. L. Stirm, agricultural meteorologist, National Weather Service, Purdue University, Lafayette, Indiana.)

Development of SCLB in 1971

SCLB was first observed and identified on susceptible volunteer corn seedlings in Clark County in southern Indiana on June 8, 1971. Within a few days it was observed and identified on volunteer corn in other southern counties and 7 days later it appeared on volunteer corn in central Indiana counties. As of June 14, 1971, SCLB had been observed and positively identified in Clay, Clark, Warrick, Vanderburgh, Pike, Gibson, Hamilton, Monroe and Tippecanoe counties on volunteer corn seedlings.

Six days after SCLB was observed on volunteer corn it had appeared on field-planted corn in southern Indiana. With dramatic suddenness it rapidly appeared in other counties and by July 15 had been observed in 74 of the 92 counties and was probably present in all Indiana counties by mid-July. The dates of first occurrence of SCLB in Indiana counties are summarized in Figure 1.

SCLB apparently originated in 1971 from homegrown inoculum from volunteer corn and infected corn cribs. There was apparently little migration of SCLB from southern states or from southern counties in Indiana.

By late June SCLB was well-established throughout the state on TMS corn and in some fields of blends. Infections spread rapidly from June 15 through July 10. While the weather cooled off in late July heavy dews were favorable for a sharp increase in blight severity on susceptible corn.

During August SCLB made little progress because of daily temperatures 3 to 4 degrees below normal combined with subnormal rainfall in all areas of the state except in the
Figure 1. Dates of first occurrence of SCLB in Indiana counties in 1971.

(Based upon specimens submitted by county Extension agents)
northeast, central and eastern counties. In late August a warming trend resulted in further spread of SCLB and appearance of stalk rot and ear husk infections on susceptible corn hybrids. September was again subnormal in daily temperatures with abundant rainfall of 4 to 6 inches across the state. Weather conditions during September did not favor SCLB development. While SCLB was widely prevalent in Indiana in 1971, it never attained the severity of 1970. Severe damage did occur in several "hot spots," but stalk rot and ear rot symptoms of SCLB were not economically severe.

Ideal weather conditions in October with daily temperatures in the upper 80's and lower 90's rapidly matured the Indiana corn crop and provided ideal harvesting conditions and permitted early completion of the corn harvest.

Stalk rot problems (Diplodia) were widely prevalent throughout the state in 1971.

Factors to Consider in the Decision of "to Spray or Not to Spray"

Indiana farmers with acreages of blight-susceptible corn were confused by conflicting suggestions as to emergency measures that might offset the threat of SCLB that appeared likely in mid-June 1971. If they had been gifted with prophetic vision that enabled them to know weather conditions that were to occur in August through October the decision would have been relatively simple. Hoosier farmers were not so gifted nor were extension personnel concerned with the SCLB problem.

By late June many Hoosier farmers were observing for themselves rapidly increasing SCLB infections on T-cytoplasm hybrids and 50-50 blends. The Purdue Extension Plant Pathologist on June 14, 1971 suggested through the mass media that Hoosier farmers with SCLB developing on susceptible corn had no practical alternative to the use of foliar fungicides applied by aerial applicators. Hoosier farmers never considered the impractical suggestion of plowing up SCLB-infected corn acreage and replacing it with sorghum or soybeans. Simple arithmetic easily indicated the cost-return factor of this suggestion was entirely impractical; there was no alternative fungicide application.

To assist the Hoosier farmer decide for himself whether circumstances justified investment in fungicide sprays for SCLB, the following guidelines were released through the Indiana mass media:

1. Potential yield and value of crop.
   Unless yields of at least 80 bushels per acre (preferably 100 bushels) are expected, a spray program should not be considered.

2. Type of hybrid grown.
   If Northern Corn Leaf Blight is not a problem in 1971, N-cytoplasm corn should not be sprayed. T-cytoplasm corn should be given first priority for fungicide applications and blends should be treated if blight develops in epidemic proportions in these fields.
   Corn that is in early dough stage when blight attains epidemic proportions
   should produce a satisfactory yield without spraying. Corn that is in early tassel
   when blight moves in will benefit most from fungicide sprays.

4. Weather conditions during tasseling to early dough stage (about July 15 through
   August 15).
   Warm (80+ degree) weather and high humidity will favor blight development.
   Have access to reliable long range weather forecasting service during this period.

5. Availability of spray application equipment.
   If blight develops in 1971, there will not be sufficient aerial and ground spray
   application equipment available to treat all of the acreage of blight-susceptible
   corn. Inquiry should be made as to the availability of spraying equipment before
   it is necessary. Contact your local county agricultural agent or area crops agent.

6. Keep informed on the National Blight Picture as it develops by contacting your county
   Extension office.
   Every county office is receiving weekly blight reports from the Dixie Early
   Warning Service, the USDA Spore Trapping and Blight Warning Service and the
   Purdue Corn Blight Quickie Reports.

7. Calculate the cost of spraying and estimate profit return.
   A. Estimate potential yield per acre before blight threatens. Multiply by an
      arbitrary figure expected price per bushel.
   B. Deduct fixed cost per acre for seed, fertilizer, herbicide, etc. This will
      be the estimated return per acre.
   C. Estimate potential yield reduction per acre by blight and subtract from (B).
      This will be the return after blight losses.
   D. Estimate an investment of $12 to $16 per acre for spray costs for 3 to 4
      sprays for blight-susceptible blends or TMS hybrids (this is season cost
      for spraying).
   E. Estimate yield to be 90 percent of expected yield in the absence of blight
      (A). Multiply by expected price per bushel. Deduct fixed costs (B) plus
      spray costs (D). Compare item (D) with item (C).

   This should give expected return from spraying as compared with return from blight-
   infected fields which were not sprayed.

   Watch the results of the Purdue corn spraying demonstrations in your region.

   Other states three weeks later finally suggested fungicide usage for blight control in
   Kentucky, Ohio, Illinois, Wisconsin and Iowa.

   The official statistics for corn production in Indiana in 1971 were as follows:
<table>
<thead>
<tr>
<th>Description</th>
<th>Acres</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total acreate</td>
<td>5,479,000</td>
<td></td>
</tr>
<tr>
<td>Acreage in normal corn</td>
<td>1,643,000</td>
<td>(30%)</td>
</tr>
<tr>
<td>Acreage in TMS corn</td>
<td>1,041,010</td>
<td>(19%)</td>
</tr>
<tr>
<td>Acreage in blends</td>
<td>2,246,390</td>
<td>(41%)</td>
</tr>
<tr>
<td>Acreage in F2 corn</td>
<td>109,580</td>
<td>(2%)</td>
</tr>
<tr>
<td>Acreage in miscellaneous corn</td>
<td>438,320</td>
<td>(8%)</td>
</tr>
<tr>
<td>Total production (November)</td>
<td>525,984,000</td>
<td></td>
</tr>
</tbody>
</table>

(Above data taken from Indiana Crop and Livestock Reporting Service, USDA Statistical Reporting Service, Lafayette, Indiana, November 1, 1971.)

A survey of Indiana aerial applicators and agricultural chemical distributors indicated that about 250,000 acres of corn were sprayed with fungicides 2 to 3 times in Indiana in 1971.

**Fungicides Approved for Application to Corn**

Although fungicides had been used for several years in Florida for the control of Northern Corn Leaf Blight, these materials were not approved for use on field corn without restriction. The fungicides approved by the E.P.A. for use on field corn are listed in Table 5.

The adjuvants suggested for use with zinc-ion maneb were:

1. BioFilm. Colloidal Products 3 ounces per 100 gallons -- ground
   6 to 8 ounces per 100 gallons -- aerial
2. Triton CS-7. Rohm & Haas 2 pints per 100 gallons
3. DuPont Sticker-Spreader,

**Methods of Application of Fungicides for Corn**

(Based in part on information taken from Rohm & Haas Aerial Application Manual)

Only two methods for applying fungicides were available to field corn producers; viz ground application and aerial application. High clearance ground application equipment was available in most areas of Indiana, whereas aerial application equipment was available only by contract from FAA licensed aerial applicators.

Advantages of aerial application:

1. Sprays may be applied when ground is too wet for tractor drawn equipment.
2. Soil compaction and crop damage is eliminated:
3. No farmer capital equipment investment.
Table 5. Fungicides approved for use on field corn

<table>
<thead>
<tr>
<th>Fungicide Trade name</th>
<th>Chemical composition</th>
<th>Manufacturer</th>
<th>Approved dosage/A</th>
<th>Restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citcose 4E</td>
<td>L 5% Cu. copper salts of fatty and resin acids</td>
<td>Cities' Service Corp.</td>
<td>2 qts.</td>
<td>Not approved for aerial application in Indiana</td>
</tr>
<tr>
<td>Maneb</td>
<td>80% WP</td>
<td>DuPont</td>
<td>2.4 lbs.</td>
<td>Sweet corn only. Do not feed treated forage to livestock.</td>
</tr>
<tr>
<td>Manzate-D</td>
<td>Manganese ethylene</td>
<td>DuPont</td>
<td>2.4 lbs.</td>
<td>Restricted to Florida. Do not feed forage to livestock.</td>
</tr>
<tr>
<td>Dithane M-22</td>
<td>Bisdithiocarbamate</td>
<td>Rohm &amp; Haas</td>
<td>2.4 lbs.</td>
<td>Discontinue 7 days before feeding treated grain or forage to livestock.</td>
</tr>
<tr>
<td>Polyram</td>
<td>80% WP</td>
<td>Niagara</td>
<td>3.2 lbs.</td>
<td>Do not feed treated forage to dairy cattle or livestock for slaughter.</td>
</tr>
<tr>
<td>Dithane M-45</td>
<td>Zinc-ion coordinated maneb</td>
<td>Rohm &amp; Haas</td>
<td>1.2 lbs.</td>
<td></td>
</tr>
<tr>
<td>Manzate</td>
<td>Zinc-ion coordinated maneb</td>
<td>DuPont</td>
<td>1.2 lbs.</td>
<td></td>
</tr>
<tr>
<td>Zineb</td>
<td>80% WP</td>
<td></td>
<td>3 lbs.</td>
<td></td>
</tr>
<tr>
<td>Dithane Z-78</td>
<td>Zinc ethylene</td>
<td>Rohm &amp; Haas</td>
<td>3 lbs.</td>
<td></td>
</tr>
<tr>
<td>Parzate</td>
<td>Bisdithiocarbamate</td>
<td>DuPont</td>
<td>3 lbs.</td>
<td></td>
</tr>
</tbody>
</table>

4. Fast coverage of large acreages.
5. Less farm labor required.
6. Less water required per acre.

Disadvantages of aerial applications:

1. High power lines, buildings, woods and small field size restrict aircraft operation.
2. High winds, low humidity, high temperatures reduce efficiency.
Whichever method of application is employed, it is vitally important to have the equipment correctly nozzled, properly calibrated and efficiently operated. Even though the farmer is not involved in the aerial application operation it is important to have some knowledge of aerial application of pesticides to judge the quality of the individual operation.

Calibration and Operation of High Clearance Sprayers

1. Gallons per acre: 20 to 40 gallons per acre of spray are required for adequate coverage of corn. Addition of a suitable adjuvant is essential for effective suspension, distribution and retention of the fungicide.
2. Pump pressure: a minimum pressure of 40 pounds psi is required.
3. Nozzle arrangement: one nozzle should be placed directly over the row with 2 side nozzles on drops on each side of the plant that can be lengthened as plant height increases.
4. Speed of travel: a maximum speed of travel of 5 mph is suggested for maximum efficiency of ground equipment.
5. Nozzle sizes: spray nozzles equipped with disc type cone tips with 25 to 50 mesh strainers are recommended for ground application equipment. Two types of such nozzles are generally available -- viz:

Spraying Systems Tee Jet

<table>
<thead>
<tr>
<th>Disc type cone spray nozzles</th>
<th>Disc and core No.</th>
<th>3 nozzles per row 40-inch spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pressure (pounds psi)</td>
<td>3 mph</td>
</tr>
<tr>
<td>D3-23</td>
<td>40</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>21.0</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>24.0</td>
</tr>
<tr>
<td>D3-25</td>
<td>40</td>
<td>24.0</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>29.0</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>33.0</td>
</tr>
<tr>
<td>D4-25</td>
<td>40</td>
<td>43.0</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>52.0</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>60.0</td>
</tr>
</tbody>
</table>

Disc Cone Tip

<table>
<thead>
<tr>
<th>Disc Cone Tip</th>
<th>Disc and core No.</th>
<th>3 nozzles per row 40-inch spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pressure (pounds psi)</td>
<td>3 mph</td>
</tr>
<tr>
<td>DC3-25</td>
<td>40</td>
<td>28.5</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>34.5</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>39.0</td>
</tr>
<tr>
<td>DC3-13</td>
<td>40</td>
<td>43.5</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>52.5</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>60.0</td>
</tr>
</tbody>
</table>

To calculate gpa capacities for other row spacings multiply above gallons per acre by factors given here:
Calibration of Ground Applicators

1. Before starting to calibrate the equipment check all nozzles by placing a container under each nozzle and measure the discharge for one minute. All of the nozzles should discharge a volume within a range of 10 per cent of the average discharge of all nozzles. Replace or clean any nozzle not meeting this standard. Clean nozzles with an air hose or old toothbrush. Never clean nozzles with a wire brush or metal object.

2. Fill the sprayer tank with a known volume of water. Check pressure gauge for correct operation.

3. Operate sprayer for 40 rods (660 feet or 1/8 mile) at the rate of speed selected for field operation. Operate in a plowed or cultivated field. Never operate a sprayer on a paved or hard surface when calibrating.

4. Measure the volume of water it takes to refill the sprayer tank after spraying 40 rods.

5. Calculate the volume of water applied per acre by the following equation:

\[
\text{gallons of water used} \times \frac{66}{\text{boom width in feet}} = \text{gallons per acre}
\]

6. To calculate amount of chemical to put in the tank, divide tank capacity by gallons applied per acre to determine acres one tank will spray. Multiply this figure by desired dosage of chemical required per acre.

7. When adding wettable powder chemicals to sprayer tank follow the procedure below:
   A. Fill tank 1/2 full with water.
   B. Make a slurry with chemical in suitable container.
   C. Start tank agitator or run pump to agitate water in tank.
   D. Add chemical slurry. Fill tank with water while pump and agitator are running.
   E. Add adjuvant after tank is filled.
   F. Run sprayer for 30 seconds while equipment is stationary and check nozzles for uniform discharge before starting the spraying operation.

Recheck calibration of equipment after 5 days operation to adjust for nozzle wear and pump fluctuation.

Calibration and Operation of Aerial Application Equipment

Type of aircraft

Any of the commonly used makes and models of fixed wing or rotary agricultural aircraft will effectively apply fungicides to corn if they are equipped with an efficient spray distributive system and are operated within their airmoving capacity as determined by wingspan, weight and airspeed.
The following types of aircraft were used for spraying corn in Indiana in 1971: Stearman fixed wing, Pawnee, Cessna Ag Wagon, Gruman Ag Cat, Bell G-2 helicopter, and Bell Tomcat helicopter.

**Spray Distribution Systems for Aircraft**

For aerial application equipment hollow cone nozzles properly clustered on booms or micronair rotary atomizer sprayers are most satisfactory for fungicide applications. Venturi spreader-seeders or gravity flow liquid fertilizer applicators are not satisfactory for fungicides.

Mini-Spin (ultra-low volume) equipment is not suitable for application of wettable powder formulations of fungicides.

**Gallonage**

The recommended total gallonage of spray per acre is 3 to 5 gallons depending upon aircraft equipment and the height and density of plants.

**Droplet Size**

Fungicides should be applied by aircraft with a medium fine droplet of 200 microns to provide good coverage and distribution and to avoid excessive drift and loss from evaporation. Coarser droplet size will result in uneven distribution and lack of lateral movement to provide necessary overlap. Very fine droplets while they give excellent coverage under ideal conditions also result in excessive drift and evaporation.

Usually droplet size may be adjusted to compensate for atmospheric and operating conditions. Early in the day when air is calm and temperatures are cool smaller droplet size may be used. Droplet size should be increased as wind velocity and temperatures increase and humidity decreases.

When temperatures exceed 90°F and/or relative humidity drops below 40 to 50 per cent, conditions such as this interfere with normal settling and deposit of fungicides. Aerial sprays should not be applied when winds exceed 10 mph because of excessive drift and evaporation. Crosswinds of 2 to 6 mph are ideal since this aids in spray distribution within and between spray swaths. Fixed wing aircraft should be flown at an altitude of 4 to 8 feet above the top of the plants while helicopters usually operate at an altitude of 3 to 6 feet.

**Nozzle Type and Arrangement**

Hollow cone nozzles are suggested for aircraft. Spraying Systems Diaphragm Tee Jet No. 4664 with whirlplate and orifice disk is preferred over whirljet or flat fan nozzles. Combinations of orifice disks from D-5 to D-12 with No. 45 or No. 46 cones will deliver 3 to 5 gallons per acre. The choice and combination of cone and orifice disks is influenced by airspeed, number of nozzles, pump pressure and nozzle location. On most aircraft 32 to 46 nozzles are used. For helicopters one nozzle is suggested for every 10 to 12 inches of boom.
Nozzles for aircraft booms should never be located symmetrically but should be grouped in clusters and kept away from wing tips to compensate for distortion of spray pattern by the propeller slipstream and secondary eddies from the undercarriage.

Efficient nozzling of aerial application equipment is a precise and difficult procedure.

Field Trials with Foliar Fungicides

Large scale, on-the-farm field demonstrations of foliar fungicides for SCLB control were established in Indiana in 1971. These were located as follows:

Northern Indiana - Gehring Farms
Rensselaer, Indiana

Williamson Farm, Custom Farm Services
Bourbon, Indiana

Central Indiana - Hamilton County Co-op
Noblesville, Indiana

Harger Farm
Rulon Farm

Coverdale Farms
Underwood Farms

South Central Indiana - Enos Ellerman, Niagara Chemical Co.
Vincennes, Indiana

Marlin Dreiman Farm
Frank Meyer Farm

Southern Indiana - Lewis Cooper, area crops agent
Tell City, Indiana

Schnur Farms, Stevenson Station
Evansville, Indiana

At these locations a total of 500 acres of corn was involved. Corn fields were made available by individual farmers who planted and maintained the areas throughout the growing season. Fungicide applications were made by aerial applicators and ground application equipment donated by professional pesticide applicators and at the expense of the farmers concerned. Harvesting of these plots was accomplished with mechanical harvesters and labor donated by the farmers concerned. The results obtained are summarized here:
Gehring Farms, Medaryville, Indiana

The Gehring Farm organization is a large agricultural enterprise devoted to the commercial production of spearmint, potatoes, onions and corn. The entire acreage is under overhead irrigation and chemical pesticides are regularly applied to the various crops by helicopter.

T-cytoplasm plot

A 45-acre planting of T-cytoplasm corn was provided for fungicide evaluation in 1971. This area was used to determine the relative effectiveness of 3 gallons per acre vs 4 gallons per acre and to evaluate the value of additional sprays applied late in the season. Dithane M-45 was applied by helicopter on a precise 7-day schedule to replicated plots 3200 feet long by 20 rows. Two replicates of each treatment were used involving 4.25 acres per plot. The results obtained are summarized in Table 6.

Although SCLB development in this area was relatively light, detailed observations on disease severity were recorded on August 16, 1971 in the early dent stage.

The standard method of recording severity of foliage infections with SCLB was used. The Ullstrup Disease Severity Index method is illustrated in Figure 2. Within each plot 50 plant samples were rated for SCLB infection severity. Three such samples were used in each replicate. The data in Table 6 on SCLB severity therefore represent observation of 300 plants for each treatment. The Disease Severity Index was converted to "Percentage of total leaf area infected with SCLB" to permit statistical analysis of the data. The data in all categories were obtained from the 8 center rows of the 20 rows involved in each plot. Data on

Table 6. Gehring Farms, Medaryville, Indiana; Corn Spray Demonstration
Hybrid: TMS PX 50 A
Aerial Application Bell G 2 Helicopter
Fungicide: Dithane M-45, 1-1/2 pounds per acre + Triton CS 7

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Av. % leaf area infected 1/</th>
<th>Av. % ear husks infected 1/</th>
<th>% stalks infected 1/</th>
<th>Yield bu/acre No. 2 corn 2/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsprayed</td>
<td>35.0 b*</td>
<td>47.0</td>
<td>74.3</td>
<td>145.3 c* b**</td>
</tr>
<tr>
<td>3 gals/acre, 4 sprays</td>
<td>6.4 a*</td>
<td>10.7</td>
<td>8.3</td>
<td>151.7 b* ab**</td>
</tr>
<tr>
<td>4 gals/acre, 4 sprays</td>
<td>7.8 a*</td>
<td>17.3</td>
<td>13.6</td>
<td>156.3 a* a**</td>
</tr>
<tr>
<td>4 gals/acre, 6 sprays</td>
<td>6.0 a*</td>
<td>12.3</td>
<td>14.0</td>
<td>158.8 a* a**</td>
</tr>
</tbody>
</table>

1/ Average of 6 observations of 50 plants in 2 replicates. Plot size = 4.25 acres.
2/ Average of 2 replicates - 8 rows - 3200 feet long.
Infection Data: Recorded August 16, 1971
Harvest date: October 21, 1971
Spray dates: 6/30/71, 7/7/71, 7/14/71, 7/21/71, 7/28/71, 8/4/71
Yields and % leaf area infected in a column followed by same letter are not significantly different at the 5%* and 1%** level according to Duncan’s Multiple Range Test.
ear husks infected and stalk infections were obtained in a similar manner by observation of 150 plants in three 50-plant samples in each replicate (total of 300 observations).

From the data presented in Table 6 all of the spray treatments reduced the severity of foliar infections. No significant differences were apparent between 3 gallons per acre and 4 gallons per acre or between 4 sprays and 6 sprays.

Although ear husk and stalk infections by SCLB did not develop to significant degree at harvest time the spray treatments greatly reduced ear and stalk symptoms of SCLB.

Yield data obtained by harvesting the 8 center rows in each 20-row plot in 2 replicates were statistically significant.

It was concluded from this plot that a gallonage of 3 gallons per acre applied by air was as effective as 4 gallons per acre and that additional sprays applied in early dent stage did not enhance disease control.

Blend Plot

A 45-acre field of blend corn (50-50) was devoted to an attempt to demonstrate the value of adjuvants for SCLB control. The results of this demonstration are summarized in Table 7. Despite the low level of disease development a statistically significant improvement in the prevention of foliage infection was obtained when adjuvants were added. No significant yield differences were obtained.

Figure 2. Scale for estimating Southern Corn Leaf Blight severity.
Table 7. Gehring Farms, Medaryville, Indiana; Corn Spray Demonstration
Hybrid: Blend Pioneer 3518
Aerial Application Bell G 2 Helicopter
Fungicide: Dithane M-45 + 1/2 lbs/acre - 4 applications

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Av. % leaf area infected</th>
<th>Av. yield/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsprayed</td>
<td>7.70 b**</td>
<td>162.20*</td>
</tr>
<tr>
<td>Dithane M-45 alone</td>
<td>4.65 b**</td>
<td>162.40*</td>
</tr>
<tr>
<td>Dithane M-45 + Triton CS 7</td>
<td>3.50 a**</td>
<td>164.70*</td>
</tr>
<tr>
<td>Dithane M-45 + Biofilm</td>
<td>2.13 a**</td>
<td>167.24*</td>
</tr>
<tr>
<td>Dithane M-45 + Miller Pinolene</td>
<td>2.40 a**</td>
<td>171.32*</td>
</tr>
</tbody>
</table>

1/ Average of 6 observations of 50 plants in 2 replicates. Plot size 4.25 acres.
2/ Average rows. 8 rows - 3200 feet long.
Infection data recorded August 16, 1971
Harvest date: October 21, 1971
Spray dates: 6/30/71, 7/7/71, 7/14/71, 7/21/71
*Yields do not differ significantly at the 5% level.
**% leaf area infected followed by the same letter are not significantly different at the 5% level according to Duncan’s Multiple Test.

Examination of spray deposit residues immediately after application clearly indicated superior distribution with Dithane M-45 when adjuvants were included. The fungicide alone gave "spotty coverage" and inferior penetration. Some difficulty was experienced with Triton CS-7 causing foaming in the helicopter spray tank.

When Biofilm or Pinolene were included residual deposition was obtained as low as two leaves from the base of the plant. Spray residues were still observable 8 weeks after the last spray application in the combinations containing Biofilm or Pinolene. No residue at this time was observable on plots receiving Dithane M-45 alone.

The data in Table 7 substantiate the recommendation for inclusion of adjuvants with fungicides for corn leaf blight prevention.

Normal-cytoplasm plot

Applications of Dithane M-45 were made to a 20-acre planting of N-cytoplasm corn at the suggestion of Gehring Farms. Although SCLB did not develop in this planting, some Northern Leaf Blight (H. turricicum) did appear at the end of the season. Throughout the growing season, normal corn receiving Dithane M-45 appeared to have a deeper green color. Spectrographic tissue analyses in the roasting ear stage made by Eldon Hood of the Purdue Soils laboratory yielded the data summarized in Tables 8 and 9.

From these data the only element significantly influenced by spray applications of Dithane M-45 was manganese. If this tissue content increase of Mn was attributable to surface residue, Zn should also have been influenced. The statistically significant yield increase (Table 8) is of interest and will be followed up in 1972 to evaluate the influence of
Table 8. Gehring Farms, Medaryville, Indiana; Corn Spray Demonstration Normal Corn Pioneer 3516
Aerial Application Bell G 2 Helicopter, 4 gal/ave.
Dithane M-45 + Biofilm - 1-1/2 lbs/acre, 4 applications

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. 2 corn 1/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsprayed</td>
<td>168.04 b *</td>
</tr>
<tr>
<td>Dithane M-45 + Biofilm</td>
<td>172.00 a *</td>
</tr>
</tbody>
</table>

1/ Average of 3 replicates. 8 rows - 3200 feet long.
Spray dates: 6/30/71, 7/7/71, 7/14/71, 7/21/71
Plot size 4.25 acres
*Yields differ significantly at the 5% level.

Table 9. Gehring Farms, Medaryville, Indiana; Corn Spray Demonstration — Tissue Analysis Test*

<table>
<thead>
<tr>
<th>Element</th>
<th>Unsprayed</th>
<th>Sprayed</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>3.4</td>
<td>3.05</td>
</tr>
<tr>
<td>p (%)</td>
<td>0.63</td>
<td>0.58</td>
</tr>
<tr>
<td>k (%)</td>
<td>1.68</td>
<td>1.85</td>
</tr>
<tr>
<td>Ca (%)</td>
<td>0.66</td>
<td>0.59</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>0.28</td>
<td>0.23</td>
</tr>
<tr>
<td>Mn (ppm)</td>
<td>63</td>
<td>178</td>
</tr>
<tr>
<td>Fe (ppm)</td>
<td>244</td>
<td>201</td>
</tr>
<tr>
<td>B (ppm)</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Cu (ppm)</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Zn (ppm)</td>
<td>38</td>
<td>37</td>
</tr>
<tr>
<td>Al (ppm)</td>
<td>94</td>
<td>83</td>
</tr>
<tr>
<td>M (ppm)</td>
<td>1.34</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Analysis made by Purdue Plant and Soils Laboratory.
*Analysis made on normal corn Pioneer 3516

Aerial applications of foliar applications of manganese, zinc and other micro elements on the development of corn in deficient soils.

Chauncey Blaydes Farm

In 1971 several SCLB "hot spots" developed in Indiana in T-cytoplasm corn. One such location was the Chauncey Blaydes Farm at Crawfordsville (Montgomery County) Indiana.

At this location SCLB leaf infections appeared in a 20-acre field of T-cytoplasm corn in early July. Leaf infections were showing on all leaves at this time and prospects for significant damage were imminent. The decision was made to apply Dithane M-45 plus Biofilm to half of the acreage and to leave the rest of the field unprotected. The results obtained are presented in Table 10 and 11. Three applications of fungicide were applied with a Pawnee aircraft at a volume of 5 gallons per acre on a 7-day schedule. At the time of the first spray application about 20 SCLB lesions per leaf were present on the third leaf from the top. The data in Table 11 shows no significant advance of SCLB during the period July 15-28 in the sprayed area whereas leaf blight infections increased six-fold during the same period in the unsprayed area. A 33% yield increase or 29 bushels per acre was a significant return for the $12 investment for fungicidal protection.

Similar results were obtained in other SCLB "hot spots" on TMS corn in other regions of the state.
Table 10. Chauncey Blaydes Farm, Crawfordsville, Indiana; Corn Spray Demonstration
(Courtesy County Agent J. A. Carroll)
Hybrid: TMS Migro 540
Aerial application Fixed Wing (Pawnee)
Fungicide: Dithane M-45 - 1-1/2 lbs/acre - 5 gals/acre - 3 applications

<table>
<thead>
<tr>
<th></th>
<th>Av. no. stalks 1/</th>
<th>Av. no. ears 1/</th>
<th>Wt. ears pounds 2/</th>
<th>% moisture 2/</th>
<th>Yield bu/acre 3/</th>
<th>Yield increase bushels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unsprayed (10 Acres)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand harvested</td>
<td>88.3</td>
<td>77.3</td>
<td>26.5</td>
<td>21.8</td>
<td>86.9</td>
<td></td>
</tr>
<tr>
<td>Machine harvested</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>87.1</td>
<td></td>
</tr>
<tr>
<td><strong>Sprayed (10 Acres)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand harvested</td>
<td>90.8</td>
<td>79.4</td>
<td>39.6</td>
<td>24.3</td>
<td>124.9</td>
<td>38</td>
</tr>
<tr>
<td>Machine harvested</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>115.5</td>
<td>29</td>
</tr>
</tbody>
</table>

1/ 2 rows 27.5 feet - 0.004 acres - 5 replicates.
2/ 3/ Average of 2 replicates - 4 rows - 890 feet - 38 inches - 0.2586 acres

Table 11. Chauncey Blaydes Farm, Crawfordsville, Indiana; Corn Spray Demonstration
(Courtesy County Agent J. A. Carroll)
Disease Severity (H. maydis)

<table>
<thead>
<tr>
<th>Date</th>
<th>Lesions per leaf 1/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sprayed</td>
</tr>
<tr>
<td>July 15, 1971 - Lesions present on all leaves</td>
<td></td>
</tr>
<tr>
<td>July 21, 1971</td>
<td>30</td>
</tr>
<tr>
<td>July 28, 1971</td>
<td>30</td>
</tr>
</tbody>
</table>

1/ Average of 10 leaves. 3rd leaf from top.

Custom Farm Services Plot

A 48-acre field of T-cytoplasm corn on the Williamson Farm, Bourbon, Indiana was planted to determine the value of ground applications of manzate vs Citcop vs manzate + Citcop for SCLB control. The results are summarized in Tables 12 and 13.
Table 12. Custom Farm Services, Bourbon, Indiana; Paul Knoop -- (Ground Application)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Av. % moisture</th>
<th>Av. test weight</th>
<th>Av. wt. per plot</th>
<th>Yield bu/acre No. 2 corn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsprayed</td>
<td>18.1</td>
<td>55.6</td>
<td>6840</td>
<td>139.1 b*</td>
</tr>
<tr>
<td>Citcorp 2 qts/acre</td>
<td>18.1</td>
<td>55.6</td>
<td>6403</td>
<td>130.6 c*</td>
</tr>
<tr>
<td>Manzate 200</td>
<td>18.3</td>
<td>55.3</td>
<td>7203</td>
<td>146.0 a*</td>
</tr>
<tr>
<td>1-1/2 lbs/acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manzate 200-3/4 lb + Citcorp 1 qt/acre</td>
<td>18.2</td>
<td>55.8</td>
<td>6970</td>
<td>142.1 ab*</td>
</tr>
</tbody>
</table>

Spray dates: 7/2/71, 7/20/71, 8/9/71
Size of plots - 4.0 acres - 3 replicates
Size of harvest plots - 85/100 acres

*Yields in a column followed by same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table 13. Custom Farm Services, Bourbon, Indiana; Paul Knoop -- (T-cytoplasm Hybrid - High Clearance Ground Applicator - 20 Gallons per Acre)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Av. % total leaf area infected *</th>
<th>Av. % ear husks infected</th>
<th>Av. % stalks infected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsprayed</td>
<td>28.1 c</td>
<td>28.0</td>
<td>46.7</td>
</tr>
<tr>
<td>Citcorp</td>
<td>9.25 b</td>
<td>10.7</td>
<td>14.0</td>
</tr>
<tr>
<td>2 quarts per acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manzate 200</td>
<td>5.5 ab</td>
<td>13.3</td>
<td>11.6</td>
</tr>
<tr>
<td>1-1/2 pounds per acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manzate</td>
<td>5.0 a</td>
<td>14.0</td>
<td>9.3</td>
</tr>
<tr>
<td>3/4 pound + Citcorp - 1 quart</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data average of 150 readings in 3 replicates
Data recorded August 12, 1971
Spray dates: 7/2/71, 7/20/71, 8/9/71
Triton B 1956 used in all sprays

*Data in this column followed by the same letter are not significantly different at the 5% level according to the Duncan Multiple Range Test.
This field had been planted to T-cytoplasm corn in 1970 and was seriously damaged by Southern Corn Leaf Blight. In 1971 sprays were applied with a high clearance ground applicator. From the data in Table 13 all treatments significantly reduced the severity of leaf blight and stalk and ear sheath infections.

Injury from Citcopol was serious especially in early growth stages. Slight injury was also noticeable in the manzate + Citcopol combinations.

It is believed better disease control and greater yield increases would have resulted if the spray intervals had been closer. 18 to 20 days between sprays is too long an interval for carbamate fungicides.

Schnur Farm, Evansville, Indiana

The Schnur farm demonstration located on the Ohio River in southern Indiana was originally designed to compare ground vs aerial equipment for application of fungicides for leaf blight control. The results obtained and presented in Table 14 were unsatisfactory for several reasons. It was not disclosed to the investigators until August 10, 1971 that a white

Table 14. Schnur Farms, Evansville, Indiana; Corn Spray Demonstration
Hybrid Blend 913 BRK and Kentucky 5921 (White Corn)
Plot size = 4-1/2 acres

<table>
<thead>
<tr>
<th>Spray program</th>
<th>Yield bu/acre</th>
<th>No. 2 corn machine harvested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsprayed</td>
<td>102.9</td>
<td></td>
</tr>
<tr>
<td>2 aerial applications</td>
<td>102.2</td>
<td></td>
</tr>
<tr>
<td>(tassel and 2 weeks later)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 aerial applications Bivert</td>
<td>101.4</td>
<td></td>
</tr>
<tr>
<td>(tassel and 2 weeks later)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 aerial applications (roasting ear and 2 weeks later)</td>
<td>102.6</td>
<td></td>
</tr>
<tr>
<td>4 applications (2 ground and 2 aerial)</td>
<td>113.7</td>
<td></td>
</tr>
<tr>
<td>5 applications insecticide in first application</td>
<td>108.9</td>
<td></td>
</tr>
<tr>
<td>(1, 2, 3 spray ground)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4 and 5 aerial)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 applications no insecticide</td>
<td>108.9</td>
<td></td>
</tr>
<tr>
<td>Fungicide Manzate 200 -- 1-1/2 pounds per acre</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
corn hybrid was included in the blend used for planting. White corn hybrid Ky 5921 is a long season hybrid and is especially susceptible to H. maydis. Aerial applications applied in tassel stage and 2 weeks later offered no protection during 2 weeks of smog and heavy dews in late July and early August. Early applications of fungicide were applied with herbicide-cultivator spray applicators that gave unsatisfactory chemical distribution. Finally, because of nonavailability of aircraft, the timing of aerial sprays was irregular and unsatisfactory and should have been continued during the high humidity period during August.

The Schmurr farm demonstration was a classical example of remote operation without adequate observation and supervision by the investigators.

Miscellaneous "on-the-farm" Demonstrations

A number of farmer demonstrations were established in central and southern Indiana. In central Indiana severe drought in late July and August prevented development of SCLB in sufficient degree to evaluate the effect of sprays for its control.

Other farmer demonstrations could not be accurately evaluated because of insufficient unsprayed swaths. Unsprayed swaths of 50 feet are inadequate for aerial applications due to drift from adjacent sprayed areas and the suppression of inoculum in the large sprayed area of the field. Unsprayed swaths of 100 to 150 feet in three areas of the field should have been established.

However, yield increases of 15 to 19 bushels per acre were obtained in farm demonstrations in fields of blends in Knox County and in the Evansville area, using three aerial applications of zinc-ion maneb plus Biofilm at 7 to 10-day intervals during the period of early silk stage to early denting.

A survey of 15 commercial applicators reported farmer satisfaction with expenditure for fungicide sprays with no complaints.

The Need for Research on Protective Chemicals for Corn Disease Control

In spite of predictions of a bumper corn crop in 1971 of 5,300,000 bushels, diseases in the corn fields of the north central states continued to cause concern among professional corn producers.

While N-cytoplasm corn in 1971 suffered minor injury from Southern Corn Leaf Blight, there were fields showing a noticeable incidence of H. maydis on T-cytoplasm foliage infections. Reports from the southern states suggest that Race 'O' of H. maydis may be increasing in prevalence on normal corn. Such reports have not been confirmed by positive race identification. In some fields in Indiana N-cytoplasm corn showed stalk and ear rot infections in the absence of foliage symptoms.

There is no positive proof that further variability in pathogenicity of H. maydis cannot recur. Should this happen a national homogeneous corn crop of N-cytoplasm corn might again be victimized by races of H. maydis or some other virulent corn phytopathogen.
Northern Corn Leaf Blight caused by *H. turcicum* was noted on N-cytoplasm corn as well as Texas Male Sterile cytoplasm corn throughout Indiana. The severity of leaf infection caused by this disease was extensive on certain varieties of N-cytoplasm corn. Yield reduction was seemingly masked by the early maturity as a result of early planting in 1971. Reduction of yield caused by *H. turcicum* could be significant in those years when early planting is not possible.

Secondary stalk rot infections, as a result of leaf infection from Southern Corn Leaf Blight and other leaf diseases were prevalent last fall. Reduction in yields from Dipolodia, Gibberella, Pythium, and Fusarium stalk rots will result from lodging and fallen corn stalks. In fields treated with fungicides primary stalk rot infections caused by Southern Corn Leaf Blight and secondary infections from stalk rotting diseases appear to be greatly reduced over non-treated fields.

In 1971 Corn Smut (*Ustilago zaeae*) was unusually prevalent and appeared to be associated with herbicide injury.

In southern Indiana counties Brown Leaf Spot (*Physoderma zaeae* maydis) occurred in noticeable degree in some fields of N-cytoplasm corn. The economic significance of this pathogen and control measures are unknown.

*Puccinia sorghi* (common rust) was also unusually prevalent in Indiana in 1971.

Other diseases that were observed in 1971 were Holcus Spot (*Pseudomonas syringae*), Yellow Leaf Blight (*Phyllosticta*) and Eyespot (*Kabatella zaeae*).

The destructive effects of *H. maydis* stalk and ear rot infections are factors for major concern.

Large scale farm demonstrations of fungicide applications for *H. maydis* control in Indiana in 1971 have been successful.

The above comments would seemingly merit an obligation to pursue a limited research program on protective fungicides for corn disease control to serve as a basis for practical applications should the need arise in the future.

**Proposed Research Program on Protective Fungicides for Corn Disease Control**

1. Fungitoxicities of organic compounds and mixtures of compounds to specific corn phytopathogens.

   A. Relative toxicity of selected carbamates, mixtures of carbamates and copper-carbamate mixtures to:
      a) *H. maydis* Race T
      b) *H. maydis* Race O
      c) *H. turcicum*
      d) *Physoderma maydis*
e) Phyllosticta sp.
f) Diplodia maydis
g) Gibberella zeae
h) Pythium aphanidermatum
i) Fusarium monilgorme
j) Ustilago maydis

B. Influence of petroleum distillates on the eradicant action of carbamate fungicides for H. maydis stalk and ear rot infections.

C. Influence of adjuvants on the fungitoxic of carbamate fungicides.

2. Systemic action of Furadan (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methyl carbamate) and other systemic fungicides in inhibition of seedling blights of corn, corn smut and Helminthosporium infections.

3. Relationship between climatology and computerized corn blight simulation and timing of protective sprays for corn blight control.

4. Potential for fungicidal chemicals for inhibition of molds of stored corn.

5. Influence of methods of application on the degree of control of leaf, stalk and ear infections.

Discussion

The potential value of fungicides for corn blight control has been a subject for disagreement throughout the corn blight debate of 1970-71. Those who have contended that fungicides are impractical and uneconomical for corn blight control had no data to support the argument and for the most part were inexperienced in the practical application of fungicides. Those who supported fungicides for corn blight control similarly had little data to support their views and were doubtless prejudiced by previous field experience with fungicides at the applied level.

Past experiences in American agriculture have demonstrated the folly of dependence upon one approach to the problem of preventing economic losses to major agricultural crops caused by plant diseases. While the genetic approach to the prevention of destructive plant diseases such as Southern Corn Leaf Blight is the major offensive weapon of control the experience of 1970 loudly proclaimed the urgency for emergency measures when genetic barriers are hurdled by phytopathogens.

Even though 1972 predictions by some scientists have been made that Southern Corn Leaf Blight is now past history and will never again cast a shadow over the fields of the central corn belt there is no factual basis for predicting whether plant diseases will again be a problem, nor is there any basis for forecasting what these diseases might be.

By these tokens, protective chemicals justified practical evaluation in 1971 and are deserving of more careful investigation in view of the favorable results obtained in 1971.
The Indiana program of fungicide evaluation for corn leaf blight control was not designed as a model of technical excellence in the realm of fundamental research. It was designed as a service to the farmers of the state to offer guidelines for fungicidal usage where no alternative was available. The reaction of Indiana farmers to the suggested use of fungicides for leaf blight control was universally favorable, and no complaints have been received that the suggestion was unjustified and impractical. Indiana farmers who used protective foliar fungicides on corn in 1971 will testify it was good insurance and in several cases prevented serious yield reduction from leaf blight.

The data presented should be acceptable as reliable evidence that foliar fungicides will prevent blight epidemics when properly used and correctly applied. Reduction of incipient ear rot and stalk rot infestations should justify further investigation of chemical controls for stalk rot, ear rot and post harvest mold prevention.

A broad national program dedicated to a long range effort to prevent disease losses to the national corn crop should include a program of basic research on fungicides for restriction of corn phytopathogens -- if the program is genuinely concerned with corn production and the farmers who dedicate their land, capital and efforts to the production of this essential commodity -- CORN.

Acknowledgments

The work summarized in this report would not have been possible without the generous cooperation and support from many individuals and organizations. No special funds were available for the support of this program, and no grants were provided by the agricultural chemical corporations. Many farmers provided land, planted the corn and provided labor for maintenance of the plots and for the harvesting operations. Several agribusiness interests supported and encouraged the program and sponsored summer field meetings in the plots. Several aerial applicators donated time, equipment and services for the demonstration programs.

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