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Evaluation of Fungicide Use and Nitrogen Rate on Wheat Yield and Quality

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Summary

- When selecting a wheat variety, you seek information about the variety's foliar disease resistance and Fusarium Head Blight (FHB) tolerance, that it has high test weight (57 lb/bu or greater), and that it is high yielding.
- Use of a protective fungicide such as Caramba or Prosaro when an outbreak of FHB occurs will help lower the resultant mycotoxin, DON (deoxynivalenol), concentration.
  - Application timing (flowering to 5 days post-flowering) is critical to ensure that the fungicide will provide optimum benefit.
  - Wheat varieties with good tolerance to FHB may not show any yield or quality benefit with fungicide use but varieties that are FHB susceptible will likely show marked yield and quality improvement.
  - An application of an FHB protective fungicide also will provide protection against late- season leaf diseases such as leaf rust, stem rust and septoria.
- The response to nitrogen observed in this study indicates that optimum yield likely will occur if the N rate for the yield goal is greater than the currently employed 1 lb N/bu. Using the data from this study, the yield goal calculation should use 1.2 lb N/bu yield goal instead of the currently recommended 1 lb N/bu. As an example, an anticipated 90 bu/a yield would require 108 lb N/a.
- Test weight for FHB susceptible variety can be improved with protective fungicide.
- Protein content increased as nitrogen rate increased. Providing adequate nitrogen is key to attaining acceptable protein. Use of fungicide did not influence protein content.

Introduction

Soft red winter wheat for commodity production is annually grown on approximately 325,000 acres in Maryland and Delaware. During the past few years, production of crop quality standards desired by the milling and baking industries has become increasingly challenging for growers who want to produce high-yielding wheat. The challenges are attributed to a number of issues. 1) The frequency of region-wide Fusarium (scab) infections that cause DON mycotoxin levels to exceed milling industry thresholds has increased. 2) At harvest rainfall events causing pre-harvest sprouting, a drop in falling number, and a reduction in the baking quality of the flour may occur during any harvest season in the Delmarva region. 3) There has been a recent demand by buyers to receive higher test weight wheat, a quality factor that receives considerable emphasis by buyers but often does not mean better milling and baking characteristics. 4) The milling and baking industries have expressed concern about lower protein concentration in the wheat they are buying from Delmarva. Wheat producers are looking for ways to produce high-yielding wheat that has the quality parameters deemed important by the milling and baking industries, maximize profits, and avoid price penalties at the grain elevator. The impact of nitrogen and fungicide use has the potential to influence wheat quality and grower profits, but, this combination of management practices has not been studied on the Delmarva.

The **objectives** of this project were to evaluate the influence of spring nitrogen rates and use of a protective fungicide to manage Fusarium head blight on the yield and quality of soft red winter wheat.

Procedures

Locations:

Three testing locations during the two years of the study.

1) Central Maryland R&E Center – Beltsville (2016-2017)
2) Wye Research and Education Center (2015-2016 and 2016-2017)

Experimental design:

Split plot factorial treatment arrangement within a randomized complete block design.

Whole plots: Wheat varieties

Jamestown – a variety that is moderately resistance to Fusarium Head Blight (Year one only)

Shirley – a variety that is moderately susceptible to Fusarium Head Blight (Both years)

MD133 – a variety that is moderately resistant to Fusarium Head Blight (Year two only)

Factorial split plots: Spring nitrogen rate (Factor A) X Fungicide at Feekes growth stage 10.5.1 or within 5 days post-Feekes 10.5.1 (Factor B).

Factor A = spring applied nitrogen rates (6) in split applications at Feekes growth stage 3-4 (greenup application) and Feekes growth stage 6 (jointing application) N rates = 0, 50, 75, 100, 125, and 150 lb N/acre. One-half of each N rate was applied at each application date.

Factor B = @ Wye - Caramba fungicide application (Yes or No) at Feekes 10.5.1 or up to 5 days post-Feekes 10.5.1. Caramba rate was 13.7 oz/acre applied in 20 gal water/acre at 35 PSI.

@ Beltsville – Prosaro fungicide application (Yes or No) at Feekes 10.5.1 or up to 5 days post-Feekes 10.5.1. Prosaro rate was 6.5 oz/acre applied in 20 gal water/acre at 35 PSI

Field activities:

Site	Previous Crop	Tillage	Fall Fertility	Plant Date	Spring N	Herbicide	Fungicide	Harvest Date
Wye 2015-2016	Corn Stalks chopped	No-till Great Plains no-till drill	30 lb N/a per FSNT P_2O_5 (80 lb/a) and K_2O (50 lb/a)	Oct. 9. 2015	1st Mar 3, 2016 2nd Mar. 23, 2016	Harmony Extra SG Mar. 19, 2016	Caramba Apr. 28, 2016 Jamestown May 5, 2016 Shirley	June 27, 2016 MF 8XP plot combine
Wye 2016-2017	Corn Stalks chopped	No-till Great Plains no-till drill	30 lb N/a per FSNT; 16 lb S/a Both at planting	Oct. 14, 2016	1st Feb. 21, 2017 2nd . Apr. 10, 2017	Harmony Extra SG Mar. 27, 2017	Caramba May 3, 2017 Both varieties	June 27, 2017 MF 8XP plot combine
Beltsville 2016-2017	Corn Stalks chopped	No-till Great Plains no-till drill	No fall N; Other nutrients per soil test recs.	Oct. 5, 2016	1st Feb. 21, 2017 2nd . Apr. 7, 2017	Harmony Extra SG Mar. 28, 2017	Prosaro May 4, 2017 Both varieties	June 21, 2017 MF 8XP plot combine

Measured variables:

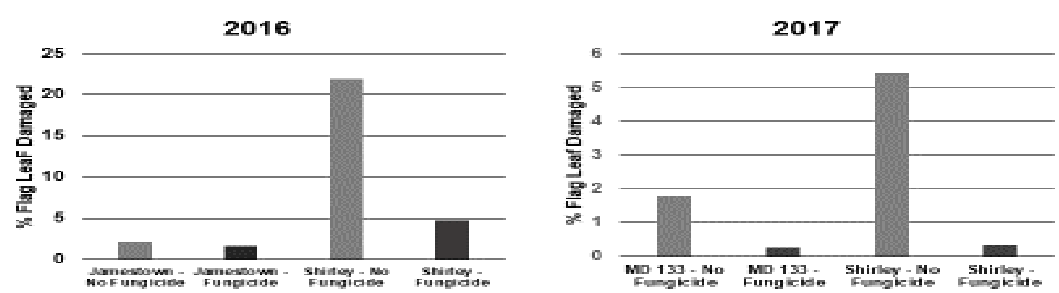
1) Visual disease assessments (Dr. Kleczewski team did this) were made at flowering and 2-3 weeks after flowering to measure foliar disease complex and head disease incidence and severity.
2) Plant height was measured and lodging amount was assessed.
3) Yield measurements, grain moisture content and grain test weight for each plot were collected when the wheat was harvested.
4) Grain quality samples were collected at harvest to measure:
    a. DON (used to measure amount of mycotoxin present for different fungicide treatments).
    b. Protein concentration of grain (used to measure influence of nitrogen rate on this grain quality parameter).
    c. Falling number (used to measure presence of pre-harvest sprouting and if it caused flour damage).

Results – Agronomic Characteristics

Foliar Diseases

The formation of leaf diseases (powdery mildew, leaf rust, septoria, etc.) on the vegetation of wheat can influence its performance particularly when the flag leaf becomes infected. Both years, assessments for leaf diseases were done a few days after flowering. Those results are shown in Figure 1. Conditions for leaf disease infection were more favorable during 2016 than 2017 (Figure 1). During 2016, Jamestown, a variety with good resistance to the leaf disease complex, had no differences in leaf disease damage on the flag leaf regardless of fungicide use. Shirley, a variety considered susceptible to the leaf disease complex, had a significant amount of flag leaf damage when no fungicide was used (Figure 1). Additionally, Shirley exhibited an increase in flag leaf damage as nitrogen rate increased (data not shown). A reduction in flag leaf damage for Shirley occurred with fungicide but even in this situation, it exhibited more flag leaf damage than Jamestown. During 2017 when less disease infection occurred, both MD 133 and Shirley had significant reductions in flag leaf damage with fungicide (Figure 1). And, as occurred for Shirley the previous year, both varieties during 2017 experienced more flag leaf damage as nitrogen rate increased (data not shown).

Figure 1. Foliar disease complex measured during 2016 and 2017 for wheat varieties with and without Caramba fungicide to provide 1) late season foliar leaf disease suppression and 2) Fusarium Head Blight protection.



Fusarium Head Blight – DON Formation

Fusarium Head Blight (FHB) is considered by agronomists and pathologists to be the most significant and damaging disease of soft red winter wheat. To minimize the damaging effects caused by this disease, there are some recommended practices including 1) planting FHB tolerant varieties (no variety is 100% resistant), 2) avoid planting into corn residue (not practical where a corn-soybean rotation is dominant), and 3) timely application of a protective fungicide. When planting into corn residue, the risk of having an FHB infection increases significantly when weather conditions at flowering are suitable. Thus, another recommendation for farmers is to be aware of the risk for FHB infection. Awareness helps producers determine if and when a protective fungicide is needed. Risk potential can be monitored during the period when wheat is most susceptible at the website, http://www.wheatscab.psu.edu/riskTool.html. During 2016, between the period May 3 and May 14, the FHB infection risk at the study site was high each day. Fungicide application to the FHB susceptible variety, Shirley, occurred on May 5. High risk of FHB infection also existed during early to mid-May 2017. Fungicide applications to the varieties occurred May 3 and 4, 2017 at Wye and Beltsville, respectively. During both years, fungicide application was considered timely.

To verify that Fusarium infection occurred, samples of harvested wheat were sent to University of Minnesota laboratory for DON analyses (Figures 2 and 3). The dark black line in each chart indicates the 1.25 ppm DON concentration that sometimes is given a premium by buyers if DON is at or below that level. Generally, wheat buyers will either reject or heavily penalize wheat with DON above 2 ppm. Jamestown (2016) had very low DON concentrations across the N rates regardless the use of fungicide (Figure 2). However, Shirley with no fungicide expressed increasing amounts of DON as N rate increased (Figure 2). And, when fungicide was used with Shirley, DON increased as N rate increased but the level never exceeded 1.25 ppm (Figure 2). The increase in DON as nitrogen increased was surprising and indicated that nitrogen may enhance the expression of this harmful mycotoxin. For 2017, FHB infection was greater at Wye than Beltsville (Figure 3). Unlike 2016, nitrogen had no influence on the amount of DON that formed at either location. At Beltsville during 2017, the amount of DON formation for varieties was below the 1.25 ppm standard. And, DON concentration was less when fungicide was used. At Wye during 2017, Shirley had a greater level of infection than MD 133 (Figure 3). Shirley, with the use of fungicide, had a significant decrease in DON but still remained greater than 2 ppm, a level that likely would result in rejection of the wheat.

Figure 2. Amount of DON mycotoxin (PPM) in Jamestown and Shirley wheat with and without protective fungicide and over a range of nitrogen rates during 2016. Acceptable DON concentration without price discount at the elevator is 1.25 PPM (dark black line).

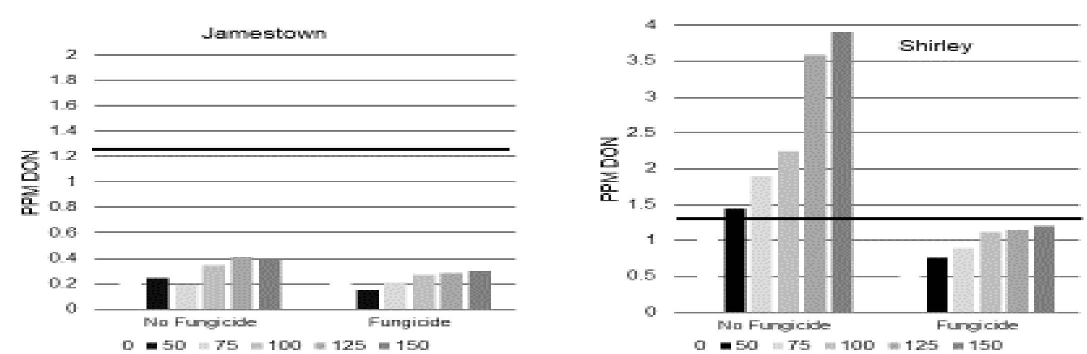
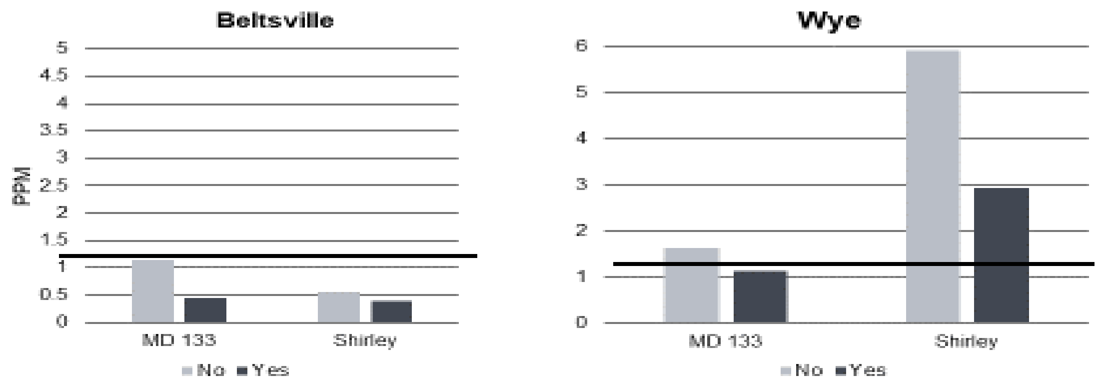


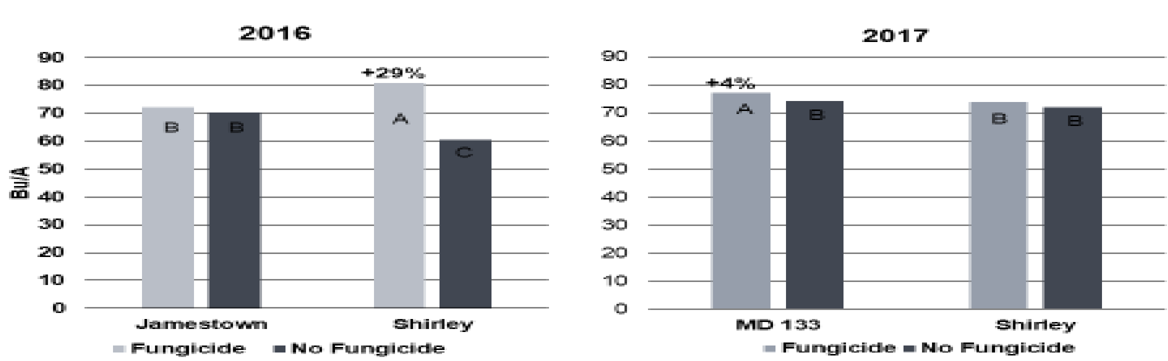
Figure 3. Amount of DON mycotoxin (PPM) in MD 133 and Shirley wheat with and without protective fungicide during 2017. Acceptable DON concentration without price discount at the elevator is 1.25 PPM (dark black line).



Yield – Fungicide Use

During 2016, yield for Jamestown and Shirley was influenced differently by fungicide use. Jamestown, a variety with good disease tolerance to leaf diseases and FHB, had no significant yield difference with and without fungicide (Figure 4). Shirley, the variety that had considerable flag damage caused by leaf diseases (Figure 1) and showed evidence of FHB infection with elevated DON (Figure 2), had a 29% improvement in yield when fungicide was used (Figure 4). During 2017, MD 133 showed evidence of little flag leaf damage caused by leaf diseases (Figure 1) and had relatively low DON levels at both locations (Figure 2). Even with these low amounts of disease pressure, this variety did respond to fungicide use with a small 4% yield increase (Figure 4). Opposite of the response for MD 133, Shirley during 2017, had more flag leaf damage than MD 133 (Figure 1) and a greater amount of DON formation (Figure 3) but did not achieve any yield benefit with fungicide (Figure 4).

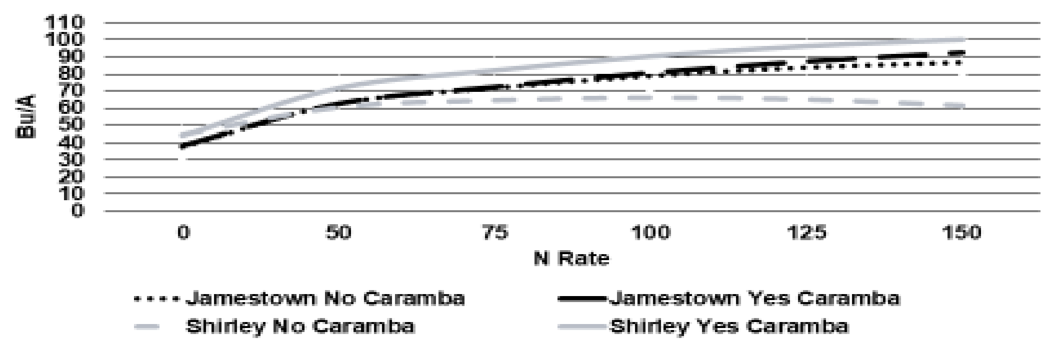
Figure 4. Yield during 2016 and 2017 for wheat varieties grown with and without fungicide to provide 1) late season foliar leaf disease suppression and 2) Fusarium Head Blight protection.



Yield – Nitrogen Response

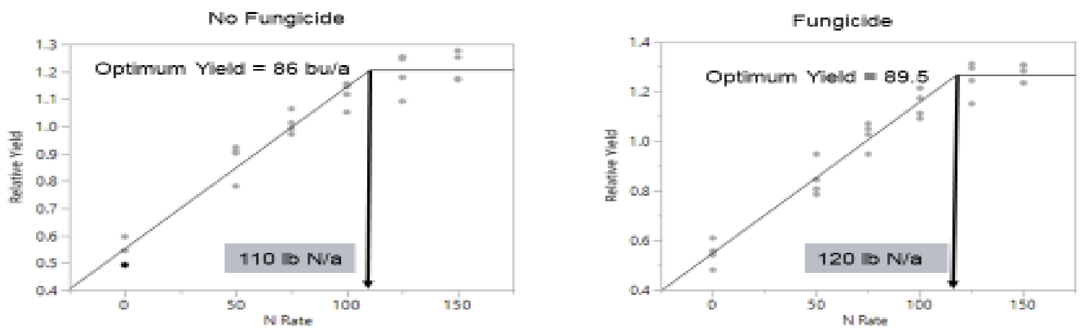
During 2016, a significant increase in yield occurred as nitrogen rate increased (Figure 4). The quadratic yield response model across the nitrogen rates for each variety that is shown in Figure 5 was developed using information from the regression analysis that was conducted. This analysis did not achieve its goal of determining where the agronomic optimum yield (the point where 1 lb N/a added no longer provided yield increase) was attained for Jamestown with and without fungicide and for Shirley with fungicide because the highest N rate of 150 lb/acre did not maximized yield (Figure 5). This quadratic model does show that as N rate increased above 125 lb/acre, the rate of yield increase lessened, and the yield differences that occurred between 125 lb and 150 lb N/a were not statistically significant. For these reasons, the data was analyzed using the linear-plateau model (Figures 6-9). The linear-plateau model allowed determination of the point where yield increase with additional nitrogen was no longer significant which allowed identification of the agronomic optimum nitrogen rate for each of the varieties with and without fungicide.

Figure 5. Quadratic yield response curve used during 2016 to model nitrogen rate response for Shirley and Jamestown wheat with and without use of fungicide for protection against 1) late season foliar disease complex and 2) Fusarium Head Blight (FHB) infection.



The yield response of Jamestown to nitrogen and fungicide during 2016 is shown in Figure 6. Jamestown did not have a significant yield response to fungicide during 2016. Its optimum yields were 86 and 89.5 bu/a without and with fungicide, respectively. And, the nitrogen rates to attain these optimum yields were 110 lb N/a (without) and 120 lb N/a with fungicide (Figure 6).

Figure 6. Linear-plateau yield response model across nitrogen rates for Jamestown during 2016 with and without fungicide.



The yield response across the N rates for Shirley during 2016 with and without fungicide is shown in Figure 7. Shirley had a large yield improvement with fungicide. This response is attributed to the protection gained with fungicide for both the flag leaf damage it experienced (Figure 1) and to the reduction in DON that occurred (Figure 2). Nitrogen was unable overcome the amount of disease pressure Shirley experienced during 2016 (Figure 7). Thus, optimum yield without fungicide was only 64.5 bu/a, and it was attained with 70 lb N/acre. When fungicide was used, optimum yield (98.5 bu/a) for Shirley was attained with 110 lb N/acre clearly showing the fungicide benefit.

Figure 7. Linear-plateau yield response model for nitrogen rates for Shirley during 2016 with and without fungicide.

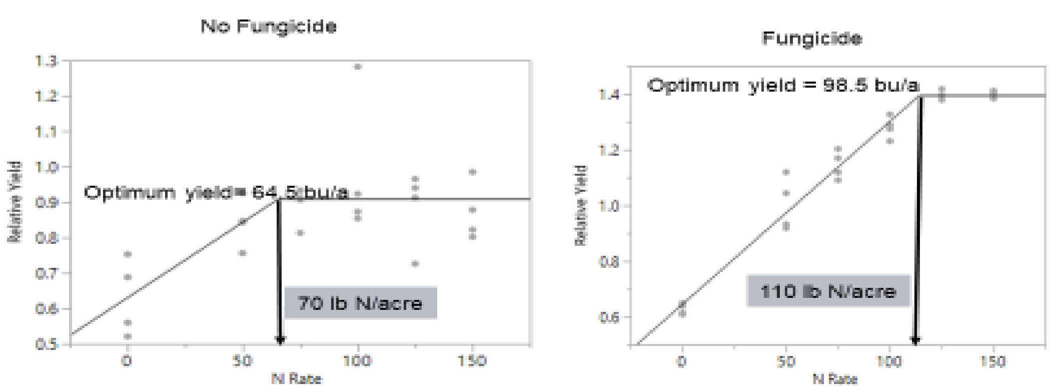
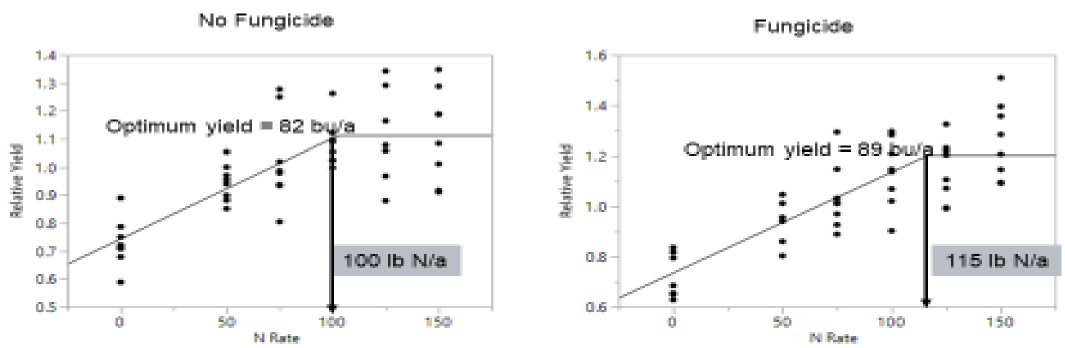


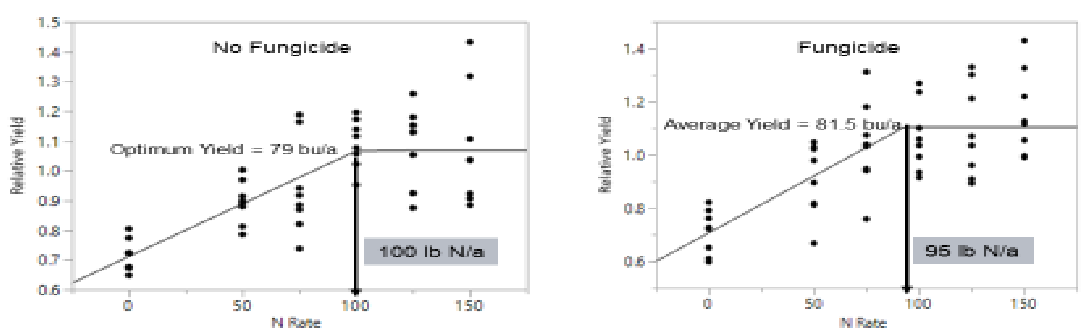
Figure 8 shows the yield response for MD 133 during 2017. Even though there was little flag leaf damage (Figure 1) and relatively low amount of FHB infection (Figure 3) on MD 133 during 2017 without fungicide, it had a sizable (nearly 10%) yield response with fungicide (Figure 8). Optimum yield (82 bu/a) was attained with 100 lb N/a without fungicide but with fungicide it was 89 bu/a attained with 115 lb N/a.

Figure 8. Linear-plateau yield response model for nitrogen rates for MD 133 during 2017 with and without fungicide.



Finally, the yield response for Shirley for 2017 is found in Figure 9. Even though Shirley had more flag leaf damage (Figure 1) and DON accumulation (Figure 3) during 2017, it did not have a significant yield response to fungicide. Its optimum yield without and with fungicide (79 bu and 81.5 bu, respectively) was similar (Figure 8) as was the N rate that attained those optimum yields (100 lb N/a without) and (95 lb N/a with fungicide).

Figure 9. Linear-plateau yield response model for nitrogen rates for Shirley during 2017 with and without fungicide.

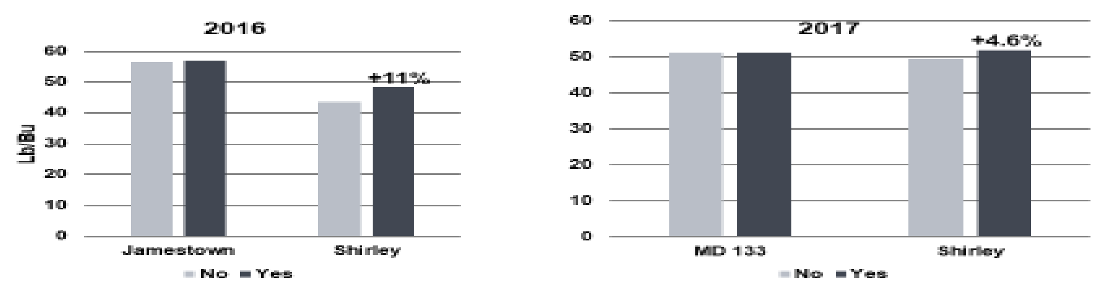


Results - Grain Quality

Test Weight

Soft red winter wheat grain buyers are emphasizing improved grain quality. One of the quality characteristics they are focusing on is test weight. In order to encourage better test weight, some buyers are providing a premium of ½ cent per 0.1 lb/bu increase above a test weight of 58 lb/bu. Though not above the 58 lb/bu industry standard, Jamestown during 2016 had 7-8 lb/bu greater test weight than Shirley (Figure 9). Jamestown had no improvement in test weight with fungicide while test weight for Shirley, which in general was very low (<50 lb/bu) improved 11% with fungicide (Figure 9). Surprisingly, during 2017 both varieties had inexplicably low test weight (<52 lb/bu) (Figure 9). Use of fungicide did not improve test weight for MD 133 but for Shirley it improved test weight 4.6%. Test weight was not influenced by nitrogen rate either year.

Figure 10. Test weight during 2016 and 2017 for wheat varieties grown with and without fungicide to provide 1) late season foliar leaf disease suppression and 2) Fusarium Head Blight protection.



Protein Content

Grain protein content followed a similar pattern both years across all varieties tested and to fungicide use. The only significant response was for nitrogen rate. And, as expected, grain protein content increased as N rate increased (Figure 11). None of the varieties tested had its protein content improved with fungicide (data not shown).

Figure 11. Grain protein content for wheat grown in this study during 2016 and 2017.