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Modeling Wheat Susceptibility to Disease

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Abstract

Fusarium Head Blight (FHB) or head scab is a disease caused by the soil-borne *Fusarium* fungus. The disease occurs frequently in southeast Kansas and can result in reductions in wheat yield and quality because of the mycotoxins developed by the fungus. Timely application of fungicides during the heading period of wheat is one option to reduce the fungus and control the infection rate. This study reports our research on use of fungicides to control head scab and improve wheat yield. We developed a model to predict wheat heading date. Accurate knowledge of wheat stage is the first step in developing a good production management tool for timely application of fungicide for disease control.

Keywords

fusarium head blight, wheat, fungicide

Cover Page Footnote

This work is supported by the USDA National Institute of Food and Agriculture, Hatch project 1003478, with partial funding from the Kansas Crop Improvement Association.

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Summary
Fusarium Head Blight (FHB) or head scab is a disease caused by the soil-borne *Fusarium* fungus. The disease occurs frequently in southeast Kansas and can result in reductions in wheat yield and quality because of the mycotoxins developed by the fungus. Timely application of fungicides during the heading period of wheat is one option to reduce the fungus and control the infection rate. This study reports our research on use of fungicides to control head scab and improve wheat yield. We developed a model to predict wheat heading date. Accurate knowledge of wheat stage is the first step in developing a good production management tool for timely application of fungicide for disease control.

Introduction
Fusarium Head Blight (FHB), or head scab, is a disease that occurs frequently in southeast Kansas. The impacts of FHB have been well documented for decades and often result in significant reductions in yield and profitability (De Wolf et al., 2018). However, the most damaging aspect of FHB is the reduction in wheat quality caused by the mycotoxin deoxynivalenol (DON or vomitoxin) associated with the disease, often rendering wheat unfit for human consumption. This leaves the producer and grain elevators with a product that needs to be segregated and hopefully is good enough to market as a feed grain. In the event of extreme infection rates, however, the grain must be destroyed because of high DON levels that render the grain unusable even as an animal feed.

Extensive research has documented the potential of controlling FHB through a management system that integrates cultivar selection, fungicide application, residue management, and crop rotations (Wegulo et al., 2015). The hard red wheat cultivar Everest has been shown to have moderate levels of resistance to FHB and is commonly planted in southeast Kansas. Application of fungicides has been shown to provide some control for fusarium infection and is most efficacious when applied near wheat heading (De Wolf et al., 2003). High humidity and rainfall during the wheat heading period create conditions for optimal development of Fusarium head blight (De Wolf et al., 2003, 2018). Therefore, knowledge of the progression of wheat development and an accurate estimation of future climate are useful management tools for timely application of fungicides for control of FHB.

Here, we report the results of experiments testing the impact of fungicides on improving wheat yield over the past three years. To reduce input costs, farmers may limit the use of fungicides. However, weather conditions in southeast Kansas during wheat flowering tend to exacerbate FHB infection in wheat. As a first step in predicting the need for fungicide, we developed a model of wheat development to predict the potential time period of wheat heading. This information can then be linked with a climate prediction model to provide farmers with a management tool to determine potential disease susceptibility for timely application of fungicides.

Experimental Procedures

Field experiments tested the impact of fungicide use on wheat in 2016, 2017, and 2018. The hard red wheat variety Everest was planted in the fall of each year in replicated plots using a Great Plains grain drill at 7-in. row spacing. The fungicide Prosaro (Bayer Crop Science, Inc.) was applied to the wheat near heading (Feekes 10-10.1) at a rate of 6 oz/a. This fungicide has been shown to provide some control of FHB when applied near heading (De Wolf, 2018). Control plots received no fungicide.

Weather information was downloaded from the Kansas Mesonet historical website (http://mesonet.k-state.edu/weather/historical/). All weather data are reported during the wheat growing season from October through June. Wheat growth models use climatic information to estimate wheat development stage. Wheat growth can be modeled using accumulated thermal time. The accumulated thermal time is calculated as the sum of daily maximum and minimum crown temperature. Some models also account for deleterious temperatures through temperature correction factors that account for temperatures that are too high or too low. In this study, we used two previously published wheat phenology models, and modified one of the models to better capture environmental growing conditions in southeast Kansas.

Results and Discussion

Wheat has distinct stages of development that are described using the Feekes scale (Lollato, 2016). The scale is a useful tool to describe wheat development and time management inputs such as fungicides and fertilizers to the appropriate growth stage. Wheat heading occurs from Feekes 10.1 (first spikelet of head is visible) through Feekes 10.5 (all heads are out of the sheath). Flowering then begins at Feekes 10.51. The critical times for application of fungicides to control FHB infection occur just prior to and at heading.

Weather at Parsons, KS, shows a distinct rainfall pattern (Figure 1), with rainfall occurring in the fall, followed by a dry winter. The wettest period occurs during the spring. Wheat planting and establishment begin in the fall. The susceptibility of wheat to low ambient temperatures varies significantly during different growing stages. During the emergence stage around October, wheat growth is optimal at daily mean temperatures above 50°F. Wheat enters a dormant period during the freezing winter. During the dormant period, wheat undergoes the process of vernalization. During this time, wheat has the greatest resistance to low temperatures, but can possibly be damaged by temperatures below 23°F and certainly below 14°F. Fortunately, during this growth stage, the growing point is protected below the soil surface. Dormancy is broken in the spring, and wheat loses cold-hardiness and begins the rapid growth stage of stem elongation. At the completion of the vegetative stage, wheat enters the reproductive stage of heading and flowering. During this stage, wheat can be very sensitive to low temperatures. This is also the critical period for fungal diseases. High humidity and warm temperatures are particularly favorable for disease infection. Control of disease during this time period is the most critical. After flowering, grain filling continues until maturation of the wheat grain.

The potential rainfall patterns for southeast Kansas have a very high probability of rainfall during the critical flowering period (Figure 1). Yield increases were observed in two of the past three years with use of Prosaro fungicide (Figure 2). In 2016, wheat yield increased from 70 to 85 bu/a with use of fungicide. In 2017, yield increased from 36 to 61 bu/a with use of fungicide. No yield increase was observed in 2018 with use of fungicide.

Acknowledgment

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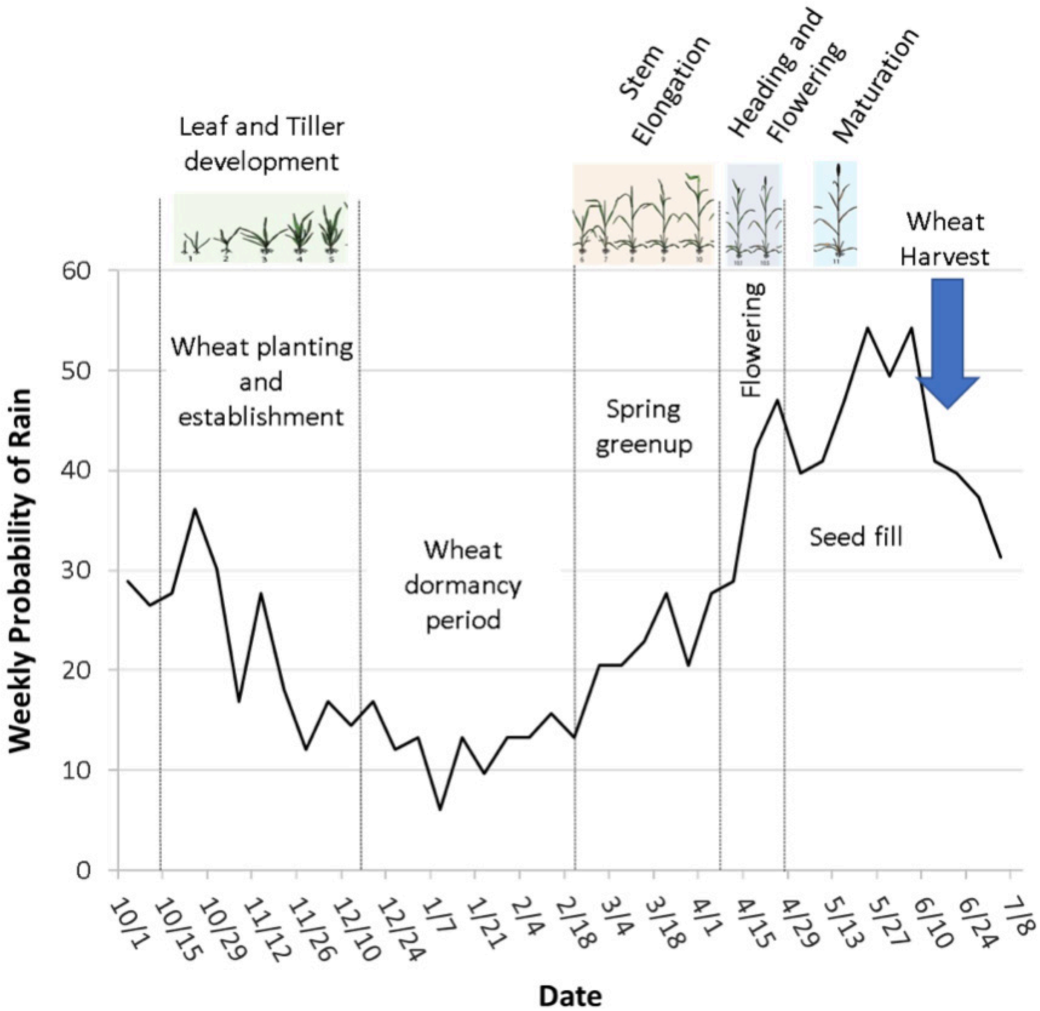

Figure 1. Wheat growth stages and probability of weekly rainfall in excess of one inch in Parsons, KS.

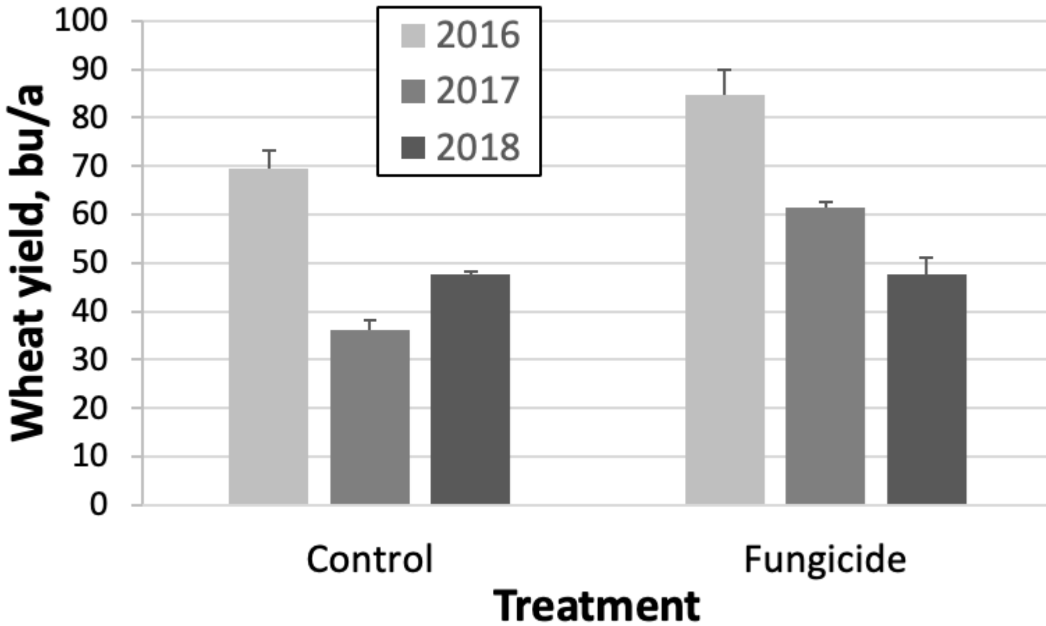

Figure 2. Impact of Prosaro fungicide use on wheat yield.