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Abstract

Farmer-reported wheat grain yield in Kansas is approximately 35 bushels per acre lower than the estimated yield potential of ~75 bushels per acre. Our objective was to determine the influence of variety selection and management on grain yield to elucidate methods to decrease the wheat yield gap in Kansas. Field experiments were conducted at three locations (Ellsworth, Conway Springs and McPherson) in Kansas during the 2015-2016 growing season to evaluate variety-specific response to nitrogen (N) and foliar fungicide. At each site, 35 to 44 winter wheat varieties were evaluated under standard management practice (SM) based on current farmer's practice of each region, versus intensive management (IM) with an additional 40 pounds of N per acre applied at Feekes growth stage 3 (GS3) and two fungicide applications (Feekes GS6 and GS10). Yield gap between the IM and SM ranged from 4 bushels per acre in McPherson to 19 bushels per acre in Ellsworth, due to a severe stripe rust (*Puccinia striiformis* Westend) epidemic. Varieties more susceptible to stripe rust had 50% cumulative probability yield gain of 13 bushels per acre across all locations studied in KS by switching from SM to IM, while resistant varieties gained 5 bushels per acre. The probability of breakeven was about two times greater in susceptible varieties as compared to resistant varieties. Our results indicate that selecting varieties with resistance to major fungal diseases can sustainably narrow the wheat yield gap in most years, reducing the need for additional fungicide. Notwithstanding, optimized management system is warranted for varieties that lack the aforementioned genetic resistance.

Keywords

Wheat yield gain, Foliar fungal diseases, Profitability, Yield gap

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Wheat Variety Response to Intensive vs. Standard Management Strategies to Narrow the Yield Gap in Kansas

A. de Oliveira Silva, A.K. Fritz, and R.P. Lollato

Summary

Farmer-reported wheat grain yield in Kansas is approximately 35 bushels per acre lower than the estimated yield potential of ~75 bushels per acre. Our objective was to determine the influence of variety selection and management on grain yield to elucidate methods to decrease the wheat yield gap in Kansas. Field experiments were conducted at three locations (Ellsworth, Conway Springs and McPherson) in Kansas during the 2015-2016 growing season to evaluate variety-specific response to nitrogen (N) and foliar fungicide. At each site, 35 to 44 winter wheat varieties were evaluated under standard management practice (SM) based on current farmer's practice of each region, versus intensive management (IM) with an additional 40 pounds of N per acre applied at Feekes growth stage 3 (GS3) and two fungicide applications (Feekes GS6 and GS10). Yield gap between the IM and SM ranged from 4 bushels per acre in McPherson to 19 bushels per acre in Ellsworth, due to a severe stripe rust (*Puccinia striiformis* Westend) epidemic. Varieties more susceptible to stripe rust had 50% cumulative probability yield gain of 13 bushels per acre across all locations studied in KS by switching from SM to IM, while resistant varieties gained 5 bushels per acre. The probability of breakeven was about two times greater in susceptible varieties as compared to resistant varieties. Our results indicate that selecting varieties with resistance to major fungal diseases can sustainably narrow the wheat yield gap in most years, reducing the need for additional fungicide. Notwithstanding, optimized management system is warranted for varieties that lack the aforementioned genetic resistance.

Introduction

Farmer-reported wheat grain yield in Kansas is approximately 35 bushels per acre lower than the estimated yield potential of ~75 bushels per acre. Although a few research studies and yield contests have reported wheat yields of ~100-120 bushels per acre in Kansas, the state average yield of ~40 bushels per acre has remained about the same for the past 30 years. This difference between average producer yield and the yield potential is known as yield gap. Previous research studies have suggested that the yield gap in the southern Great Plains is possibly due to suboptimal management practices rather than inferior genetic potential of current varieties. Yield gain from fungicide applications has been inconsistent depending on variety resistance, disease pressure, crop management and climate variability, while split-N application has increased yield and N use-efficiency in wheat in several studies. Hence, development of studies with variety-specific crop management strategies is crucial to improve yield in diverse farming systems. Furthermore, a comprehensive characterization of varieties under a wide range of cropping systems will assist producers to select varieties best suited to their area and consequently narrow the yield gap in wheat production with profitability. This study was conducted to determine the influence of variety selection and management on grain yield to elucidate methods to reduce the wheat yield gap in Kansas.

Procedures

Rainfed on-farm research studies were conducted in three locations in Kansas during the 2015-2016 growing season: Conway Springs (CO), Ellsworth (ELL), and McPherson (MP) (Table 1). Weather data were collected on a daily basis (from sowing to harvesting) from the Kansas Mesonet station located at the vicinity of the experiment sites (Table 1). The predominant soil type was Bethany silt loam in CO and Crete silt loam in ELL and MP (Table 1). At all sites, the seeding rate was 60 lb/a. Conventional tillage was performed in the fall prior to wheat sowing for all locations. Wheat field trials were sown with a 6-row Hege small plot cone sower with row spacing of 7.5 inches and plot length of 15 feet. Insect and weed occurrence was minimal and controlled with commercially available chemical products as needed.

A total of 35 to 44 wheat varieties commercially available and experimental units were tested at each location, in combination with the official K-State Wheat Performance tests (Table 2). Varieties differed in year of release, maturity range, disease resistance, and yield potential. Only the average of varieties will be discussed in this report. The experimental design was a strip plot with variety as the main factor and management practices as the sub-factor. The varieties were arranged in a randomized complete block design with three replications, while the two management practices were non-randomized and applied as strips. The management treatments tested were (i) standard management (SM), with the N rate calculated based on K-State fertilizer recommendations for approximately 70 bushels per acre yield goal and no fungicide application; and (ii) intensive management (IM), comprising the SM treatment, the additional N rate of 40 lb N/a applied as urea (46-0-0) at Feekes GS 3, and two fungicide applications at Feekes GS 6 and 10.5 for KS (Table 2). For the SM treatment, the N rate, source and timing of application slightly varied across locations depending on soil N profile and each farmer's practice (Table 2).

Plots were harvested with a small plot combine (Winterstieger Delta) and grain yield was adjusted to 12% moisture. The average yield recorded for the past 3- to 5-years prior to the establishment of the field trials in these regions were 49, 60, 62 bu/a for ELL, CO, and MP.

Statistical analysis was conducted using SAS 9.4 (SAS Institute Inc., Cary, NC). The yield differences (or yield gap) between management treatments were estimated prior to analysis and used as a dependent variable. At each location, the yield gap was estimated by subtracting the yield from the standard management (SM) by the yield from the intensive management (IM). Varieties were grouped into three categories of resistance levels to stripe rust (resistant (RES), intermediate (INT) and susceptible (SUS)) for the yield gap, cumulative probability of yield gain, and probability of breakeven analyses.

Results

The weather conditions were conducive to high wheat yield during the 2015-2016 growing season in KS. The mild temperature and adequate precipitation during the fall helped with the early vegetative growth of the crop. Although very dry conditions and few freezing events were observed during the winter, the increase of precipitation events in the spring, together with cool temperatures, promoted a good grain filling period. However, the latter conditions also benefited the occurrence of the stripe rust disease (*Puccinia striiformis* Westend).

The average yield across all varieties for each management treatment at each location was 73 and 54 bu/a, 74 and 68 bu/a, and 66 and 62 bu/a, respectively for the IM and SM management practices in ELL, CO, and MP locations (Table 2). The minimum and maximum yield observed when averaged for all varieties and management treatments at each location were 24 and 126 bu/a in ELL, 45 and 96 bu/a in CO, and 30 and 97 bu/a in MP.

This large yield variability was due to the variety differences in resistance levels to stripe rust, and consequently in response to the fungicide applications. At all locations, varieties that are more susceptible (SUS) to stripe rust or have intermediate (INT) susceptibility to stripe rust had larger yield gaps than resistant (RES) varieties. One example of the yield obtained under IM and SM for different wheat varieties in the ELL location is shown in Figure 2. Yield gain was significantly greater in varieties susceptible to stripe rust as compared to resistant varieties. The greatest yield gap of ~19 bu/a was observed in the ELL location, possibly due to the severe stripe rust epidemics relative to CO and MP locations with yield gap of 6 and 4 bu/a, respectively, during the growing season (Figure 3).

Likewise, probability of yield gain resulting from the IM treatment was larger for susceptible than for resistant varieties (Figure 4). Susceptible varieties had 50% cumulative probability yield gain of 13 bu/a across all studied locations in KS by switching from SM to IM, while resistant varieties gained 5 bu/a. Additionally, stripe rust decreased late-season green canopy cover in susceptible varieties from as much as 99% under IM to 56% or less for the SM (Figure 5). On average of the three locations, the probability of breakeven was about two times greater in susceptible varieties as compared to resistant varieties (42 vs. 21%) (Figure 5). Breakeven probability (%) was estimated using $4/bu wheat price and total nitrogen and fungicide cost of $52/a.

Preliminary Conclusions

Our results indicate that selecting varieties with resistance to major fungal diseases may narrow the wheat yield gap in Kansas most years, potentially reducing the need for additional fungicide. On the other hand, intensive management may be a viable alternative for varieties that lack the aforementioned genetic resistance. This study is an initial step towards reducing the current yield gap in wheat production by assisting producers to implement variety-specific management.

Table 1. Site information

Location	Coordinates	Sowing date	Harvesting date	Previous crop	Cum PPT (in.)	Cum ET (in.)
Ellsworth	38°34'36.16"N 98°18'44.78"W	10/9/2015	7/19/2016	Wheat	20	674
Conway Springs	37°27'34.94"N 97°37'43.33"W	10/13/2015	6/7/2016	Soybean	30	793
McPherson	38°15'56.99"N 97°35'34.04"W	10/7/2015	6/28/2016	Wheat	20	772

Note: There were no solar radiation data available for the fall period in Ellsworth, therefore average evapotranspiration in this location represents values from January to June (harvesting).
Plot coordinates, sowing and harvesting dates, previous crop, cumulative precipitation (Cum PPT) in inches and cumulative evapotranspiration (Cum ET) in inches at each location during the 2015-2016 growing season in Kansas.

Table 2. Number of varieties tested, total nitrogen (N) rate (lb/a) and average grain yield (bu/a) at 12% moisture adjustment for standard management and intensive management at each location in the 2015-2016 growing season in Kansas

		N rate (lb/a)		Grain yield (bu/a)	
Location	Varieties #	IM	SM	IM	SM
Ellsworth	35	155	115	73	54
Conway Springs	44	244	140	74	68
McPherson	44	135	95	66	62

Differences in total N rate reflect variation in soil NO_3-N profile at each location.
SM = Standard management.
IM = Intensive management.

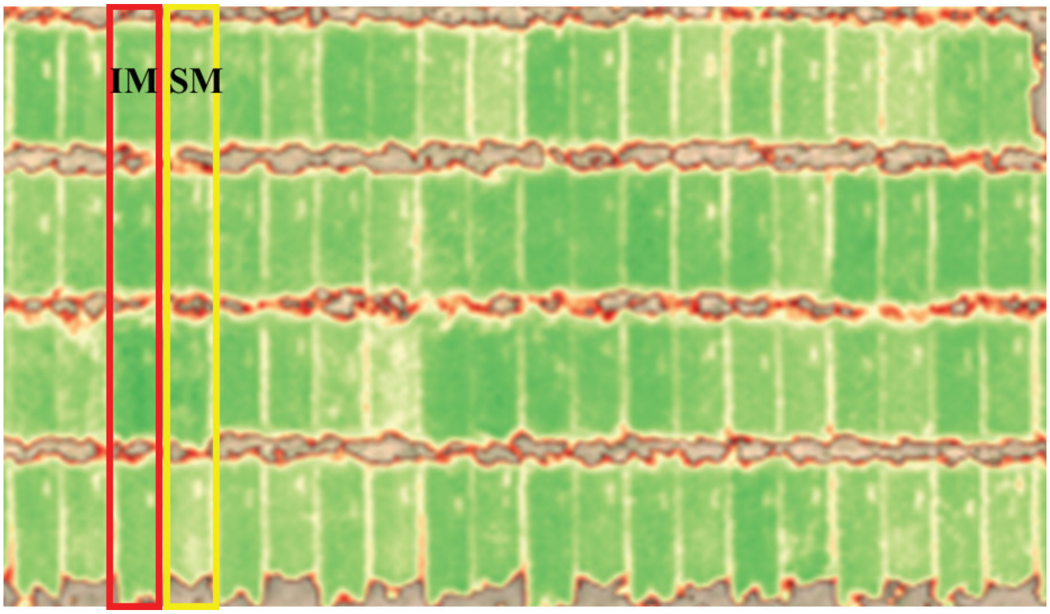

Figure 1. Paired plot design and experiment layout for three locations Conway Springs (CO), Ellsworth (ELL), and McPherson (MP) in Kansas, 2016.

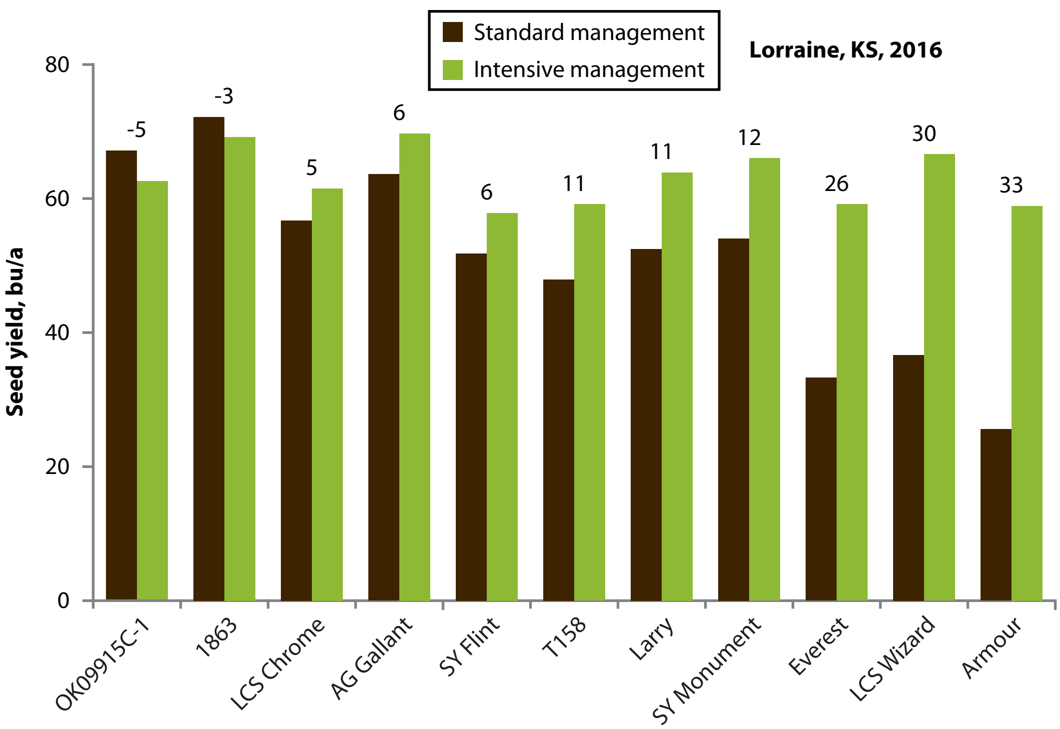

Figure 2. Wheat grain yield as affected by variety and management strategy in Lorraine and Ellsworth, KS, during the 2015-2016 growing season. Varieties with greater susceptibility to stripe rust, such as Everest, LCS Wizard, and Armour, also show the greatest yield gap.

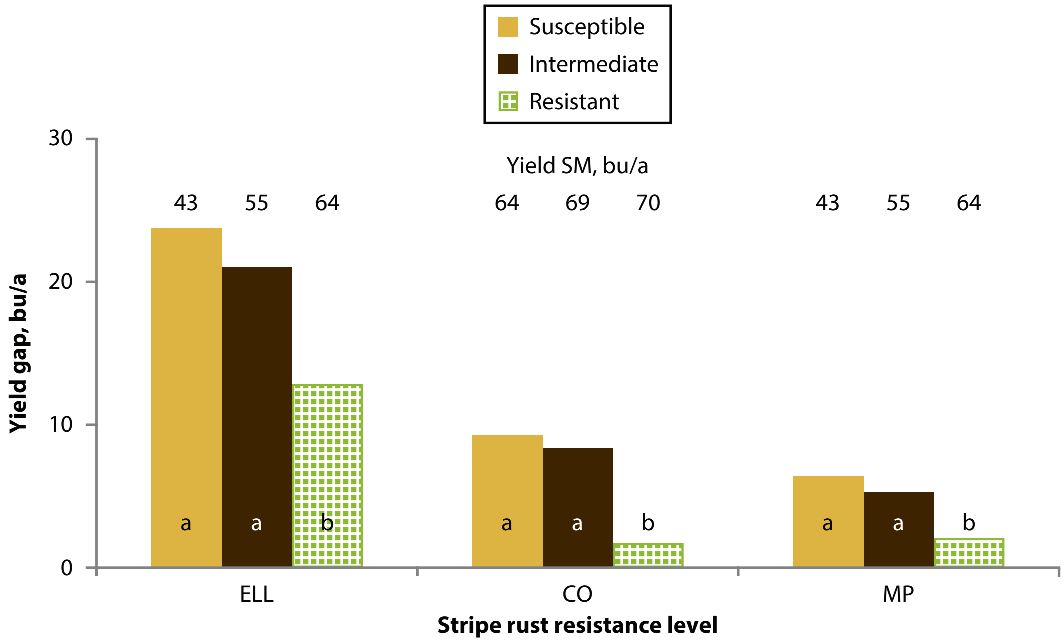

Figure 3. Yield gap between standard (SM) and intensive management (IM) for different variety resistance levels to stripe rust disease at three locations in Kansas, 2016. Within location, means for each resistance level with the same letter are not significantly different at $P < 0.05$ (LSD).

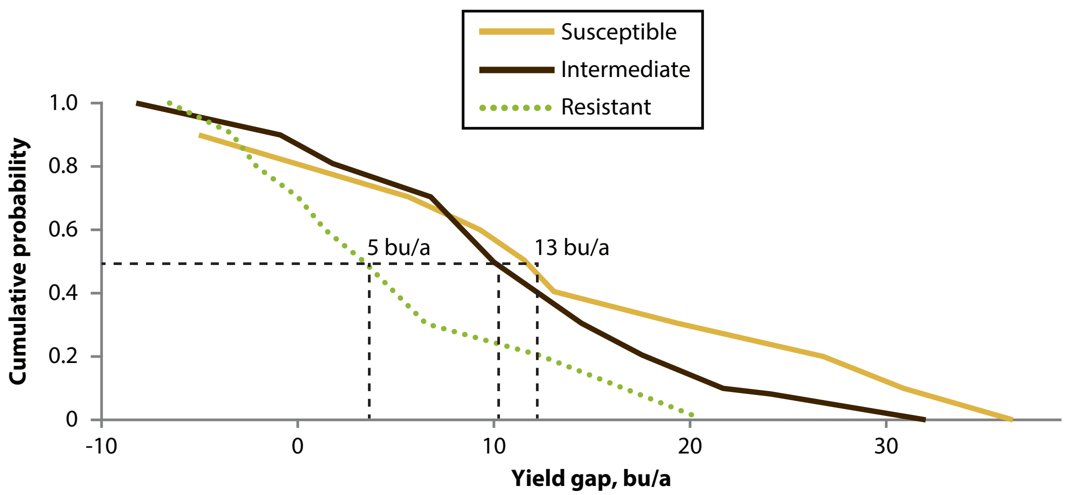

Figure 4. Cumulative probability of yield gain from standard (SM) to intensive management (IM) for different variety resistance levels to stripe rust disease at three locations (ELL, CO, and MP) in Kansas, 2016.

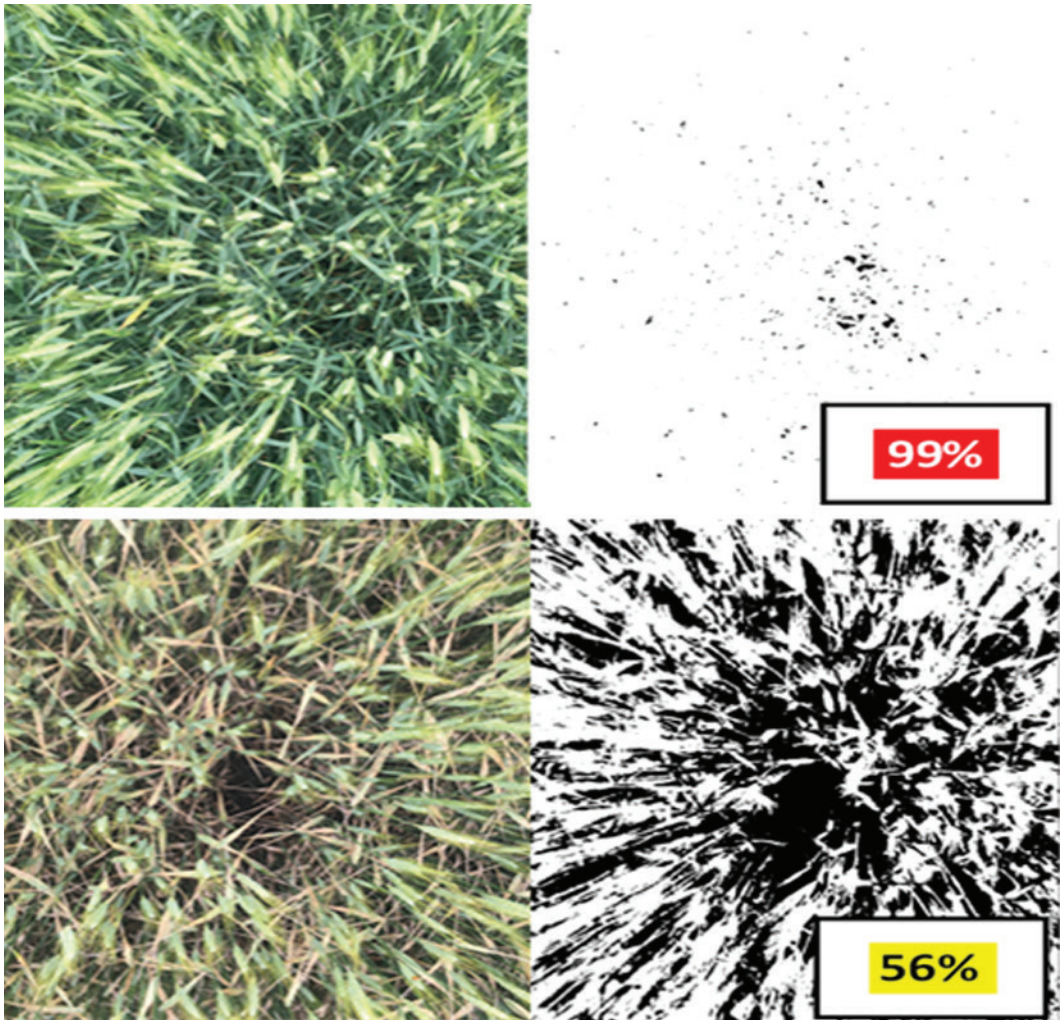

Figure 5. Comparison of green canopy coverage between intensive (IM) and standard management (SM) for a susceptible variety at the Ellsworth location in Kansas, 2016.

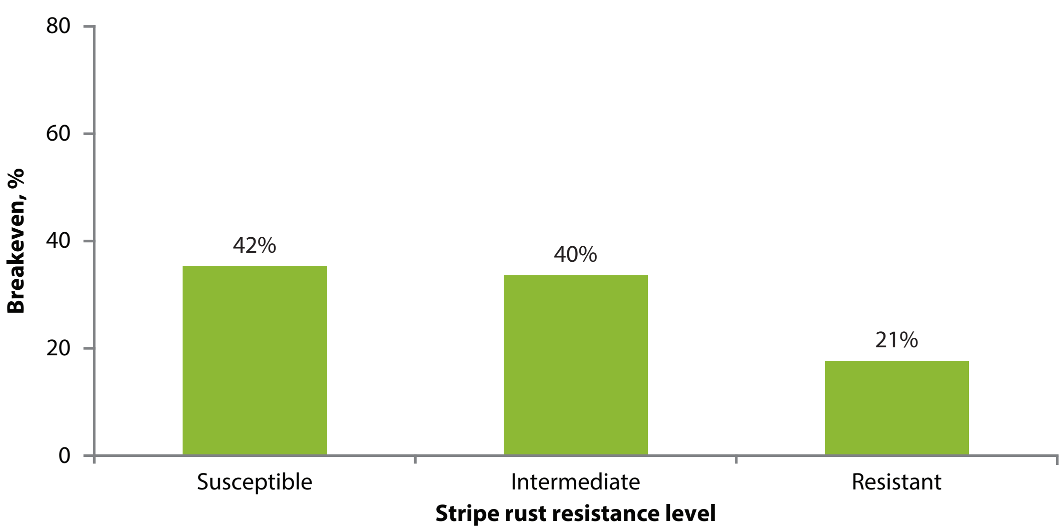

Figure 6. Probability of breakeven (%) for the additional nitrogen rate (40 lb/a) and two fungicide applications. Means for three locations Conway Springs (CO), Ellsworth (ELL), and McPherson (MP) in Kansas, 2016.