Title: Evaluation of Palisade and Alternative Fungicide Timings for Intensive Wheat Production FINAL REPORT

Dr. Cory Whaley[a] Sussex County Agricultural Agent
Dr. Nathan Kleczewski[a,b] Extension Field Crop Plant Pathologist
[a]*University of Delaware Cooperative Extension Service*
[b]*University of Delaware Department of Plant and Soil Science*
nkleczew@udel.edu ph 302-300-6962

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Project overview:

Growers in Maryland and Delaware strive to produce high-yielding, high quality wheat. Intensively managed wheat in our area has involved applying nitrogen at appropriate rates and timings and applying fungicides to control diseases, but plant growth regulators have not typically been included in these programs. Palisade is a fairly new plant growth regulator that may have a fit in intensively managed wheat in our area to increase productivity. This product offers a wide window of application for wheat producers as opposed to other growth regulators, which have narrow application windows and may injure plants if applied outside of this window. Palisade works by reducing plant height and claims to improve overall strength of the stem, thereby reducing lodging. Thus, the use of Palisade in intensively managed wheat may allow growers to further push yields by increasing nitrogen rates without a concern for lodging, particularly under irrigated conditions where water stress can be eliminated as a limiting factor to yield. However, increasing nitrogen rates could potentially increase plant disease issues, as this favors lush dense canopies early in plant development. Dense canopies trap moisture and provide an environment conducive to many plant diseases. Currently it is not known what impact Palisade and additional nitrogen may have on disease development in wheat.

The use of Palisade may also impact management of Fusarium head blight (FHB) and other wheat diseases. Concerns about vomitoxin contamination due to FHB have resulted in more growers applying fungicides prophylactically around flowering (Feekes' 10.5.1). There is concern that a single application of fungicide may not be sufficient in some high production fields where residue-borne diseases such as leaf blotch complex and powdery mildew may occur earlier in the season and potentially impact yield. Historically, fungicide programs in Delaware and Maryland were targeted at protecting the flag leaf and not the flowering head. These programs are unfortunately not efficacious for suppression of FHB. Palisade can be applied between FGS 4-7 (greenup - 2nd joint visible). Some growers and consultants are experimenting with a, "wait and see" Palisade and nitrogen application at FGS 7 (2nd joint visible) on fields that appear to have high yield potential. Including a fungicide with Palisade at this timing may provide foliar protection that could carry over until flowering (FGS 10.5.1). Thus, intensively managed wheat growers using Palisade may be able to address early season disease concerns and still use fungicides to suppress FHB at FGS 10.5.1 without sacrificing yield due to foliar diseases. The use of fungicides applied with Palisade at FGS 7 has not been evaluated. In addition, because growers are interested in Palisade use, unbiased research is needed to assess Palisade and its potential fit in Mid-Atlantic wheat production systems.

The **objectives** of this project were: 1) to examine the utility of Palisade in intensively managed wheat production systems that include different fungicide programs and nitrogen rates 2) to examine the utility of early fungicide applications at FGS 7 for suppressing diseases compared to standard fungicide application timings (FGS 8-10.5.1), with and without Palisade, 3) to determine the effect of Palisade on wheat yield under different conditions.

Progress to date and how objectives have been met:

In 2015 and 2016 the study was conducted at the University of Delaware Warrington Irrigation Research farm located in Harbeson, DE. The variety SS8500 was planted in 7.5" rows on October 27, 2014 at 1.8 million seeds / A with a no-till Great Plains precision drill. The field was turbo-tilled two times before planting to provide a suitable seedbed and to size the residue from the previous corn crop. SS8500 was chosen because it has yielded well in state variety trials, has some moderate susceptibility to leaf blotch complex and powdery mildew, and is a tall variety. Nitrogen was applied in the spring as a 50:50lbs split application of N. High N treatments received an additional application of 20lbs N at FGS 7. Fungicides were applied alone or in combination with Palisade or N according to Table 1. Wheat was rated for chemical damage, foliar and head disease, height, test weight, and yield. Each treatment was randomized into a spatial block and each block replicated four times per study. The entire study was replicated three times, twice in 2015 and once in 2016. In 2015, one study site received 5.5 additional inches of overhead irrigation from 4/20/2015 through 6/15/2015. A total of 11 irrigation events occurred over this period in time, with each event providing 0.5 inches of water.

Table 1. Overall treatment list for the studies conducted in 2015.

Treatment	Spring N	Product	Timing (Feekes)	rate (oz/A)
1	100	untreated control		
2	100	Palisade	6 to 7	10.5
3	100	Palisade + Quilt Xcel	6 to 7	10.5+10.5
4	100	Palisade FB Quilt Xcel	6 FB 8/9	10.5 FB 10.5
5	100	Palisade FB Prosaro	6 FB 10.5.1	10.5 FB 6.5
6	100	Palisade+ QXL FB Prosaro	6 FB 10.5.1	10.5+10.5 FB 6.5
7	120	untreated control		
8	120	Palisade	6 to 7	10.5
9	120	Palisade + Quilt Xcel	6 to 7	10.5+10.5
10	120	Palisade FB Quilt Xcel	6 FB 8/9	10.5 FB 10.5
11	120	Palisade FB Prosaro	6 FB 10.5.1	10.5 FB 6.5
12	120	Palisade+ QXL FB Prosaro	6 FB 10.5.1	10.5+10.5 FB 6.5

FB= Followed by. Experiment replicated under irrigated and dryland conditions.

Summary of Important Findings

Our data indicate that Palisade® applied at the rates and timings used in this study can significantly reduce plant heights compared to untreated controls. Across the three sites, Palisade reduced plant heights by approximately 8% (Figure 1). Inclusion of Quilt Xcel at FGS 8 resulted in increased plant height compared to other treatments containing Palisade; however, these plants were still shorter than controls by approximately 3%. It is possible that this increase in height was due to an effect of the fungicide on plant nutrient allocation and growth, as well as disease severity. Statistical analysis indicated that plant height was correlated with lower disease levels and higher yields (Table 2).

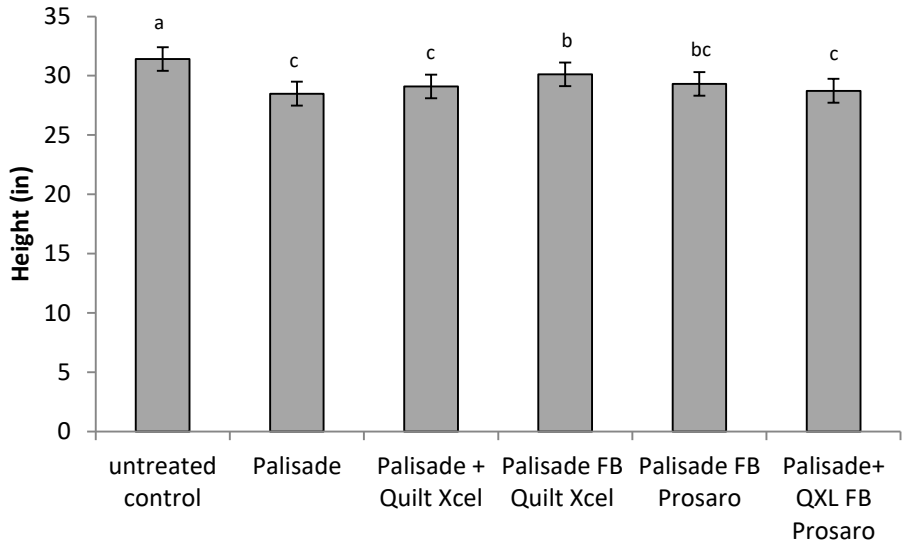
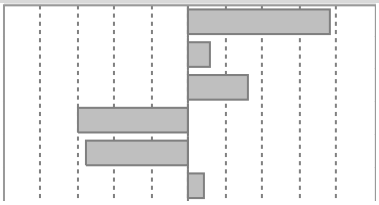


Figure 1. The effects of Palisade and fungicides, averaged across nitrogen treatments, on heights of soft red winter wheat variety SS8500. Different letters indicate statistically significant differences using Fisher's Protected LSD (α=0.05).

Table 2. Spearman's correlations, which show the relationship between pairs of variables. A positive relationship indicates that one increases at the same time the other increases. Negative values indicate one increases while the other decreases. The closer to 1 or -1 the stronger the relationship.

Variable	by Variable	Spearman ρ	Prob>|ρ|
bu/A	Test Weight	0.7693	<.0001*
Height (cm)	Test Weight	0.1179	0.1731
Height (cm)	bu/A	0.3272	<.0001*
Disease sev	Test Weight	-0.5922	<.0001*
Disease sev	bu/A	-0.5480	<.0001*
Disease sev	Height (cm)	0.0877	0.3065



Data showed that Palisade, when used alone, may have yield and disease penalties under the conditions tested. All treatments receiving fungicide, regardless of product or timing, resulted in increased yields compared to controls and the Palisade only treatments (Figure 2). Similarly, disease was elevated in Palisade only treatments when compared to those containing a fungicide, particularly when additional nitrogen was added at FGS 7 (Figure 3). Palisade impacts gibberellin activity in the plant, which could have an impact on aspects of plant growth and defense. Consequently, if growers are currently investing in Palisade application, these data indicate the incorporation of a foliar fungicide application may be beneficial. FGS 7 fungicide applications had no significant stand alone benefit on yields. However, 2 pass systems using this timing plus a FGS 10.5.1 application resulted in greater yields than the FGS 10.5.1 application alone. Fungicides containing a QOI mode of action such as Quilt Xcel typically have better residual disease control than fungicides containing a DMI mode of action only (e.g. Tilt). In this study, Leaf blotch complex (LBC), consisting of Stagonospora leaf blotch and tan spot, was the dominant disease. There was light powdery mildew in 2016, but this did not persist in the canopy after FGS 8 and therefore was not ratable. In addition, FGB and glume blotch were not present at ratable levels. LBC is residue borne and typically moves slowly from the base of the plant up the canopy over time. FGS 7 applications of Quilt Xcel appear to have offered some additional reduction in foliar disease potential, which may have contributed to cleaner overall canopies and improved yields in the 2 pass

system (approximately 15 bu/A greater than untreated controls or Palisade only treatments). We did not detect any significant impact of FGS 8 vs FGS 10.5.1 applications on foliar disease control or yield, suggesting that either timing can be used for suppressing LBC under some conditions. These data also indicate that growers could see a dual benefit from a FGS 10.5.1 fungicide application without significant impact on foliar disease control and yield, while simultaneously suppressing FHB.

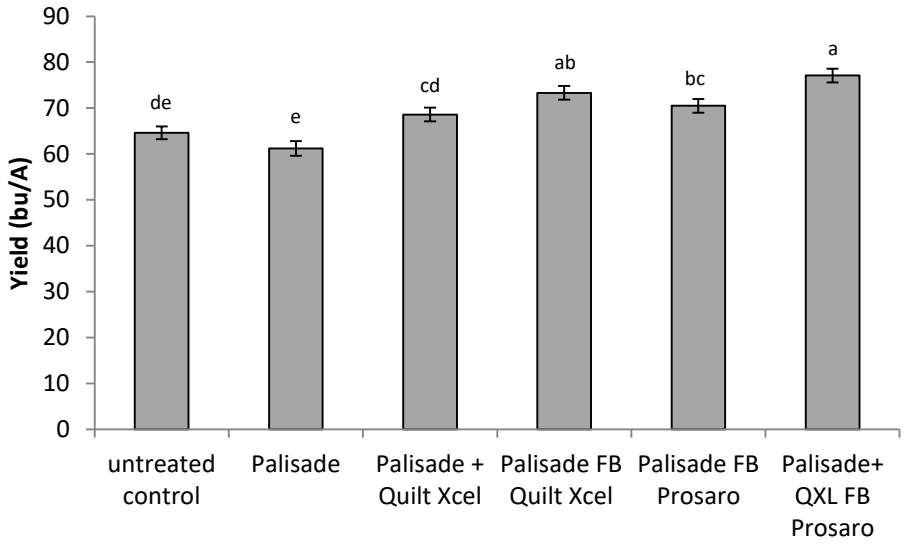


Figure 2. The effects of Palisade and fungicides averaged across treatments on yields of the soft red winter wheat variety SS8500. Different letters indicate statistically significant differences using Fisher's Protected LSD (α=0.05).

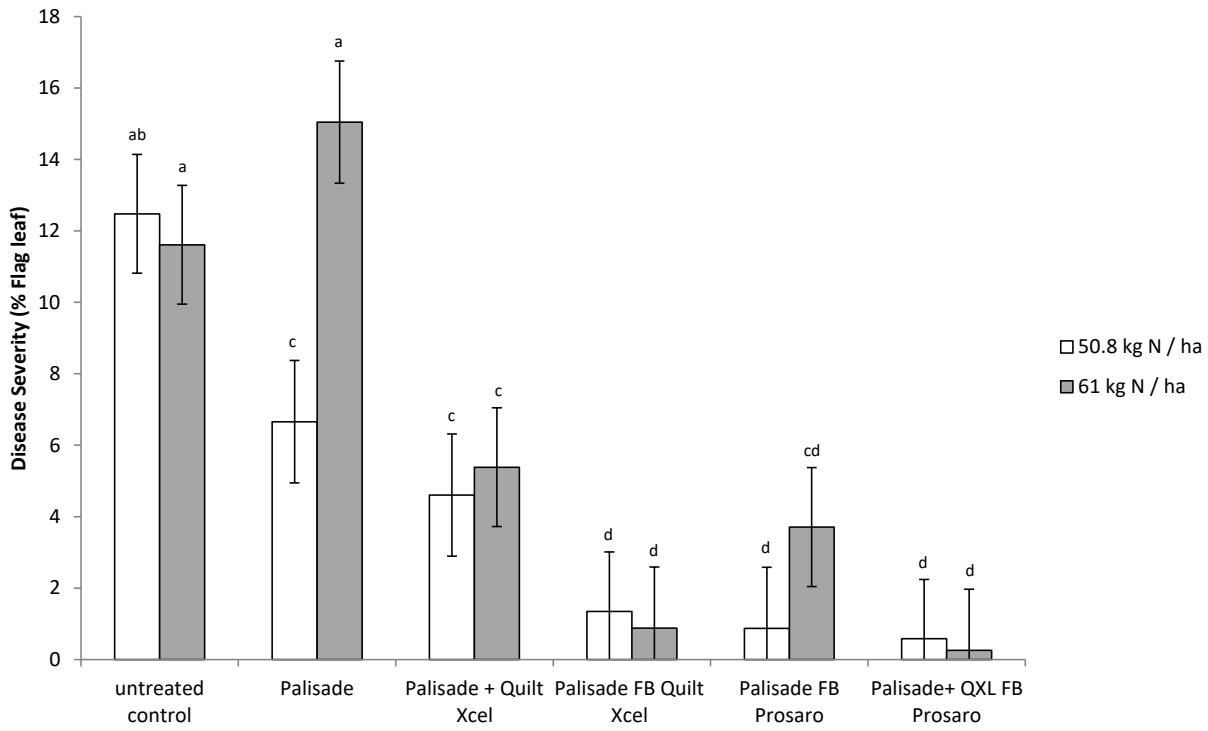


Figure 3. The effects of Palisade, nitrogen, and fungicides on foliar diseases of SS8500 . Different letters indicate statistically significant differences using Fisher's Protected LSD (α=0.05).

Lastly, test weights were influenced by treatment but not by the additional nitrogen application, and followed a similar trend to yield (Figure 4). The 2 pass fungicide program resulted in a 6% increase in test weight compared to untreated to controls. All other treatments containing fungicides, regardless of timing or application, increased test weights over untreated controls or Palisade only treatments. Figure 4.

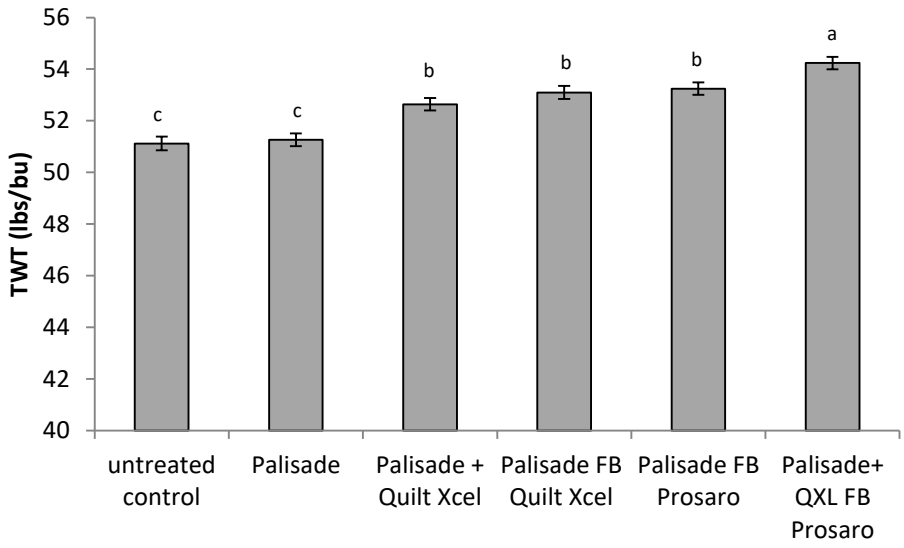


Figure 4. The effects of Palisade and fungicides on test weights of the soft red winter wheat variety SS8500. Different letters indicate statistically significant differences using Fisher's Protected LSD (α=0.05).

We used our data set to estimate net returns of the various programs across nitrogen treatments (Table 3). Our data indicate that the use of fungicides in conjunction with Palisade can result in net losses at prices less than $4.00 / bu. When prices exceed $5.00 / bu the 2 pass fungicide program including the FGS 10.5.1 application and the single pass, FGS 8 fungicide program returned a profit ($11.81 and $6.08 / bu, respectively). These data demonstrate that Palisade use can be profitable in the absence of lodging when commodity prices increase over $5.00 / bu. However, our net returns do not include potential losses from lodging, as none was observed in these studies. In cases where lodging occurs, Palisade use may provide additional yield benefits and therefore increase overall returns. Situations where this may occur include settings where poultry manure or other manure is spread heavily, excessive N rates, tall varieties with susceptibility to LBC are used, and with fields or a history of lodging issues. Growers not encountering these situations may not benefit from incorporation of Palisade in their SRWW programs.

Table 3. Net returns for the various chemical programs used in this study . No interactions of Study or main effects of study were detected. Therefore data were assessed across all sites (N=138). Different letters indicate statistically significant differences using Fisher's Protected LSD (α=0.05).

Treatment	Timing (FGS)	Rate	net increase (bu)	$3.00 / bu	$4.00 / bu	$5.00 / bu
untreated control			0.00 d	$0.00 a	$0.00 a	0.00 ab
Palisade	6 to 7	10.5	-3.26 d	-$28.95 c	-$32.21 c	-35.48 c
Palisade + Quilt Xcel	6 to 7	10.5+7	4.01 c	-$17.01 bc	-$13.01 ab	-9.02 b
Palisade FB Quilt Xcel	6 FB 8/9	10.5 FB 10.5	8.72 ab	-$11.35 ab	-$2.64 ab	6.08 ab
Palisade FB Prosaro	6 FB 10.5.1	10.5 FB 6.5	5.97 bc	-$22.94 bc	-$16.97 bc	-11.00 b
Palisade+ QXL FB Prosaro	6 FB 10.5.1	10.5+7 FB 6.5	12.50 a	-$13.19 b	-$0.69 a	11.81 a

Preliminary results of this project were presented as a poster at the APS Potomac Meeting held in Richmond VA in 2016. The MSGUB was noted in the Acknowledgements as the funding source, and the MSGUB logo used with permission.