CROP INSIGHTS

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Maximizing the Value of Foliar Fungicides in Corn

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Summary

- Pioneer Hi-Bred has conducted extensive research to better understand the value of foliar fungicides treatments in corn production.
- Corn yield increased an average of 7.0 bu/acre in response to a foliar fungicide application across 475 on-farm trials conducted from 2007 to 2011.
- The average yield response to foliar fungicide application among on-farm trials was greater with practices that leave large amounts of residue on the soil surface, such as corn-following-corn, and no-till or strip-till.
- Fungicide yield response varied greatly among ten small-plot research locations in 2009, from 0.6 bu/acre to 22.6 bu/acre, due to differences in disease pressure.
- Results of a three-year University of Tennessee/Pioneer study showed that the probability of using a fungicide profitably is directly related to the susceptibility of a hybrid to the predominant leaf diseases in the field.
- Among Pioneer on-farm trials, grain moisture of fungicide-treated corn was only slightly higher (+0.3 points) than untreated corn.
- Later-maturing fields can be at greater risk for yield loss due to foliar diseases and therefore are more likely to benefit from a fungicide application.

Introduction

Over the span of only a few years, foliar fungicide treatments have progressed from a mostly new and untested practice to a trusted component of many growers' management systems. This has occurred as research results and grower experience have demonstrated that fungicides can be very effective tools for managing foliar diseases and protecting yield in corn. However, studies have also shown that fungicide applications do not always result in an economic benefit for growers. Extensive Pioneer research conducted over the last five years has demonstrated that the potential value of fungicide applications depends on disease pressure, hybrid suscepti-bility, previous crop and tillage.

This *Crop Insights* summarizes the key findings of three major foliar fungicide research projects conducted between 2007 and 2011. These studies involved several different foliar fungicide products and included both aerial and ground applications, but all were focused on application timings between tasseling and brown silk (VT – R2).

A positive return from a fungicide application is more likely when conditions favor foliar disease development.

- **On-farm fungicide trial survey:** Survey of on-farm foliar fungicide side-by-side trials conducted between 2007 and 2011.
- **Pioneer small-plot research:** 2009 study conducted to identify factors influencing yield response of multiple hybrids to foliar fungicide application across several Midwestern sites.
- **University of Tennessee/Pioneer small-plot research:** 2006 to 2008 study comparing foliar fungicide response among hybrids with differing levels of genetic resistance to gray leaf spot at a site chosen specifically due to its history of high GLS pressure.

Yield Response to Fungicide Treatment

Between 2007 and 2011, Pioneer researchers conducted a total of 475 on-farm fungicide trials comparing yield and moisture of untreated corn to corn treated with a foliar fungicide between tasseling and brown silk. Across these trials, the average yield response to fungicide application was an increase of 7.0 bu/acre (Figure 1). A positive yield response to fungicide application occurred in 80 percent of the trials. Yield response varied widely among many of the trials, as was expected given differences in weather conditions, disease pressure, and trial locations.

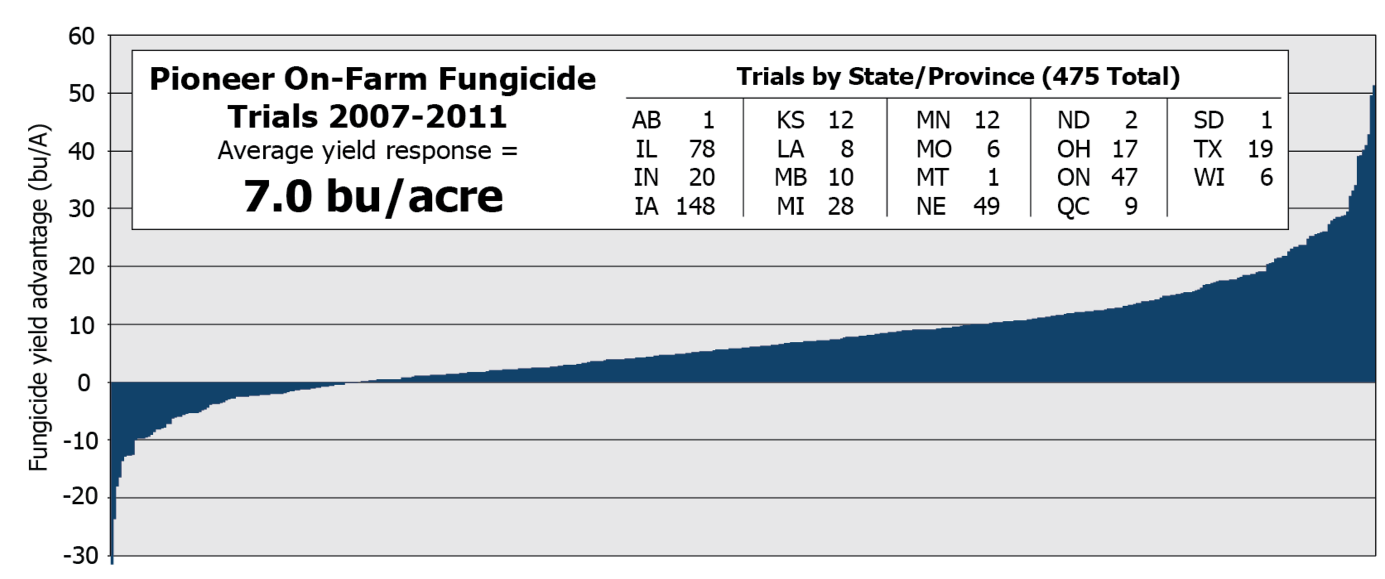


Figure 1. Corn yield response to foliar fungicide application in 475 Pioneer on-farm trials conducted from 2007 to 2011.

Pioneer small plot research found similar results, with an average yield response to fungicide treatment of 8.9 bu/acre across ten research locations in 2009 (Table 1). Average yield response varied among locations, ranging from 0.6 to 22.6 bu/acre, largely due to differences in disease pressure.

Table 1. Average corn yield response to foliar fungicide treatment at Pioneer small-plot research locations in 2009.

Location	Previous Crop	Tillage	Yield Response
			bu/acre
Mankato, MN	Soybean	Conv.	6.4
Waltham, MN	Soybean	Conv.	4.6
Janesville, WI	Soybean	Conv.	0.6
Minburn, IA	Corn	Strip	10.6
Breda, IA	Corn	Conv.	11.5
Alleman, IA	Soybean	Strip	8.0
Seymour, IL	Soybean	Conv.	11.8
Macomb, IL	Soybean	Conv.	7.1
Windfall, IN	Corn	Conv.	5.8
Gwynneville, IN	Soybean	No-till	22.6
Average			**8.9**

The economic viability of a fungicide application can vary greatly according to the price of corn and cost of the fungicide and application. Higher corn prices and lower treatment costs both reduce the break-even yield response; while lower corn prices and higher costs increase it (Table 2).

Table 2. Yield response necessary to cover the cost of fungicide and application over a range of costs and corn prices.

Fungicide + Application Cost /Acre	Corn Price/bu					
	$3	$4	$5	$6	$7	$8
	---------------- bu/acre ----------------					
$22	7.3	5.5	4.4	3.7	3.1	2.8
$24	8.0	6.0	4.8	4.0	3.4	3.0
$26	8.7	6.5	5.2	4.3	3.7	3.3
$28	9.3	7.0	5.6	4.7	4.0	3.5
$30	10.0	7.5	6.0	5.0	4.3	3.8
$32	10.7	8.0	6.4	5.3	4.6	4.0

At a break-even yield response of 4 bu/acre, 60% of the Pioneer on-farm trials conducted over five years would have seen an economic benefit from fungicide application (Figure 1). However, at a break-even point of 7 bu/acre, the success rate drops to only 45%.

Factors Influencing Yield Response

Disease Pressure

Pioneer research has shown that one of the most important factors determining the value of a foliar fungicide application is disease pressure. 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. Most widely grown hybrids have at least moderate resistance to the major leaf diseases; which may be sufficient protection against low to moderate disease pressure. However, in years when weather conditions are very conducive for disease, a fungicide application can provide a substantial economic benefit.

There are two basic types of disease cycles among the fungal diseases that infect corn leaves. Most of the pathogens, such as northern leaf blight, overwinter in diseased corn leaves, husks and other plant parts. Spores are produced on this crop residue when environmental conditions become favorable in the spring and early summer. These spores are spread by rain splash and air currents to the leaves of new crop plants, where primary infections are produced. Secondary spread then occurs from plant to plant, and even from field to field as spores are carried long distances by the wind. As the plants die, the fungi remain in the dead plant tissue.

The rust diseases have a different cycle because they do not overwinter in crop residue and can't survive the winters throughout much of the Corn Belt. Instead, disease starts in corn fields in the southern US and spores are windblown long distances into the Corn Belt. Disease onset depends on weather systems that carry the spores northward combined with favorable conditions for infection. Secondary spread occurs similarly to the other leaf diseases.

Foliar infections can occur at any growth stage, and the earlier lesions develop, the more leaf area is reduced and the more damage results. However, plants are generally more susceptible to infection after silking. Damage may include yield losses due to decreased photosynthesis, and harvest losses if secondary stalk rot infection and stalk lodging accompany loss of leaf area.

Figure 2. Pioneer® hybrid 35F44 (HXX,LL,RR2) treated with a fungicide (left) compared to the same hybrid, untreated, showing severe common rust symptoms (right). As expected, yield was greatly improved by the fungicide application due to high disease pressure at this Pioneer plot near at Seymour, IL.

The Pioneer small-plot research trials conducted in 2009 demonstrated the degree to which yield response to foliar fungicides can vary due to differences in disease pressure. The wide variation in yield response to fungicide application among locations was largely attributable to differences in common rust pressure. Common rust was prevalent at several Iowa, Illinois and Indiana locations in 2009. Average yield response across locations in these states was 11.4 bu/acre (Table 1). Conversely, average yield response at Minnesota and Wisconsin locations where common rust was less prevalent was only 3.9 bu/acre. At sites with high common rust pressure, yield response to foliar fungicide application was greatest among hybrids with a low level of genetic resistance to the disease (Figure 2).

Hybrid Disease Susceptibility

In Pioneer and university studies with multiple hybrids of varying disease resistance, the probability of using a fungicide profitably has often been directly related to the susceptibility of a hybrid to the predominant leaf diseases. Pioneer hybrids are rated on a scale of 1 to 9 for their level of genetic resistance to major foliar diseases, with 1 to 3 indicating a susceptible hybrid, 4 to 5 moderately resistant, 6 to 7 resistant, and 8 to 9 highly resistant. In cases where a foliar disease is not severe, a foliar fungicide application may not provide an economic benefit with a resistant or highly resistant hybrid. Hybrids that are susceptible to a common foliar disease are more likely to benefit from a fungicide application and should be monitored for disease symptoms, particularly when weather conditions are favorable for disease development.

A research project was conducted from 2006 to 2008 at the University of Tennessee Research and Education Center at Milan. The primary goal of this study was determining the yield benefit associated with foliar fungicide management of gray leaf spot in hybrids with differing levels of resistance. The research site was specifically chosen due to a history of high gray leaf spot pressure. The plot area was in irrigated no-till corn production for four years prior to the start of the study, with a high level of gray leaf spot each year. Three Pioneer® brand corn hybrids with varying levels of resistance to gray leaf spot were included in the study (Table 3).

Table 3. Gray leaf spot resistance ratings of hybrids used in a 3-year foliar fungicide study at the Univ. of Tennessee.

Pioneer® Hybrid	GLS Rating	GLS Resistance
32T22 (RR2)	3	susceptible
33R76 (RR2)	5	moderately resistant
33V14 (RR2)	7	resistant

Results of the study demonstrated the potential for gray leaf spot to cause substantial reductions in yield when disease pressure is very high. Hybrid resistance was effective in mitigating a large portion of yield loss due to gray leaf spot; however, even with the most resistant hybrid, the yield benefit of the foliar fungicide application was great enough to likely cover the cost of product and application (Figure 3). Under more moderate disease pressure, a fungicide application would likely not provide an economic benefit on a resistant hybrid.

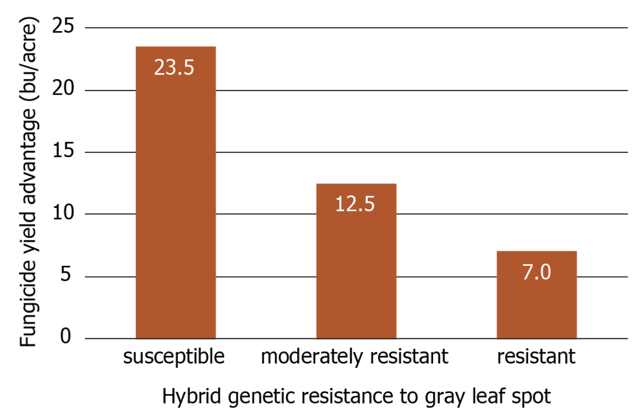


Figure 3. Average yield increase of hybrids susceptible, moderately resistant, and resistant to gray leaf spot due to foliar fungicide application in a three-year University of Tennessee/Pioneer research study.

Another example is the Pioneer small-plot study described previously, where common rust was prevalent at some of the locations. Yield response to foliar fungicide application in this study was greatly influenced by genetic resistance of hybrids to this disease. Among locations with high common rust severity in Illinois and Indiana, yield response to fungicide application was much greater for susceptible hybrids compared to hybrids with a moderate level of resistance (Figure 4). At Minnesota and Wisconsin sites with low common rust severity, a fungicide application could still have been profitable on susceptible hybrids (depending on prices), but most likely would not have been profitable on moderately resistant hybrids.

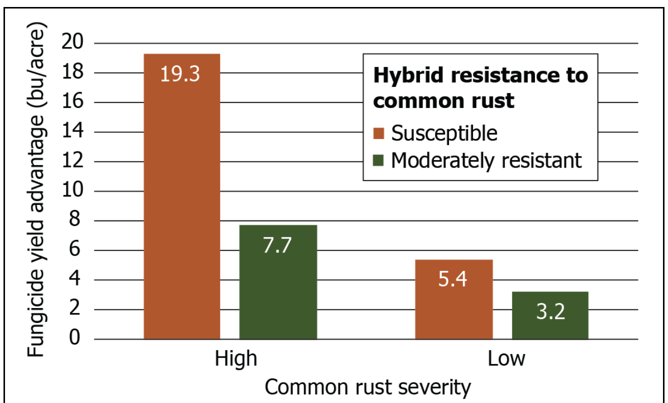


Figure 4. Average fungicide yield response of hybrids with low resistance (3 on a 1-9 scale) and moderate resistance (4-6) to common rust in Pioneer small-plot trials.

Common rust was prevalent at a trial at Macomb, IL, along with low to moderate levels of gray leaf spot and northern leaf blight. Notable differences in disease symptoms and yield response to fungicide were observed in this location (Figure 5). These research results from 2009 demonstrate the value of foliar fungicides in protecting yield when disease outbreaks occur; however, genetic resistance of hybrids may also provide adequate protection and should be considered in fungicide treatment decisions.

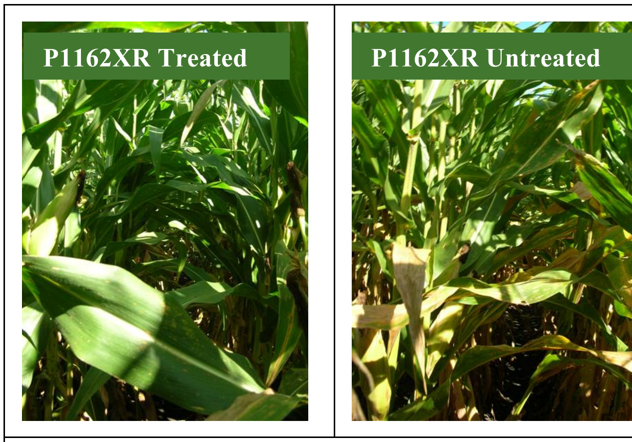
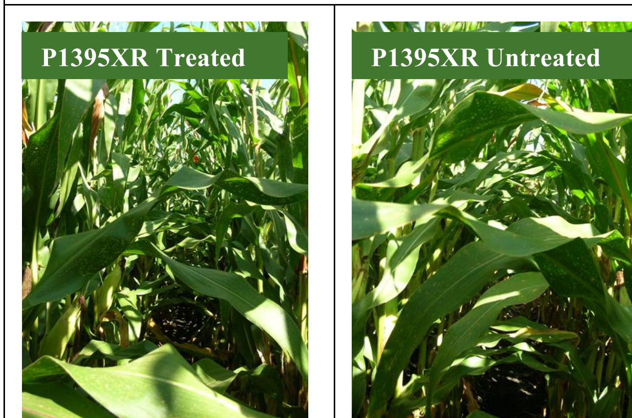


Figure 5. Pioneer® hybrid P1162XR (HXX,LL,RR2) (above) and P1395XR (HXX,LL,RR2) (below) treated (left) and untreated (right) with fungicide at Macomb, IL. The fungicide helped to protect yield in P1162XR but was not necessary on P1395XR, which had minimal disease.



Previous Crop and Tillage

Research results have clearly shown that 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 can lead to earlier infection and higher disease incidence and severity in the subsequent corn crop. 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.

Research studies have confirmed that tillage can influence disease pressure and potential benefits 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.

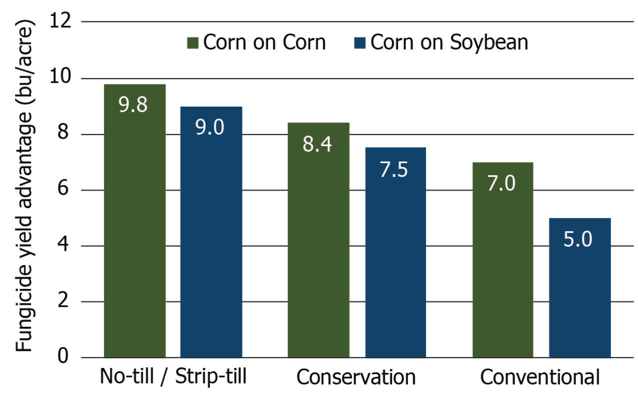


Figure 6. Average yield response to foliar fungicide application as influenced by tillage and previous crop in on-farm trials (289 trials, 2007 to 2011).

Survey results from 289 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 6). 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. These results support that recommendation and indicate that rotation with soybean does have a positive impact on reducing disease pressure; however, residue levels still appear to have an impact on disease pressure in corn following soybean.

The 2009 Pioneer small plot trial also included different cropping sequences and tillage practices among locations (Table 1). Average yield response to fungicide application tended to be higher among locations planted to corn the previous year and locations using no-till or strip-till practices; however, high yield response at some locations was driven primarily by common rust pressure. Common rust does not overwinter in crop residue, so would not be affected by crop rotation or tillage practices.

Other Considerations

Grain Moisture

One concern with fungicide treatments in corn is the potential for increased grain moisture at harvest, resulting in higher drying costs. Observations have varied among university trials with some showing a small increase in moisture in treated vs. untreated corn, and some showing no difference. Among Pioneer on-farm trials, grain moisture of fungicide-treated corn was only slightly higher (+0.3 points) than untreated corn (Figure 1). This difference was not greatly affected by overall moisture level at harvest. In trials where harvest moisture of the untreated corn was greater than 25%, treated corn averaged 0.4 points wetter.

One possible reason a fungicide application could increase grain moisture at harvest is that disease pressure in the untreated corn was severe enough to cause premature death of the plant. In such a case, the increase in moisture would probably be accompanied by an increase in yield, which may more than offset any additional drying costs.

There is some evidence of this trend among the Pioneer on-farm trials. Among those trials in which the harvest moisture of the treated corn and untreated corn was similar (treated corn < 0.3 points wetter), the average yield response to fungicide application was 6.4 bu/acre. In trials where the treated corn was more than 2.0 points wetter, the fungicide yield advantage was 8.7 bu/acre. Finally, in the small number of trials where the treated corn was more than 2.5 points wetter, the average fungicide yield response was 15.5 bu/acre.

Hybrid maturity and planting date

Hybrid maturity and planting date have also been found to influence susceptibility to yield loss from foliar diseases (data not shown). These factors are important relative to the timing of disease development. Later planted fields and/or later maturing hybrids can be more vulnerable to yield loss because they are still filling grain while disease development is peaking in late summer. Therefore, these later fields are often more likely to benefit from a fungicide application.

HXX - Herculex® XTRA contains both the Herculex I and Herculex RW genes. LL - Contains the LibertyLink® gene for resistance to Ignite® herbicide. RR2 - Contains the Roundup Ready® Corn 2 gene.