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Fungicides on corn: Disease control, physiology of the plant, and yield

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An estimated two million acres of corn were sprayed with fungicides (strobilurin or a strobilurin/triazole combination) in Iowa in 2007. Reasons for spraying vary and include the high price of corn, potential to control diseases, and a possibility of improved yield from “plant health” benefits. Until this year fungicide applications to production corn fields was rarely practiced in Iowa because they were not profitable.

Rumors persist that abnormal ear development has occurred in certain fields because of a fungicide application. Could this be true? It is not surprising to hear these reports given the large acreage sprayed and the lack of experience with large-scale fungicide applications on all of our parts. Ear developmental issues may be due to a pesticide application but could also easily be due to environmental (primarily moisture or temperature) or other stress events (such as nutrient deficiency or insect feeding). In many cases, it is impossible to decipher the cause because no control strips were left in the affected fields.

Where would an increase (or decrease) in yield come from if it was directly correlated with a fungicide application at tasseling (VT)? Significant insight can be gained from understanding yield determination in corn and when certain ear dimensions are set. Yield is the accumulation of five key elements expressed as:

$$A \times B \times C \times D \times E = \text{YIELD}$$

Plants per acre x Ears per plant x Rows per ear x Kernels per row x Weight per kernel = YIELD per acre

In general, the five yield determining factors are set in order of left to right as the season progresses. Although environmental influences will affect the equation, such as plant removal due to severe insect damage, hail, greensnap, and stalk lodging.

To understand how fungicide protection at tasseling (VT) and shortly thereafter might affect final yield, it is necessary to see which of the yield components could potentially be impacted. The following descriptions shed light on which of the factors (A, B, C, D, or E) could be impacted by a fungicide application at VT:

Plants per acre (A)

The final number of plants per acre is largely determined through a combination of seeding rate, seed quality, seed germination, soil, and environmental characteristics at planting and germination.

IMPACT: A fungicide applied at VT would not have any impact on plant population.
**Ears per plant (B)**

Ears per plant are determined by the 5th or 6th leaf stage. Ear shoots are visible by dissection at V10. The primary ear will form at the 12th to 14th node depending on hybrid, with sub apical ears forming on lower nodes. Although ear shoots are initiated on all aboveground nodes except the upper five to nine nodes, usually only one ear develops kernels.

**IMPACT:** A fungicide applied at VT would not impact the maximum number of ear shoots per plant or how many ears receive priority from the plant and develop into harvestable ears.

**Rows per ear (C)**

The maximum number of rows around an ear is determined by V6. Hybrid genetics is instrumental in determining the potential number of rows per ear. Severe environmental factors do have a negative influence at this time of development.

**IMPACT:** A fungicide applied at VT will not increase the number of rows around an ear since this is determined significantly earlier.

**Kernels per row (D)**

The maximum number of kernels per row is determined between V12 and tasseling (VT). The potential number of kernels that exist are highly dependent on growing conditions prior to silking (R1) while the number of harvestable kernels is in response to conditions during and after silking.

If stress occurs around the pollination window, the synchronization between pollen shed and silk receptivity may not align resulting in reduced pollination and fertilization. Moisture stress causes silk emergence to slow while pollen shed accelerates. Some kernels will simply not develop due to a failure in pollination or fertilization. Kernels can be aborted in response to stress from R1 through the milk stage (R3). Abortion typically occurs in the “tip” kernels first because those were the last to pollinate and are therefore the first to be expended.

Although nearly all potential kernels (spikelets) have been differentiated by R1 (silking), the ear is only at the beginning of a rapid elongation period. In fact, researchers document that ear size is only 40% of final ear size at R1 (silking). Maximum ear length is actually achieved at approximately twelve days after silking. See Figure 1.

Pre-silk ear growth determines the capacity of an ear shoot to set kernels. Any stress experienced by the plant prior to silking could interfere or reduce the capacity of the ear to set kernels, i.e. the maximum number of kernels is reduced. The beginning of silk exsertion is the most sensitive time frame for determining actual kernel number. Stresses could include factors such as high plant populations, moisture stress, pesticide stress, etc.
Reduced ear length occasionally could result in what some call the blunt ear syndrome (BES) if the upper half of the ear was never developed (this is different than the appearance of an ear with tip kernel abortion). It is speculated that a period of fluctuating, cold temperatures may cause reduced ear size if it falls during this window coupled with other stress agents. Iowa experienced four to five nights of temperatures below 60°F during the last few days of June. This could have affected ear elongation.

**IMPACT:** A fungicide application at VT to R1 may reduce the number of aborted kernels per ear if diseases are controlled. This improved retention would be expected to be first visible in the tip kernels, as those would be the first aborted if stress was present. In terms of achievable maximum ear length, a fungicide may cause either an increase or decrease dependent on other stress variables at the time. Stunted ears are possible if stress occurs prior to or following R1; ears that are half the size of neighboring ears may occur based on when they halted in development (see Figure 1).

**Kernel weight (E)**

Kernel weights are accumulated until physiological maturity (R6) is reached (at this point a black layer is formed at the base of the kernel). Stress that occurs before R6 reduces starch accumulation in the kernel, resulting in lighter seed (lower kernel weight). The converse is true...
as well: a stress-free or minimal stress environment between R1 and R6 may cause greater starch accumulation leading to heavier kernel weights.

IMPACT: A fungicide application may increase kernel weights if stress is limited due to disease control. Corn experiencing less stress could be expected to also potentially stay greener, longer, into the fall than stressed neighbors; the plant acquires nutrients from its leaves and does not cannibalize leaf and stalk tissue as quickly.

**Summary**

Although stress inherently reduces yield, the plant has great capabilities for responding to adverse growing conditions. Yield is obviously not a result of one or two factors but instead a combination of several criteria over the entire length of the growing season. Applying a fungicide that has a 2- to 3-week window of viability is simply protecting the plant for a small window of time. If a disease condition exists during that time that significantly reduces yield, then the producer may see a yield response to a fungicide application. The number of kernels per row and kernel weight are the factors most expected to respond to a fungicide application at VT. Plant population, ears per plant, and rows per ear would respond very little, if any, to an application.

Maximum yield potential is determined by VT. After this, the focus is completely on preserving that yield potential. Late-season stress will reduce that yield potential, but nothing can increase the maximum level of what is possible. The clearest yield response to a fungicide application is expected to occur by kernel retention and/or an increase in kernel weights. We will examine 2007 data to determine where yield response occurred and whether this is directly correlated to controlling diseases for two to three weeks after tasseling and/or affecting the plants’ physiology (by improving “plant health”).

To investigate the effect of fungicides on corn production, trials were initiated across Iowa during the 2007 growing season. While it was important to collect yield data, data on disease severity were also collected in addition to data on agronomic practices. Our goal is to be able to use these data to improve fungicide application on corn recommendations in the state of Iowa.

**Materials and methods**

Plots were located in producer fields at 20 locations across Iowa (Figure 2). The trials consisted of three designs: (A) fungicide x hybrid (replicated), (B) fungicide (replicated), and (C) fungicide (side-by-side). When two hybrids were used, one would have high disease tolerance to gray leaf spot (GLS) and common rust (CR) and the other with poor tolerance, based on company ratings. Treatment 1 was a control that received no fungicide and treatment 2, received 6.0 oz/a Headline fungicide applied via ground application or aerial application at the VT or R1 growth stage. Foliar disease ratings were made late August to early September, ranging from 30-40 days after treatment (DAT). Stalk rot rating occurred in late September to early October, roughly 75 DAT.

Foliar disease pressure was assessed by counting the number of lesions or % of leaf area covered on the ear leaf, and/or leaf below, and/or the leaf above the ear. For statistical analysis, the total lesions of gray leaf spot and common rust on the ear leaf were analyzed. One hundred plants per treatment were accessed in the middle two rows of each plot in groups of 5 plants, 50 paces apart. If replicated, the 100 total plants were divided between the replicates. Gray leaf spot
lesions and common rust lesions were recorded. If above 75 lesions per leaf, a percent scale was used to determine disease pressure. A reference card with % lesions of gray leaf spot and common rust was used to determine values above 75 lesions per leaf.

Stalk rot pressure was assessed by splitting the lower 3-4 above ground nodes of 50-60 plants per treatment and rating them according to the following scale: 1 = no disease symptoms, 2 = 1 or 2 discolored nodes, 3 = 1 or 2 discolored or disintegrated nodes, 4 = >2 disintegrated internodes still with pith tissue around vascular bundles, 5 = complete disintegration of tissue. Plants were assessed in groups of 3 or 5 at least 50 paces apart. If the plot was replicated, the 50 total plants were divided between the replicates.

Results and discussion

At the time of writing these proceedings, the following disease data have been collected from a total of 20 locations across Iowa: gray leaf spot (14 locations), common rust severity (13 locations), and stalk rot severity (11 locations). Yield data will be discussed relative to the disease ratings during the conference. The following results are based on the mean leaf severity data (sum of severity on each leaf assessed/number of leaves assessed) and disease severity on the ear leaf only. Since severity was assessed in one of two ways (number of spots or % area diseased), an attempt was made to convert % area to number of spots.

Foliar disease pressure, both GLS and common rust, was greatest in southwest Iowa (Harrison County) which though unusual was probably a result of the extremely wet conditions that occurred in August. High GLS pressure occurred in Harrison county, but common rust severity was extremely low. Disease pressure in central and northwest Iowa was relatively low. Significant eyespot occurred in northwest Iowa. Stalk rot severity was similar across all locations.

Analysis of pooled mean leaf severity data across the 14 locations for which disease data were received showed that an application of Headline fungicide at growth stage VT significantly (P<0.001) reduced gray leaf spot, common rust and stalk rot severity. However, there was a significant location*treatment interaction for each type of data.

At individual locations, a fungicide application significantly reduced (P<0.001) gray leaf spot on the ear leaf at the Harrison, Keokuk 1 and Lee county locations (Figure 3). At all other locations, there was no significant reduction in GLS severity as a result of fungicide application. Common rust severity on the ear leaf was significantly reduced (P<0.001) by an application of Headline only at the Harrison and Webster county locations (Figure 4).

Stalk rot severity was significantly (P<0.05) lower in those plots sprayed with Headline in the following counties: Harrison (P=0.025), Keokuk 1 (0.005), Somers (P=0.049) and Webster (P=0.017) (Figure 5). It should be noted that in Harrison, Keokuk and Webster counties Headline applied at VT significantly impacted foliar disease. Stalk rot severity and foliar disease severity are known to be highly correlated so these results are not unexpected.
Figure 2. Locations in Iowa where experimental plots investigating the effect of fungicides on corn were located.

Gray leaf spot severity (ear leaf)

Figure 3. Mean disease severity ratings for gray leaf spot in unsprayed (spotted) and sprayed (grey) strips. Y axis scale = 0-120 gray leaf spot lesions. Stars indicate significance at the 1% (**) and 5% (*) level.
Figure 4. Mean disease severity ratings for common rust in unsprayed (spotted) and sprayed (grey) strips. Y axis scale = 0-300 common rust lesions. Stars indicate significance at the 1% (**) and 5% (*) level.

Figure 5. Mean disease severity ratings for stalk rot in unsprayed (spotted) and sprayed (grey) strips. Y axis scale = 0-5 assessment scale where 0 = healthy and 5 = completely disintegrated stalk. Stars indicate significance at the 1% (**) and 5% (*) level.
References


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