Foliar Fungicide Effects on Corn Yield
by Mark Jeschke, Sr. Research Associate

Summary

• To improve understanding of the value of foliar fungicide use in corn, a survey was conducted of fungicide efficacy data from recent Pioneer side-by-side field trials and 10 years of university research trials.
• Corn yield increased an average of 7.4 bu/acre across 430 trials in response to a foliar fungicide application.
• The average yield benefit of foliar fungicide application was greatest in the southeastern states.
• The yield advantage with a foliar fungicide application was greater for hybrids less resistant to gray leaf spot and at sites with significant disease pressure.
• The average yield response to foliar fungicide application was greater with practices that favor high levels of residue such as corn-following-corn, and no-till or strip-till.
• Rare cases of crop injury associated with fungicides are likely due to treatment prior to tasseling and use of non-ionic surfactants.

Introduction

Generally positive yield responses have driven increased use of foliar fungicides by corn growers. Though Pioneer research has most often confirmed the value of fungicide application, it has also revealed instances in which the fungicide was not profitable. In general, disease resistant hybrids, or those grown in rotation or cropping systems that effectively reduce corn residue on the soil surface have been less responsive to fungicide application in Pioneer studies.

To further determine what factors most influence the response of hybrids to foliar fungicide application, Pioneer continued its studies in 2008. In addition to fungicide efficacy data from Pioneer side-by-side field trials, this summary includes 3rd-party efficacy trials conducted by university researchers. The results are reported below.

Objectives

The primary objective of this survey study was to determine the value of foliar fungicide use in corn by:

1) Evaluating corn yield response and economic benefit associated with foliar fungicide use at a large number of sites under a wide range of growing conditions.
2) Identifying agronomic factors likely to influence the probability of a positive economic response from fungicide application.

Methods

The key information collected in the study was the grain yield response of corn to the application(s) of any foliar fungicide. Several university trials conducted from 1999 to 2006 were included in a combined analysis with Pioneer on-farm trials. University studies conducted in 2007 are reported separately. Only treatments where fungicide was applied between tasseling and brown silk were included. Very few sites included comparisons among multiple fungicides; therefore it was not possible to effectively rank the efficacy of commonly used fungicides. Fungicide trials conducted from 1999 to 2008 were included, however the majority of data collected was from 2006 to 2008. Fungicides included in the trials were Headline® (292 trials), Stratego® (37 trials), Quilt® (33 trials), and Quadris® (7 trials). Multiple fungicides were used in 48 trials.
Figure 1. Corn yield response to foliar fungicide application in 74 university and 356 on-farm trials.

Results

The average yield response across 74 university trials and 356 on-farm trials to the application of a fungicide spray was an increase of 7.4 bu/acre (Figure 1). A positive yield response to fungicide application occurred in 80% of the trials. The economic viability of a fungicide application varies greatly according to the price of corn. Assuming a break-even yield response of 5.5 bu/acre (corn price = $4.00/bu, fungicide + application cost = $22/A), fungicide application was economically beneficial in 56% of the trials, with an average net return of $7.60/acre.

Table 1. Summary of foliar fungicide survey results from trials conducted in 2006 and 2007.

<table>
<thead>
<tr>
<th>Summary Data</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trials</td>
<td>85</td>
<td>224</td>
</tr>
<tr>
<td>Overall yield advantage</td>
<td>8.1 bu/acre</td>
<td>6.9 bu/acre</td>
</tr>
<tr>
<td>Positive yield response</td>
<td>82%</td>
<td>79%</td>
</tr>
<tr>
<td>Economically beneficial</td>
<td>65%</td>
<td>54%</td>
</tr>
<tr>
<td>Average net return</td>
<td>$10.40</td>
<td>$5.60</td>
</tr>
</tbody>
</table>

The data showed similar results between 2006 and 2007 (Table 1). The average yield response across 85 trials in 2006 was an increase of 8.1 bu/acre, with a positive yield response in 82% of the trials. In 2007, the average yield response across 224 trials was an increase of 6.9 bu/acre, with a positive yield response in 79% of the trials. Fungicide application was economically beneficial in 56% of the trials in 2006 and 54% of the trials in 2007 with average net returns of $10.40/A and $5.60/A, respectively.

Table 2. Summary of foliar fungicide survey results from trials conducted in the U.S. and Canada in 2008.

<table>
<thead>
<tr>
<th>Summary Data</th>
<th>U.S.</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trials</td>
<td>46</td>
<td>39</td>
</tr>
<tr>
<td>Overall yield advantage</td>
<td>6.6 bu/acre</td>
<td>4.3 bu/acre</td>
</tr>
<tr>
<td>Positive yield response</td>
<td>78%</td>
<td>77%</td>
</tr>
<tr>
<td>Economically beneficial</td>
<td>52%</td>
<td>41%</td>
</tr>
<tr>
<td>Average net return</td>
<td>$4.40</td>
<td>-$4.80</td>
</tr>
</tbody>
</table>

Out of 85 trials conducted in 2008; roughly half were in the U.S. and half in Canada. The average yield response across 46 trials in the U.S. was 6.6 bu/acre, with a positive yield response in 78% of the trials (Table 2). Fungicide application was economically beneficial in 52% of the trials with an average net return of $4.40/acre. Results were less favorable in Canada. The average yield response in 39 trials was 4.3 bu/acre, with a positive yield response in 77% of the trials. However, fungicide application was economically beneficial in only 41% of the trials resulting in an average net loss of $4.80/acre.

Factors Influencing Yield Response

Location. Foliar diseases can occur anywhere corn is grown in North America, but are more common in the warmer, more humid growing areas of the South and East. The more consistently favorable conditions for disease development in
these regions increase the likelihood that a fungicide application will be profitable.

The survey results showed that, in general, the yield benefits of foliar fungicide sprays were greater in southern regions, although yield responses at individual sites varied widely within all regions (Figure 3).

**Figure 3.** Average corn yield response to foliar fungicides by region (1999-2008).

Number of trials: NW=152, NE=116, SW=43, SE=33, Canada=39.

The average yield advantage with fungicides was 8.6 bu/acre for southern locations west of the Mississippi River, and 12.3 bu/acre for southeastern trials. In the northeastern and northwestern sections of the Corn Belt, yield response was 7.7 bu/A and 6.8 bu/A, respectively. The lowest average yield response was 4.3 bu/acre in Canada, with trials located primarily in southern Ontario and Quebec.

**Hybrid Disease Susceptibility.** The probability of using a fungicide profitably is directly related to the susceptibility of a hybrid to the predominant leaf diseases. Pioneer has typically not recommended fungicide use on hybrids rating 6 or higher (on the Pioneer 1 to 9 rating system) for the disease in question (Munkvold, 2006). Most current Pioneer hybrids have at least moderate resistance (rating of 4 or 5) to gray leaf spot, the principle foliar disease in the study area. As expected, the yield response to the application of a foliar fungicide was the lowest for the more resistant hybrids (Figure 4). For moderately resistant hybrids, the average yield increase exceeded the break-even response in corn following corn and corn following soybean. The average yield response for resistant hybrids however, was less than the break-even response.

**Figure 4.** Average yield response of Pioneer® brand hybrids to foliar fungicide application according to gray leaf spot disease rating (206 trials, 1999-2008). Break-even yield response = 5.5 bu/acre.

**Previous Crop and Tillage.** Corn-following-corn fields are at a higher risk and more likely to benefit from a fungicide application than corn-following-soybean fields. Survival of diseases in corn residue leads to earlier and more extensive disease infection and higher disease incidence in this production system. Many common diseases including gray leaf spot, northern leaf blight, southern leaf blight, eyespot and northern leaf spot overwinter in corn residue, providing a source of inoculum to infect corn planted the following season.

**Figure 5.** Average yield response to foliar fungicide application as influenced by tillage in corn following corn and corn following soybean (180 trials, 1999-2008). Break-even yield response = 5.5 bu/acre.
Tillage can influence disease pressure and potential benefit of fungicide application in much the same way as cropping sequence. By leaving more crop residue on the soil surface, conservation tillage and no-till can greatly increase the disease inoculum load.

Survey results from 192 on-farm trials where previous crop and tillage practices were reported showed an inverse relationship between tillage intensity and yield response to foliar fungicide application in both corn following corn and corn following soybean (Figure 5). In corn following corn the average yield advantage with fungicide application exceeded the break-even yield response in all three tillage systems. Fungicide yield response was 8.9 bu/acre in no-till or strip-till, 8.2 bu/acre in conservation tillage, and 5.9 bu/acre in conventional tillage.

In corn following soybean, the yield advantage with fungicide in no-till or strip-till was 9.5 bu/acre, which exceeded the break-even yield response. The average fungicide yield response in conservation and conventional tillage did not exceed the break-even response, with average yield responses of 4.4 bu/acre and 2.7 bu/acre in the two tillage systems, respectively. Rotation away from corn to a different crop, such as soybean, is often recommended as a way to manage corn diseases by reducing inoculum levels. However, these results suggest that under a high-residue system, such as no-till or strip till, disease pressure in corn following soybean may still be sufficient to justify a fungicide treatment.

2007 University Studies

In 2007, fungicide yield results from trials located in Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Wisconsin, and Ontario were summarized by researchers at the University of Illinois. Additionally, Iowa State University researchers conducted fungicide trials at several locations in Iowa in 2007. Key findings from both of these studies are summarized below.

2007 University of Illinois Summary

- 168 fungicide trials were conducted in 12 Midwestern states and Ontario (primarily small plot trials with at least three replications.)
- Average yield response was 3.0 bu/acre.
- Fungicide application was profitable in 38% of trials ($3.50 corn, fungicide + application: $20).
- Corn yield increase with fungicide was greater among hybrids susceptible to gray leaf spot.
- In trials conducted in Illinois, the greatest yield increases were observed in regions that had the most rainfall in July.

Both university studies had a lower average yield response than the Pioneer survey. When looking specifically at Pioneer on-farm trials located in Iowa in 2007, however, the average yield response (5.1 bu/acre) was closer to that observed in the Iowa State study (3.3 bu/acre).

The reason for the difference in yield results between the Pioneer survey and the University of Illinois survey is unclear. As shown in this Crop Insights, many factors can influence corn yield response to foliar fungicides, including disease pressure, previous crop, hybrid disease resistance, tillage, and location.

Risk of Crop Injury

The occurrence of crop injury associated with fungicide application was reported in a limited number of cases (less than 1% of treated fields, according to fungicide manufacturers) in 2007. The most frequent damage was partial to completely arrested cob development (Figure 6).

2007 Iowa State University Study

- 10 replicated and 16 non-replicated trials were conducted in Iowa.
- Average yield response was 3.3 bu/acre
- Fungicide application was profitable in 27% of trials ($3.75 corn, fungicide + application: $22).
- Yield response was greater at locations with greater disease pressure.
- Previous crop and gray leaf spot resistance did not influence yield response; however, this may be due to low disease pressure in Iowa in 2007.

Figure 6. Arrested ear development in a field treated with fungicide in 2007. Application was made prior to tasseling.
Damage was often associated with fields that were treated prior to tasseling or treatments that included non-ionic surfactants (NIS). Research conducted at the University of Illinois in 2008 confirmed these observations. In corn treated one week prior to tasseling, Headline® + NIS and NIS alone resulted in a high occurrence of ear damage, whereas damage in corn treated with only Headline® did not differ from the untreated check (Table 3).

Table 3. Ear damage resulting from pretassel application of fungicide and NIS (Nafziger 2008).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% of ears damaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>4</td>
</tr>
<tr>
<td>Headline® 6 oz</td>
<td>4</td>
</tr>
<tr>
<td>NIS 0.25%</td>
<td>58</td>
</tr>
<tr>
<td>NIS 0.50%</td>
<td>80</td>
</tr>
<tr>
<td>Headline® + NIS 0.25%</td>
<td>69</td>
</tr>
<tr>
<td>Headline® + NIS 0.50%</td>
<td>90</td>
</tr>
</tbody>
</table>

References


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*Quadris and Quilt are registered trademarks of a Syngenta Group Company.
*Stratego is a registered trademark of Bayer.