Quantifying the Effect of Pyraclostrobin on Grain-fill Period and Kernel Dry Matter Accumulation in Maize

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Abstract
Strobilurin fungicides are effective against a wide range of foliar fungal diseases on several crops and may offer additional physiological benefits, including plants staying green longer than normal (the "stay-green effect"). It has been hypothesized that the stay-green effect may extend the grain fill period leading to increased grain yield due to a longer period of dry matter accumulation. We investigated the effect of pyraclostrobin fungicide applied at tasseling on foliar disease suppression, stalk rot severity, the stay-green effect of leaves in the upper canopy, dry matter accumulation, time at physiological maturity, grain yield, and moisture at harvest in maize from 2008 through 2010 in Iowa at six location years. Foliar disease severity was <5% in all location years. Pyraclostrobin-treated plots had a significantly higher area under green leaves incidence curve compared to non-treated maize. Although grain yield and grain moisture at harvest were not different \( P > 0.1 \) between pyraclostrobin-treated and non-treated maize in all location years, treated plots tended to have higher yield and grain moisture. Time at physiological maturity did not differ between pyraclostrobin-treated and non-treated plots \( P > 0.1 \). Although we demonstrated an application of pyraclostrobin to maize delayed senescence of the leaves thus contributing to the stay-green effect, our data did not show grain-fill period extension.

Introduction
Foliar fungicides have traditionally only been used in the United States on seed or specialty maize \( (\text{Zea mays} \text{ L.}) \); however since 2007, their use has become more widespread on hybrid maize (34). Maize is susceptible to numerous foliar fungal pathogens, including \textit{Cercospora zeae-maydis}, which causes gray leaf spot, \textit{Exserohilum turcicum} (northern leaf blight), \textit{Aureobasidium zeae} (eyespot), and \textit{Puccinia sorghi} (common rust). These pathogens have been managed through use of cultural practices such as resistant hybrids, crop rotation, and residue management (34). Recently, however, there has been increased use of fungicides in corn, especially the strobilurin group in the US. In 2010, for example, more than 20% of hybrid maize acres in the US were treated with a fungicide between tasseling (VT) and blister (R2) (31). The increased use of strobilurins and other fungicides in maize is attributed in part to production practices which increase risk of disease outbreak such as reduced tillage or no-till, increased maize acreage, and maize following maize (34).

Fungicide products registered for use on maize contain active ingredients from two chemical groups: triazoles, which belong to the demthylation inhibitors (DMI) and strobilurins [quinone outside inhibitor (QoI)]. Strobilurins interfere with fungal respiration by blocking electron transfer at the site of quinol oxidation (32). Both triazoles and strobilurins provide excellent preventive (inhibit fungal infection) and some level of curative (slow down existing fungal infection) protection of plants from a wide range fungal pathogens (2,23,32) and consequently protect yield potential.
Strobilurins also have been shown to provide physiological benefits to plants. Application of strobilurin fungicides to wheat delayed senescence of the flag leaf (3,4,10,24,25,27,33,35), improved water-use efficiency in well-watered plants (21), and increased nitrogen levels in above ground winter wheat plant tissue (25). Because of these reported physiological benefits, fungicides containing a strobilurin have been applied to maize in the absence of disease to increase yield (8,33).

In the US, greater maize grain yields have been reported as a result of an application of a fungicide containing a strobilurin (29,34). Farmers and agribusiness personnel have observed that canopy senescence is often delayed in maize crops treated with a strobilurin fungicide. This phenomenon is commonly referred to as the "stay-green effect." They hypothesized that since the canopy remains greener for a longer period of time, that the grain-fill period may be extended, thereby increasing kernel weights.

In maize, photosynthates translocate to developing grain between growth stages R3 (milk stage) and R6 (physiological maturity) (1,20,28). Dry matter accumulation in kernels occurs in three stages (28). The first stage, also known as the lag phase, consists of active cell division and differentiation. The second phase, or effective grain-filling period, is linear and results in reserves deposited in the developing grain. The third phase occurs when kernels achieve maximum dry weight at which point they reach physiological maturity (R6) (28). At R6, an abscission layer, commonly referred to as the “black layer,” forms between the attachment of kernel and the cob (9). Once this layer has formed, no more assimilates can enter the seed (1,5,6,7,13). Thus, while strobilurins might delay senescence of the leaves in the upper canopy of maize, the grain-fill period may only be extended if the formation of this abscission layer in the developing grain is delayed.

The goal of this study was to determine the effect of an application of the strobilurin fungicide, pyraclostrobin, on grain-fill period extension and kernel dry matter accumulation in maize in Iowa. Furthermore, we assessed the effect of this fungicide on (i) foliar disease severity and stalk health, (ii) incidence of green leaves in the upper leaf canopy (stay green; ear leaf and above), and (iii) maize yield.

Field Experiments

Field experiments were conducted in Iowa at one location in 2008, three locations in 2009, and two locations in 2010 (Table 1). Details regarding cropping history, hybrids, and planting date are in Table 1. All fields were cultivated in spring with an application of pre-emergent herbicide. Treatments included an application of pyraclostrobin (Headline 110 g a.i./ha, BASF Corp., Research Triangle Park, NC) applied at tasseling or silking (VT/R1), and a non-treated control. Pyraclostrobin belongs to the strobilurin fungicides that have the Quinone outside inhibitor (QoI) mode of action (Fungicide Resistance Action Committee classification 11). The fungicide was applied using a Hagie high-clearance sprayer at 345 kPa with TXVS-2 nozzles spaced every 0.38 m, and a delivery rate of 93.5 liters/ha. Treatments were arranged in a randomized complete block design with four replicates and plot size was 10 m wide (four rows spaced 0.75 m apart) by 9 m long. Research plots were managed according to Iowa State University recommended agronomic practices for fertilizer and weed management.
Table 1. Location, cropping history, hybrid, foliar disease rating, planting, and fungicide application dates of field trials conducted during the 2008, 2009, and 2010 maize growing seasons in Iowa.

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Previous crop</th>
<th>Hybrid</th>
<th>Foliar disease rating</th>
<th>Planting date</th>
<th>Fungicide application date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>Ames</td>
<td>Soybean</td>
<td>Pioneer 34A16</td>
<td>6</td>
<td>6</td>
<td>May 15</td>
</tr>
<tr>
<td>2009</td>
<td>Ames</td>
<td>Soybean</td>
<td>Pioneer 36V75</td>
<td>5</td>
<td>4</td>
<td>May 20</td>
</tr>
<tr>
<td></td>
<td>SERF</td>
<td>Maize</td>
<td>Dekalb 61-69</td>
<td>5</td>
<td>3</td>
<td>Apr 23</td>
</tr>
<tr>
<td></td>
<td>SERF</td>
<td>Soybean</td>
<td>H-8531 GT/CB/LL Brand</td>
<td>5</td>
<td>3</td>
<td>May 11</td>
</tr>
<tr>
<td>2010</td>
<td>Ames</td>
<td>Soybean</td>
<td>Pioneer 33W84</td>
<td>5</td>
<td>5</td>
<td>May 19</td>
</tr>
<tr>
<td></td>
<td>Boone</td>
<td>Soybean</td>
<td>Agrigold 6325RR</td>
<td>7</td>
<td>8</td>
<td>May 3</td>
</tr>
</tbody>
</table>

V Foliar disease rating to gray leaf spot and northern leaf blight based on company ratings: Agrigold, 1 = Low tolerance, 10 = High tolerance; Dekalb, 1 = Excellent, 9 = poor; Pioneer, 1 = Poor, 9 = outstanding; Golden Harvest, 1 = high tolerance, 5 = average tolerance).

w GLS = gray leaf spot caused by Cercospora zeae-maydis.

x NLB = northern leaf blight, caused by Exserohilum turcicum.

y SERF = Iowa State University Southeast Research and Demonstration Farm.

z SWRF = Iowa State University Southwest Research and Demonstration Farm.

Data Collection

Foliar disease severity was assessed on the ear leaf of five consecutive plants in the third row at the dough developmental stage (R4). The severity of all diseases found on the ear leaf was recorded as the percentage of leaf area covered by disease lesions. Disease severity estimation was aided by standard area diagrams produced using Severity Pro (22).

Stalk rot severity was assessed at physiological maturity (R6) on four randomly selected plants (destructive) in the outer rows (two plants per row) in each plot using the University of Illinois disease severity scale (18) in 2010 and 2011. This scale ranges from 0-5, where 0 = no visible discoloration of nodes or pith, 1 = internal discoloration at one node below ear, 2 = internal discoloration at nodes and in pith below the ear, 3 = pith separation below ear, 4 = complete discoloration and decay of pith in two or more nodes below ear, and 5 = stalk lodged below the ear due to stalk rot.

The effect of an application of pyraclostrobin on incidence of green leaves in the canopy above the ear leaf (stay-green) was assessed at four of the six field locations. A leaf was considered green if more than 75% of the leaf area was still green. Thus, the percent incidence of green leaves was calculated by counting the number of leaves (ear leaf and above) that were >75% green in appearance divided by the total number of leaves in the upper canopy (ear leaf and above) multiplied by 100, on each of four systematically chosen plants (two per each outer row) in each plot every four to seven days from one to two weeks after the dent developmental stage (R5) through approximately two weeks after R6.

The primary ear from each of the four plants per plot assessed for green leaves incidence was simultaneously hand harvested at each assessment date to evaluate dry matter accumulation. Labeled ear samples were transported to the laboratory and 200 kernels shelled by hand from the middle of each ear. The kernels from the middle of the ear represent the "average" as variation exists from the base (butt) to the tip of the ear (1). In 2008 and 2009, the kernels were weighed to determine fresh (wet) weight and then oven dried at 90°C until they reached constant weight (equilibrium). In 2010, three 15-g kernel subsamples were oven heated for 72 h at 103°C, according to the Grain Inspection Packers, and Stockyards Administration (GIPSA) procedure (16). Grain moisture content for each sampling time was obtained from the expression [1- (dry weight/fresh weight)] × 100.
The center rows of each plot were harvested using a plot combine (model MF 205; Massey Ferguson Ltd, Hesston, KS) in 2008 and grain weight and moisture content determined in the laboratory. In 2009 and 2010, a plot combine model JD9410 (Deere and Company, Moline, IL) fitted with a Harvest Master High Capacity GrainGage system (HCG100; Juniper Systems Inc. Logan, UT) that also recorded the grain weight and moisture content was used. Grain yield was adjusted to 15.5% moisture content.

**Statistical Analyses**

Disease severity and grain weight data were subjected to ANOVA using PROC GLM (SAS 9.2, SAS Institute Inc., Cary, NC) to detect differences between fungicide-treated and non-fungicide-treated plots. Incidence of green leaves in each plot was plotted against time of assessment (day of year) and area under green leaf incidence curve (AUGIC) was calculated. AUGIC was also subjected to ANOVA to detect treatment differences. Stalk rot scores were subjected to Wilcoxon one-way nonparametric analysis using PROC NONPAR1WAY (SAS 9.2). Two analyses were used to determine the effect of a strobilurin fungicide on physiological maturity (R6). Dry matter weight data were subjected to “broken-line” nonlinear regression (26) using PROC NLIN (SAS 9.2) as follows:

\[
DMW = a + bx, \quad x < x_0
\]

\[
DMW = a + b x_0, \quad x > x_0
\]

where DMW is dry matter weight, \(a\) = intercept, \(b\) is rate of grain fill, \(x\) is day of year of sampling, \(x_0\) is day of year when DMW was maximum. The day of year (time point) when the linear increase in DWM was at maximum was determined as the point of physiological maturity (PM) as there can be no further increase in dry weight (1). The obtained day of year at which no dry matter increase occurred was subjected to ANOVA to detect differences in the time to reach PM between treated and non-treated plots at each location in each year.

The grain moisture content associated with kernels that have reached physiological maturity has been found to be 35% with minimal variation across hybrids and year (1,28). Therefore, moisture content (MC) was regressed with day of year of sampling and the regression equation was used to determine day of year when kernels reached 35% MC for each treatment. The day of year when MC was 35% for each treatment was then subjected to ANOVA to detect treatments differences at each location in each year.

**Effect of Pyraclostrobin on Foliar Disease and Stalk Rot**

In all site years, disease severity on the ear leaf at R4 was less than 5% in the non-treated control (Table 2). Common rust and eyespot were the predominant diseases although gray leaf spot and northern leaf blight were also present but to a far lesser extent. Foliar disease severity was lower (\(P < 0.1\)) in pyraclostrobin-treated plots (1.3, 0.9, 0.5, and 1.7%) than non-treated plots (2.5, 1.2, 4.0, and 3.0%) at four locations (Ames 2009, SERF, SWRF 2009, and Boone 2010, respectively). These data agree with previous findings that pyraclostrobin is effective against foliar diseases in maize (28).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean foliar disease severity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyraclostrobin</td>
<td>1.10 a</td>
</tr>
<tr>
<td>Non-treated</td>
<td>1.13 a</td>
</tr>
</tbody>
</table>

* SERF = Iowa State University South East Research Farm.

**Table 2.** Mean foliar disease severity (%) on the ear leaf of maize at dough (development stage R4) treated with either pyraclostrobin or non-treated at six locations in Iowa from 2008 through 2010. (N = 5 consecutive plants in middle two rows of each plot).

* Means followed by the same letter in a column are not significantly different, \(P < 0.1\) based on Tukey’s honestly significant difference.
Stalk rot severity was also very low in all the six-location years. Stalk rot severity was reduced ($P < 0.05$) by an application of pyraclostrobin at two locations (SERF and SWRF) (Table 3). At Boone and Ames locations in 2010, application of pyraclostrobin did not affect stalk rot severity ($P > 0.05$). Stalk rot development has been associated with plant stresses including foliar diseases in maize (11). At SWRF, foliar disease severity was highest compared to that which occurred at the other site years, so the improved stalk health we detected in pyraclostrobin-treated maize may have been a result of reducing foliar disease severity. Limited stalk rot in the absence of significant foliar disease due to an application of pyraclostrobin has been previously reported in Iowa (30).

Table 3. Stalk rot severity of maize treated with either pyraclostrobin or non-treated at four locations in Iowa from 2009 through 2010. Stalk rot severity was scored using the University of Illinois Stalk rot severity score.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>SERF$^\text{x}$ 2009</th>
<th>SWRF$^\text{z}$ 2009</th>
<th>Boone 2010</th>
<th>Ames 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>pyraclostrobin</td>
<td>20.50 (2.1)</td>
<td>24.6 (1.1)</td>
<td>18.7 (1.4)</td>
<td>11.7 (1.7)</td>
</tr>
<tr>
<td>Non-treated</td>
<td>12.5 (3.1)</td>
<td>13.9 (2.2)</td>
<td>21.4 (2.1)</td>
<td>10.1 (2.1)</td>
</tr>
<tr>
<td>$p$-value</td>
<td>0.0174</td>
<td>0.0024</td>
<td>0.4266</td>
<td>0.5415</td>
</tr>
</tbody>
</table>

$^x$ Stalk rot severity scored using the University of Illinois Stalk rot severity score (18).

$^y$ SERF = Iowa State University South East Research Farm.

$^z$ SWRF = Iowa State University South West Research Farm.

**Effect of Pyraclostrobin on the Canopy**

Fungicide studies on wheat have reported delayed flag leaf senescence in wheat due to an application of a strobilurin (4,25). Similarly, we report that senescence of the upper canopy of maize can also be delayed with an application of a fungicide containing a strobilurin. AUGIC was significantly greater ($P < 0.1$) in pyraclostrobin-treated plots at all locations except SERF (Table 4). The highest AUGIC among the pyraclostrobin-treated plots occurred at the Boone 2010 location while SERF had the lowest AUGIC. The SERF location had also the lowest AUGIC in the non-treated plots. There are numerous reasons why strobilurins could extend the life of the canopy including control of foliar disease or physiological effects on the plant, for example inhibition of ethylene production that accelerates senescence (17). In our study, conditions were not favorable for severe disease development and consequently the "stay-green" phenomenon we report was likely due to a physiological effect on the crop.

Table 4. Area under green leaves incidence curve (AUGIC) for maize treated with either pyraclostrobin or non-treated at four locations in Iowa from 2008 through 2010. The incidence (%) of green leaves (ear leaf and above, $N = 4$) was plotted against day of year of sampling and area under the curve was determined by the integration method.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ames$^\text{x}$ 2008</th>
<th>SERF$^\text{y}$ 2009</th>
<th>SWRF$^\text{z}$ 2009</th>
<th>Boone 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyraclostrobin</td>
<td>1934.82 a*</td>
<td>1440.5 a</td>
<td>1669.84 a</td>
<td>2644.30 a</td>
</tr>
<tr>
<td>Non-treated</td>
<td>1477.63 b</td>
<td>1113.89 a</td>
<td>1363.84 b</td>
<td>1403.31 b</td>
</tr>
</tbody>
</table>

$^x$ AUGIC data not assessed for Ames location 2009 and 2010.

$^y$ SERF = Iowa State University South East Research Farm.

$^z$ SWRF = Iowa State University South West Research Farm.

* Means followed by the same letter in a column are not significantly different, $P = 0.1$ based on Tukey’s highly significant difference.
Effect of Pyraclostrobin on Physiological Maturity

Applying pyraclostrobin did not affect time to 35% moisture content or time to maximum dry matter weight, both of which are indicators of physiological maturity (PM). The time when PM was reached, as determined by the day of year when moisture content (MC) reached 35%, did not differ between pyraclostrobin-treated and non-treated plots in all locations (P > 0.1; Table 5). At three locations (SWRF, Ames 2009, and Boone 2010), grain moisture reached 35% on the same predicted day for both fungicide and non-fungicide treatments, while grain moisture reached 35% one day later than the non-treated check at the Ames 2008 and Ames 2010 locations, and two days later than the check for the SERF 2009 location.

Similarly, day of year when kernel weight was maximum in treated plots was not different from non-treated plots in all locations (P > 0.1; Fig. 1). Maximum kernel weight in pyraclostrobin-treated plots occurred from 0 to 6 days after non-treated plots had reached a maximum kernel weight.

We conducted this research to test the hypothesis that an application of pyraclostrobin extends the grain-fill period in corn by delaying the formation of an abscission layer between the kernel and cob (that is, by delaying PM). Our data do not support this hypothesis. Thus, even though the canopy of a fungicide-treated crop remained green and therefore photosynthetically active for a longer period of time than a crop not treated with a fungicide, length of the grain-fill period was not affected, since PM and therefore abscission layer development occurred at the same time. Therefore, assimilates produced after PM could not have contributed to either the grain-fill period or increased grain yield. Previous researchers reported similar findings of limited kernel weight gain when assimilates were not limiting after effective grain-fill period (5,7,12,15,18,19). Gambin et al. (14) reported timing of assimilate availability at early kernel developmental stages (R2 to R4) was important in determining final kernel weight compared to the post-effective grain-filling period (post R5). In our work we did not evaluate assimilate availability at the beginning of grain fill.

Table 5. Day of year when moisture content (MC) was 35% in maize treated with either pyraclostrobin or non-treated at six locations in Iowa from 2008 through 2010.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Day of year&lt;sup&gt;x&lt;/sup&gt; moisture content = 35%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ames 2008</td>
</tr>
<tr>
<td>Pyraclostrobin</td>
<td>286 a*</td>
</tr>
<tr>
<td>Non-treated</td>
<td>285 a</td>
</tr>
</tbody>
</table>

<sup>x</sup> Day of year obtained from accumulating days in a year from January 1 = 1 and December 31 = 365, e.g., 286 = October 12. Day of year when MC = 35% was obtained from the linear regression equation of MC versus day of year of kernel sampling as a substitution for x when y was 35%.

<sup>y</sup> SERF = Iowa State University South East Research Farm.

<sup>z</sup> SWRF = Iowa State University South West Research Farm.

* Means followed by the same letter in a column are not significantly different, P = 0.1 based on Tukey’s highly significant difference.
Effect of Pyraclostrobin on the Grain Yield

Grain yield was not different between the pyraclostrobin treatment and non-treated control in all locations ($P > 0.1$; Table 6), although yields were always numerically greater in pyraclostrobin-treated maize. The Ames 2009 and SWRF 2009 locations had the highest grain yield, respectively, while Boone 2010 and
Ames 2010 had the lowest grain yield. Grain yield did not have a significant linear relationship with AUGIC ($P > 0.05$) (Fig. 2), indicating higher AUGIC did not result in increased yield.

Table 6. Grain yield and moisture content at harvest of maize treated with either pyraclostrobin or non-treated at six locations in Iowa from 2008 through 2010. Grain yield was adjusted to 15.5% moisture basis.

<table>
<thead>
<tr>
<th>Variable/Treatment</th>
<th>Locations</th>
<th>Locations</th>
<th>Locations</th>
<th>Locations</th>
<th>Locations</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (t/ha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyraclostrobin</td>
<td>13.54 a*</td>
<td>14.79 a</td>
<td>13.04 a</td>
<td>14.26 a</td>
<td>10.70 a</td>
<td>7.73 a</td>
</tr>
<tr>
<td>Non-treated</td>
<td>12.28 a</td>
<td>14.50 a</td>
<td>12.71 a</td>
<td>13.89 a</td>
<td>9.98 a</td>
<td>6.85 a</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyraclostrobin</td>
<td>17.78 a</td>
<td>24.12 a</td>
<td>21.86 a</td>
<td>20.65 a</td>
<td>14.82 a</td>
<td>17.08 a</td>
</tr>
<tr>
<td>Non-treated</td>
<td>17.30 a</td>
<td>23.64 a</td>
<td>20.81 a</td>
<td>19.83 a</td>
<td>14.78 a</td>
<td>17.05 a</td>
</tr>
</tbody>
</table>

* SERF = Iowa State University South East Research Farm.

Fig. 2. Relationship between grain yield and area under green leaves incidence curve (AUGIC). Green leaves incidence curve was obtained by plotting percent incidence of green leaves (ear leaf and above) versus day of year of sampling. Yield and AUGIC data points are means of four replicates.
Despite the delay in senescence of the upper canopy of maize with an application of pyraclostrobin, this did not result in a corresponding increase in yield. These results are in agreement with more recent findings in wheat in which there was limited yield benefit associated with delayed senescence of the flag leaf beyond 700°C days after anthesis (22). Similarly, grain moisture at harvest was not different between the pyraclostrobin treatment and non-treated control in all locations (P > 0.1; Table 6), although grain moisture of treated grain was 0.5 to 1.0% higher than non-treated grain in four of the six site years. Higher grain moisture in fungicide-treated grain are commonly reported particularly when the grain is harvested at greater than 20% moisture.

Since foliar disease severity was very low at our locations, this may explain why yield was not significantly greater in the pyraclostrobin-treated plots when compared with the non-treated plots. Wise and Mueller (34) recently analyzed data from maize fungicide trials across the Corn Belt and found a higher probability of break-even yield response when disease severity at R5 was greater than 5%. Similarly in sweet corn, the profitability of strobilurin (pyraclostrobin or azoxystrobin) was only significant when applied at a threshold level of 20% severity for both common rust and northern maize leaf blight (29). Another recent study on use of strobilurins on mid-Atlantic wheat crops concluded that application of strobilurins was not profitable in the absence of significant disease pressure (33). Bertelsen et al. (3) also reported that yield from non-inoculated wheat plants did not differ from non-inoculated but treated with azoxystrobin; however, azoxystrobin had a significant effect on yield compared to non-treated when plants were inoculated with with Cladosporium macrocarpum and Alternaria alternata under glasshouse conditions, indicating that strobilurins increase yields primarily through controlling fungal diseases.

**Summary**

Reports of greater yields in the absence of disease and observations that maize crops sprayed with a fungicide remain greener for longer than those crops that were not treated, led to our hypothesis that a fungicide application extends the grain-fill period resulting in greater yields. We examined this hypothesis at six Iowa locations over three years. We documented that the area under the green leaves incidence curve (leaves in the upper canopy from the ear leaf and above) was greater with the application of pyraclostrobin, indicating that an application of fungicide did delay canopy senescence. We found however, that the day of year at which kernels reached 35% moisture content and the day of year when maximum kernel weight occurred, both of which are indicators of physiological maturity, did not differ between pyraclostrobin and non-treated plots.

**Acknowledgment**

This study was funded by BASF. We thank John Shriver for all the assistance planting, spraying and harvesting the trials. We thank Nathan Bestor, Sally Mallowa, and all student helpers who helped in collecting and processing samples. We would like to thank Dr. Charles Hurburgh and his laboratory assistants for automated dry matter and grain moisture measurements.

**Literature Cited**