Applied Research Results on Field Crop and Vegetable Disease Control

2015

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The research described in this book was designed to evaluate strategies for improving disease control and the efficiency of crop production in Delaware and Maryland. Commercial products are named for informational purposes only. Delaware Cooperative Extension and University of Delaware, do not advocate or warrant products named nor do they intend or imply discrimination against those not named.

The primary purpose of this book is to provide cooperators and contributors a summary of the results of field research. Many data summaries and conclusions in chapters from this book have been submitted to the American Phytopathological Society for publication in *Plant Disease Management Reports* in 2015. Other work may be published in other peer reviewed scientific journals as appropriate. Reprints of these publications are available upon request.

The authors would like to thank the collaborators, farm crews at UD and UMD, funding groups, and industry for assistance with many aspects of these projects. Without your help, the applied plant pathology programs would not be possible.

Table of Contents

Small Grains

Wheat yields averaged 65 bu/A on 65,000 harvested acres. Overall production was estimated at 4,225,000 bu. Harvested acres was down from 85,000 in 2013, a likely result of high input costs in combination with poor commodity prices. A hot, dry season during critical stages in growth reduced overall yields, which were down approximately bu / A from 2014. Cereal leaf beetle outbreaks also contributed to lower than average yields in many fields. Leaf blotches, predominantly tan spot, were the most common diseases encountered in Delaware and arrived late in the growing season. Incidence of powdery mildew and rusts was minimal in 2015. Fusarium head blight was present at extremely low levels as the conditions were dry around flowering. Viral diseases were largely absent. Powdery mildew was present early in some fields but hot, dry conditions quickly minimized its impact and spread. The largest issue for production was persistent rains after dry down, which reduced test weights and falling numbers.

Barley yields averaged 80 bu/A on 22,000 harvested acres. Overall production was estimated at 1,760,000 bu. Diseases overall were not an issue in barley due to dry conditions during much of the growing season. Some reports of net blotch and spot blotch at low levels occurred early in the growing season but did not require control. Powdery mildew also was detected in susceptible varieties early but did not likely impact yields due to hot, dry growing conditions.

Host (*Triticum aestivum* Dynagro 'Shirley')
Fusarium head blight; *Fusarium graminearum*

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Effect of Experimental Fungicides on Fusarium head blight in Delaware, 2015.

The trial was conducted at the Carvel Research and Education Center located in Georgetown, DE. The wheat variety Dynagro 'Shirley' was planted at 1.7 x 10^6 seeds per acre on 20 Oct 14 in rows 7.5-in apart. The previous crop was corn, disked before planting. Experimental units were 5 x 23 ft. There were two untreated buffer rows between adjacent plots and 5-ft of untreated wheat at plot ends. Fertilization and weed management practices was applied following University of Delaware Cooperative Extension recommendations. The experimental design was a completely randomized design with 4 treatment replications. Fungicide applications were applied with a CO_2 pressurized backpack sprayer with three Teejet 8002 flat fan nozzles spaced 20-in apart and angled forwards at 30° on an offset handheld boom. Applications were made at 35 psi at a pace to deliver 20 gal/A of spray solution. Treatments were applied at 16 May FGS 10.5.1. A suspension containing 5 x 10^6 spores ml of mixed *F. graminearum* isolates was applied 2 hours after fungicide application, at dusk. Plots were harvested on 7 Jul and a 100 g subsample of grain harvested from each plot was evaluated for deoxynivalenol (DON). Data were analyzed by ANOVA, and Fisher's LSD at $P \leq 0.05$ was calculated for mean comparisons. Yields were calculated based on a 60 lb bushel weight and adjusted to 13.5% moisture.

Disease pressure was low despite application of *F. graminearum* spores. All fungicides reduced FHB index and DON relative to controls. All fungicides increased test weights relative to controls, though Experimental compounds 1 and 2 resulted in the greatest test weights of products tested. No effects of yield were noted. No other diseases were present in this study.

Treatment[z]	**FHB Index**		**DON (ppm)**		**TWT (lbs/bu)**		**Yield (bu/A)**
untreated control	4.37	a[y]	0.34	a	52.7	a	95.1
Prosaro 421 SC 6.5 oz	1.11	b	0.07	b	53.8	b	99.1
Caramba 90 EC 13.5 oz	0.83	b	0.09	b	53.9	b	103.7
EXP 1	0.752	b	0.09	b	54.7	c	108.9
EXP 2	0.282	b	0.1	b	54.8	c	97.8
EXP 3	1.503	b	0.13	b	53.4	b	100.2
EXP 4	1.641	b	0.12	b	53.5	b	96.8
EXP 5	0.841	b	0.13	b	53.6	b	97.2
P(F)	<0.001		<0.001		<0.0001		NS

[z] All products with NIS 0.125% (v/v)

[y] Column numbers followed by the same letter are not significantly different at *P*=0.05 as determined by Fisher's LSD.

Host (*Triticum aestivum* Agripro 'Oakes')
Leaf Blotch Complex

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Effect of Foliar fungicides and fungicide timings on powdery mildew and leaf blotch complex in Delaware, 2015.

A 16 treatment trial assessing different fungicides, timings, and adjuvants was conducted at the Carvel research and education center. The area was seeded with 1.8 million seeds / A of Syngenta Oakes on October 8, 2016 on 7.5 inch rows. Seeds were planted no till into heavy corn residue worked twice with a turbo till. Plots were arranged into 4 blocks of 16 treatments and were 5 feet wide by 23 feet long with 5 feet of boarder between plot length and 7 feet of boarder at plot ends. Treatments were applied with a 3 nozzle offset, CO_2 pressurized hand held boom set to deliver 19.3 gal/ A. The boom was outfitted with 80v02 flat fan nozzles. Treatments were applied at either Feekes growth stage (FGS) 5/6, 8/9, and or 10.5.1. Plot establishment and growth was uneven in spots due to unexpected residue or nutrient residues from the previous corn crop. This effect was not evident until FGS 5/6. To address this in the future, we are using this field only for wheat fungicide research with wheat plantings separated by a summer cover crop. Oakes was selected due to its relatively high susceptibility to powdery mildew, and moderate response to leaf blotch complex. A hard winter impacted powdery mildew, which did not appear in the region until late. Although an attempt to infest plots with field-derived powdery mildew was made at FGS 7, extreme dry weather and hot temperatures were not conducive to disease development. Supplemental irrigation was implemented after FGS 8 to encourage foliar disease. This helped with disease development somewhat, but extreme temperatures and lack of rain resulted in rapid dissipation of humidity within the canopy.

Leaf blotch complex started to develop in the lower canopy around flowering but never reached the flag leaf at ratable levels. Consequently, we did not expect to see any detectable differences in yields. A total of 10 f-1 leaves per plot were rated for leaf blotch severity. Leaf blotch consisted primarily of *Stagonospora nodourm* but low levels of Septoria and tan spot were also noted. Overall, we saw differences in treatments but no differences in yield or test weight, as expected. Due to the disease arriving late, as is typical in Midatlantic growing conditions, applications at FGS 5 were not as efficacious compared to those applied at FGS 8 or 10.5.1 and did not improve disease suppression relative to controls. Quilt Ecel Trivapro+COC applied at FGS 8 provided significantly greater levels of leaf blotch suppression when compared to Stratego YLD (FGS 5 and 8) Priaxor (FGS 5), Priaxon FB Caramba, Caramba, Twinline, and Fortix programs. No phytotoxicity was noted for any treatments.

Product[z]	**Timing (FGS**[x]**)**	**Rate (oz/A**[y]**)**	**Severity f-1 (%)**		**Yield (bu/A)**	**twt**
untreated			8.03	a*	60.6	57.0
Stratego YLD	5	2	5.21	a	65.7	56.0
	8	4	1.23	cdef	69.4	57.2
Stratego YLD + Prosaro	5 FB 10.5.1	4 FB 6.5	0.49	efg	68.7	57.5
Prosaro	10.5.1	6.5	0.75	defg	69.3	55.2
Trivapro + NIS	8	14.5	0.63	defg	62.0	57.2
Trivapro+COC	8	14.5	0.31	g	67.1	58.0
Priaxor	5	2	7.03	a	62.6	57.3
	5	4	5.18	ab	67.2	57.9
	8	4	0.33	fg	69.2	57.0
Priaxor FB Caramba	5 FB 10.5.1	4 FB 13.5	1.25	cdef	67.3	57.5
Caramba	10.5.1	13.5	1.71	cdef	68.4	56.4
Twinline	8	9	4.6	cde	65.0	56.6
Aproach Prima SC	8	6.8	0.46	efg	63.6	57.1
Quilt Xcel 2.2 SE	8	10.5	0.15	g	69.7	59.3
Fortix	8	5	2.54	bc	65.2	56.8
P(F)			<0.001		NS	NS

[z] All products with NIS 0.125% (v/v)
[y] FB = followed by
[x] FGS = Feekes growth stage
[*] Column numbers followed by the same letter are not significantly different at *P*=0.05 as determined by Fisher's LSD.

Fusarium Head Blight Survey 2015

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Fusarium head blight (FHB) is the most damaging disease throughout wheat growing areas in the United States. Rainy weather just prior to flowering through 10 days after flowering provides opportunities for spores of the fungus to grow into florets and enter the wheat head. Once the fungus enters the head, it can grow in the water conducting tissues, choking off water and nutrient movement. This results in bleaching of the individual floret or portions of the head above the infection point. The fungus can also produce a mycotoxin (DON or vomitoxin) which can contaminate grain. DON levels exceeding 2ppm are often docked by elevators and higher levels can be rejected. Research has shown that Fusarium head blight is best managed by 1) planting a moderately resistant wheat variety and 2) using a fungicide for FHB suppression (Prosaro, Proline, Caramba) applied during a 6 day window from the start of flowering. Integration of these two methods can suppress Fusarium head scab severity and DON by 70% when compared to untreated, susceptible checks. Our goal is to help wheat producers in the region improve wheat quality and ultimately profitability by improving management of Fusarium head blight. *The objective of this project is to document potential impacts of management practices (variety selection, fungicide use, irrigation, rotation, and or tillage) at the field level over a two to three year span. This information, is then shared with the participants and can assist in increasing grower knowledge and profitability in the long term.*

This spring, a 24 wheat fields were surveyed across Delaware or the Delaware / Maryland boarder for FHB severity and vomitoxin levels. Information on variety, irrigation history, and use of fungicide were noted. Approximately 15-20 days after flowering, ten heads were randomly sampled from 30 feet of row at ten sites within each field. Approximately 15 days later, the same sampling strategy was used to collect wheat heads. These samples were hand threshed and sent to the University of Minnesota Mycotoxin lab for assessment of vomitoxin (DON). These data are summarized in **Table 1**.

Overall, the season was not conducive to FHB in the majority of Delaware and Maryland due to dry weather during the flowering period. Grain elevators were reporting negligible DON levels in the vast majority of loads received, consistent with our observations.. This was evident in the fields included in this survey as none of the 24 fields surveyed exceeded the 2ppm DON threshold at sampling. DON values ranged from <0.05 to 1.8ppm. Although levels were low, FHB index was reduced over 52% in moderately resistant varieties when compared to susceptible varieties (0.45 vs 0.85). In addition, DON was reduced roughly 22% in moderately resistant varieties when compared to susceptible varieties (0.29 vs 0.37ppm). Fungicide applications at anthesis were associated with reductions in FHB severity (0.33 sprayed vs 3.54 in unsprayed fields) and DON (1.26ppm sprayed vs 0.22ppm in unsprayed fields). Irrigation only slightly increased DON (0.38 irrigated vs 0.33 unirrigated) although in some fields, DON and FHB levels differed significantly between irrigated and unirrigated areas of the same field. See Fields **5 and 6** for such a comparison. Fields 9-12 provide another illustration of irrigation effects on FHB and DON. As you look at the data, it may help to look at the relative differences between treatments or management practices, not the absolute numbers. In a dry year like 2015, it was rare to see major issues, but trends or percent reduction compared to say, the 5 fields with the greatest FHB or DON, may give you an indication of performance in a more disease-conducive season.

Table 1. Field number, agronomic data, and FHB data for 24 fields assessed for FHB and DON in 2015. Overall weather was not conducive to FHB, but trends in FHB and DON were noted between management practices.

Field	FHB Resistance Rating*	Fungicide at Anthesis	Irrigation	Anthesis Fungicide	FHB Index	DON[z]
1	S	y	n	y	0	0.05
2	S	y	n	y	0.16	0
3	MR	y	n	y	0.24	0
4	S	y	n	y	0.16	0.07
5	**S**	**y**	**y**	**y**	**1.53**	**0.82**
6	**S**	**y**	**n**	**y**	**0.08**	**0.05**
7	MR	y	y	y	0.16	0
8	S	y	y	y	1.3	0.06
9	MR	y	y	y	0.42	0.87
10	MR	y	n	y	0.16	0.15
11	MR	y	y	y	2.09	0.77
12	MR	y	n	y	0.05	0.05
13	S	y	n	y	0.01	0.35
14	S	y	n	y	0.07	0.06
15	S	y	y	y	0.06	0.21
16	S	y	y	y	0.2	0.18
17	S	y	n	y	0.02	0.15
18	S	y	n	y	0.08	0
19	S	y	n	y	0.2	0.26
20	S	n	n	n	6.3	1.8
21	S	n	n	n	2.52	0.69
22	S	n	n	n	1.8	1.3
23	MR	y	y	y	0.035	0.2
24	S	y	y	y	0.04	0.3

* based off of industry ratings, industry ratings may not be reliable if they are based off of field observations and not misted screening nurseries.

[z] a 0 indicates that the reading was below the detection limit of 0.05 ppm DON

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

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Introduction:

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 Feekes growth stage (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.

Irrigated wheat poses a potentially high yield environment where moisture stress can be eliminated, particularly during the rapid growth phase of April to May where a majority of vegetative tissue is produced. Eliminating moisture stress during this period may help maximize wheat growth and nutrient absorption, but may also lead to tall plant growth and a dense canopy, particularly if higher than standard nitrogen rates are used. In some years, the establishment of an early dense canopy may increase the potential for disease development and may require an early fungicide application. 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 **goals** of this project are: 1) to examine the utility of Palisade in intensively managed dryland and irrigated 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, and 3) to determine the effect of Palisade on wheat yield in dryland and irrigated conditions.

Study setup:

In 2015, 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. 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, greenness, foliar disease, height, and yield.

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.

Results

Irrigation and Rainfall

Overall, there was 3.1 inches of irrigation applied to the irrigated study. Irrigation was initiated on 5/11 at FGS 10 (boot stage), which was 1 week before flowering. Irrigated plots received 2.3 inches of irrigation before flowering to bring soil moisture level up to field capacity. No irrigation was applied during flowering. Within 1 week after flowering, irrigated plots received a total of 1 inch of irrigation to bring soil moisture level back up to field capacity.

From April 20 to June 1, a critical period for wheat, there was only 1.6 inches of rainfall received. Due to the dry conditions during this critical period, supplemental irrigation before and after flowering improved the yield in the irrigated setting over the yield in the dryland setting (Figure 1). In addition, irrigation also resulted in greater plant "health" ratings, as measured in NDVI during the soft dough stage, compared to the dryland setting (Figure 4).

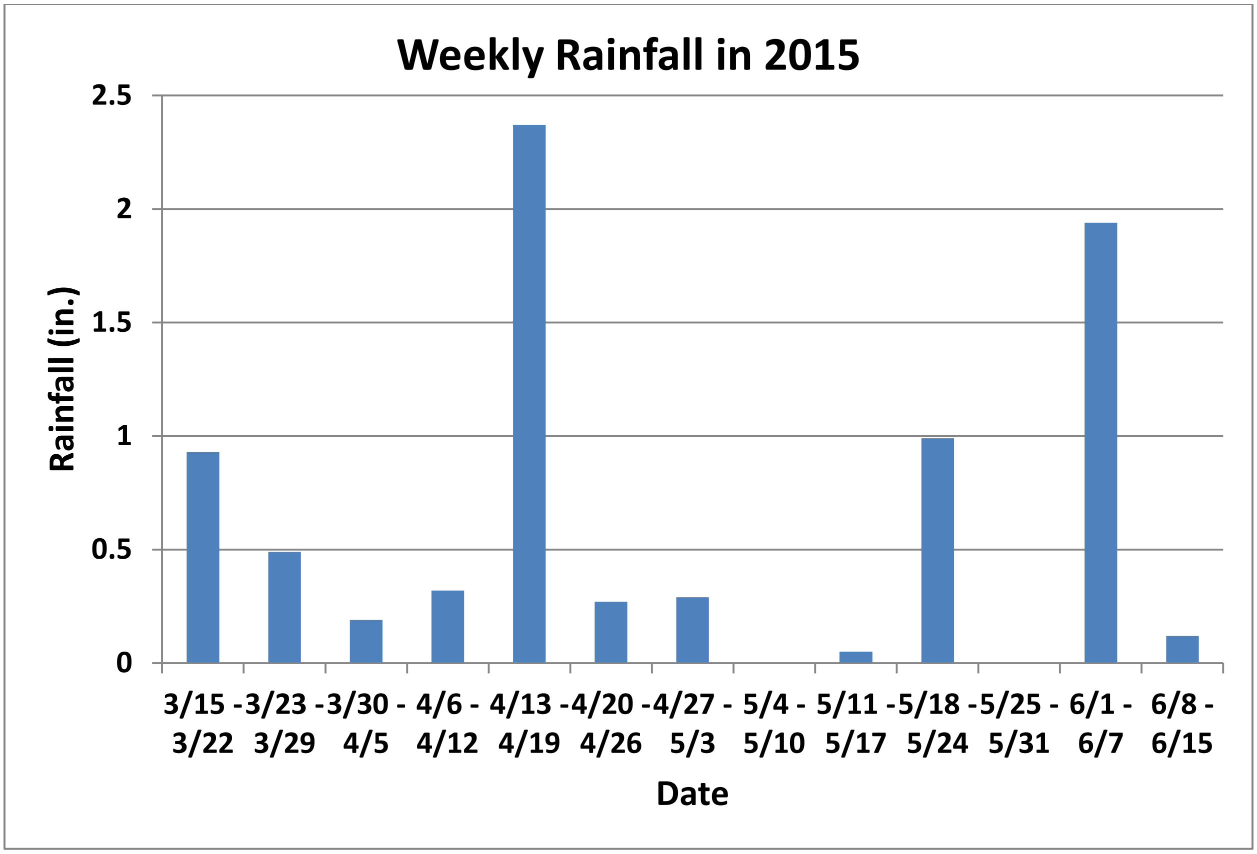

Figure 1. Rainfall at the UD Warrington Irrigation Research Farm in 2015.

Due to environmental conditions in spring of 2015, both studies received the 2nd shot of nitrogen (50 lbs N/A) at FGS 7. This 2nd nitrogen application should have ideally occurred at FGS 5, which occurred about 10 days earlier. Studies did receive 0.3 inches of rainfall 3 days after this application, but the next significant rainfall did not occur until flowering (18 days later). The late application of the 2nd shot of nitrogen and the limited amount of rainfall after the application may have limited yields this year, particularly in the dryland study. In the irrigated study, irrigation was initiated 1 week before flowering, 13 days after the 2nd nitrogen application. The irrigation that occurred before flowering may have allowed the irrigated wheat to better utilize the nitrogen applied compared to the dryland study. One of the advantages of irrigating wheat is the ability to move the applied nitrogen into the soil profile for the crop to utilize in building the plant. In future studies, irrigation will be applied soon after the 2nd shot of nitrogen, if necessary, to improve nutrient uptake and build the plant well in advance of flowering, as well as to maximize the chance of observing any benefits of the additional N application included in the Palisade programs.

Effects of Treatments on Yield

Fungicide program, but not nitrogen level, significantly impacted yield in both studies {P(F) = 0.0003 irrigated; 0.0258 dryland). In the irrigated study, the 2-pass system resulted in significantly greater yields (89 bu/A) compared to other programs or controls (Figure 2). The FGS8 (flag leaf) and FGS 10.5.1 (flowering) fungicide programs improved yields over both untreated and Palisade controls but less than the 2-pass system (80 bu/A standard; 81 bu/A flower). Yields were significantly lower in the dryland study when compared to the irrigated study (54 bu/A dryland; 79 bu/A irrigated). Unlike the irrigated system, no program significantly improved yields compared to one another or untreated controls, although the standard and 2-pass programs out yielded the Palisade only treatment (Figure 2).

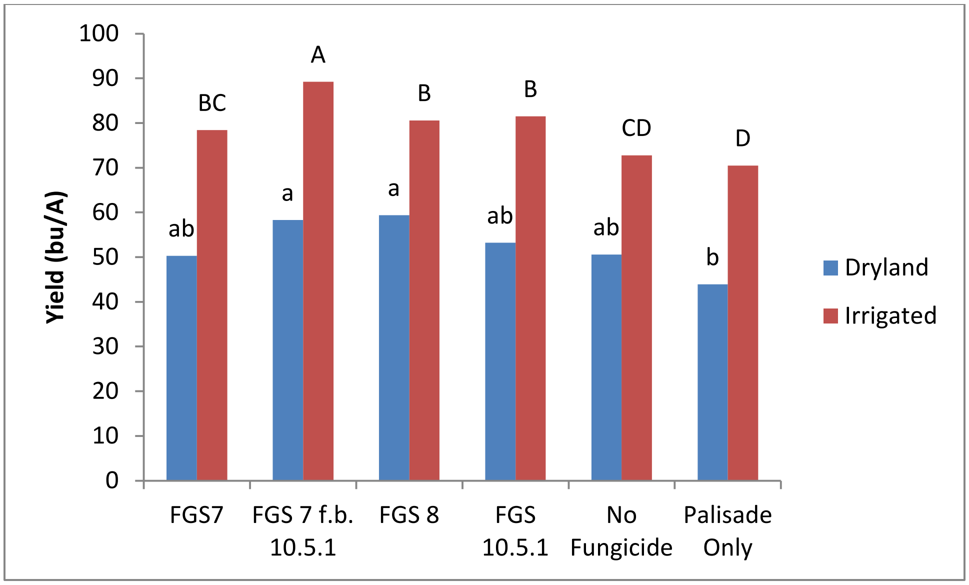

Figure 2. Fungicide programs in combination with Palisade significantly impacted yield in both irrigated and unirrigated settings. Different letters within each capitalization scheme indicate significant differences using Fisher's Protected LSD (α = 0.05). Yield was corrected to 13.5% moisture.

Effects of Treatments on Foliar Disease Control

Fungicide programs, but not nitrogen level, significantly impacted foliar disease in both dryland and irrigated settings {P(F) <0.0001}. Overall, disease severity was approximately 100% greater in dryland wheat when compared to irrigated wheat (6.6% dryland; 3.05%; irrigated). In both settings, fungicide use, regardless of timing, significantly reduced disease relative to untreated or Palisade only controls (Figure 3). In both dryland and irrigated settings, disease severity was similar among the FGS 8 (standard), FGS 10.5.1 (Flowering) and 2-pass systems; however the 2-pass system did provide significantly greater reduction in disease severity when compared to the FGS 7 (early) fungicide application program. Interestingly, Palisade applied alone reduced disease severity compared to untreated controls in both studies (Figure 3).

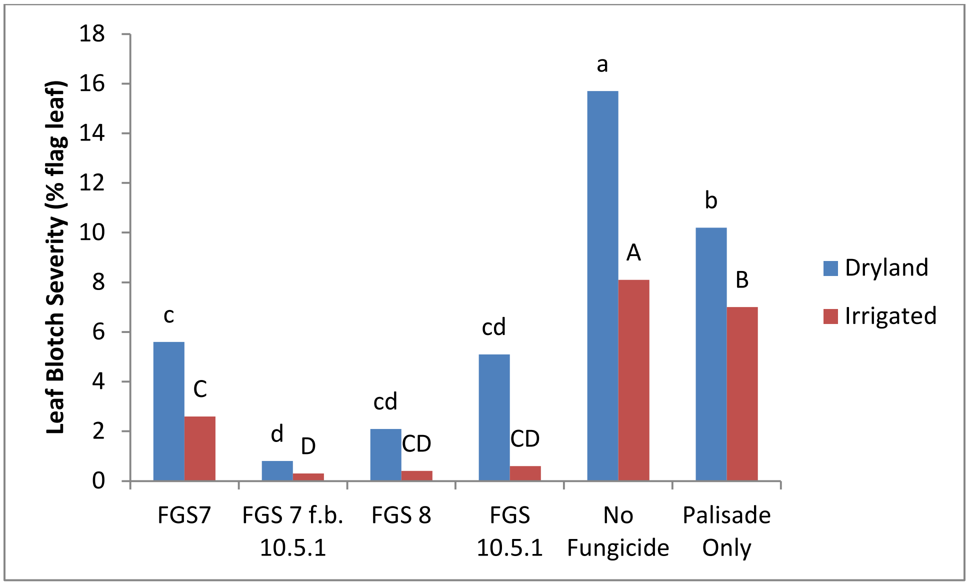

Figure 3. Fungicide programs in combination with Palisade significantly impacted foliar disease severity in both irrigated and dryland settings. Different letters within each capitalization scheme indicate significant differences using Fisher's Protected LSD (α = 0.05).

Effects of Treatments on Plant Heights

Fungicide programs, but not nitrogen level, impacted plant heights relative to controls (Figure 4). Across both dryland and irrigated studies, a standard fungicide application marginally increased plant heights to a level statistically similar to untreated controls. However, programs that incorporated a fungicide at the time of Palisade application (FGS 7) or at flower (FGS 10.5.1) significantly reduced plant heights relative to untreated controls.

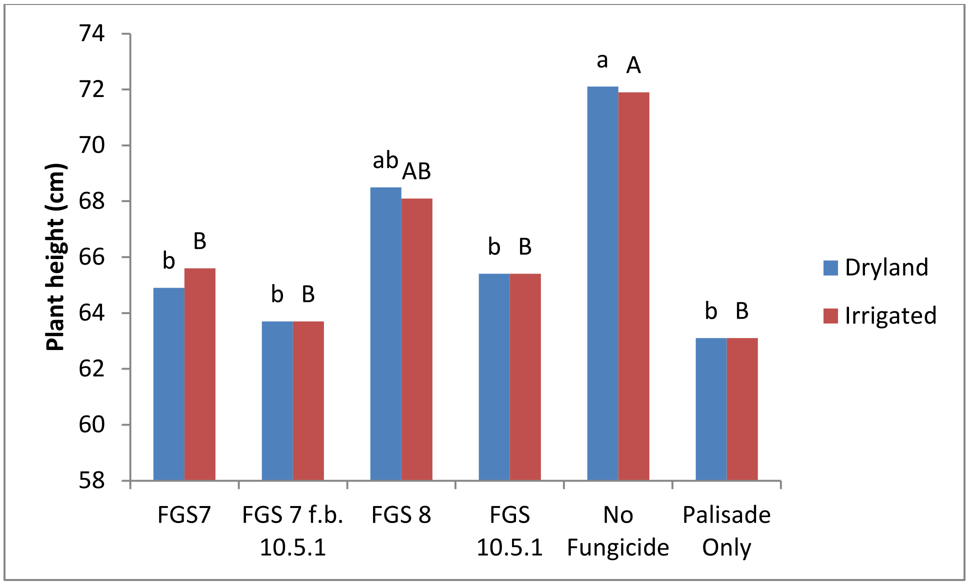

Figure 4. Fungicide programs in combination with Palisade and Palisade alone significantly impacted plant heights. Different letters within each capitalization scheme indicate significant differences using Fisher's Protected LSD ($\alpha = 0.05$).

Title: Examining the utility and economic returns of different fungicide application programs to manage Leaf blotch complex of wheat.

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Introduction

Fungal diseases of small grains can pose significant limitations to wheat production. These diseases can reduce green leaf tissue and impact both yield and grain quality. In the Mid-Atlantic, foliar diseases, particularly residue-borne fungal pathogens belonging to the Leaf blotch complex of diseases (LBC), are present in many fields to varying degrees each year. This is likely a result of increased conservation tillage in the region, resulting in higher levels of fungal inoculum. If foliar diseases reach the upper 3 leaves or glumes before grain fill is complete, yield losses may occur. Traditional fungicide programs to manage foliar disease of wheat call for a single fungicide spray at Feekes Growth Stage (FGS) 8/9 to protect the flag leaf from foliar disease. However, threats to wheat production by Fusarium head blight (FHB) have forced growers to reevaluate their chemical management programs. FHB is a disease of the head, and can only be suppressed when specific fungicides are applied at flowering (FGS 10.5.1), 1-2 weeks after traditional FGS 8 applications. The application of both an FGS 8 and FGS 10.5.1 fungicide application is not practical in Mid-Atlantic production systems due to applicator limitations and cost. Growers can also apply fungicides early when nitrogen is applied at greenup (FGS 5) which is advertised as a means to protect against early onset of foliar diseases. Fungicide applications at FGS 5 are often combined along with an application at FGS 8/9 or FGS 10.5.1. **The efficacy of these “new” FGS 5 and FGS 10.5.1 timings have not been adequately assessed for their efficacy and potential to promote yields compared to standard, FGS 8/9 applications.**

Fungicide application costs differ depending on product, rate, and number of applications. Most fungicide studies focus on the “best” fungicide in terms of ability to suppress disease and improve yield. Few unbiased, replicated studies examine fungicide programs for their potential to improve grower profits. For example, it is possible that a FGS 5 + 8 fungicide program may be the best in terms of disease suppression and yield protection. However, product and application cost relative to the yield improvement may not result in the greatest net profit. A single application or cheaper product may deliver similar benefit at reduced cost, therefore resulting in greater potential net returns. **Currently there is no information on the potential profitability of fungicides in Mid-Atlantic wheat production systems.**

To address these questions, the first year of a two year study was established in Delaware and Maryland. Thirteen fungicide application programs plus an untreated control at four locations were evaluated in 2015. Five commonly used fungicides were applied at a variety of timings to represent programs currently being used by growers in Maryland and Delaware. Percent disease severity, NDVI readings or plant “health”, and yield data were collected. In addition, local agriculture businesses were surveyed for fungicide and application costs. At the end of each season, data are analyzed statistically, and data used to determine the efficacy and profitability of programs relative to FGS 8/9 fungicide applications and untreated controls. At the end of two seasons data will be combined and probability of profitability charts will be produced for fungicide programs across a range of cost and commodity prices. These charts can be used by producers to assist in fungicide management decisions.

Progress to Date

This study was replicated at four locations in DE and MD in 2015, and will be replicated across seven locations across DE, VA, PA, and MD in 2016. The goal of using multiple sites and years is to generate a range of production conditions. Our design allows us to assess fungicide efficacy and profitability across environments. This ultimately enables us to better estimate the overall fungicide program performance and potential profitability for the region. If we only evaluated fungicides on a highly susceptible variety under heavily irrigated conditions, data would be unfairly skewed towards disease favorable environments. Although this information is important in terms of understanding what products offer the greatest disease suppression, it does not account for other situations where disease may not be as severe and yield increase may not be apparent. In our study, the goal is to maximize the environmental variability between fields, thereby improving our confidence when assessing fungicide programs, products, and economics.

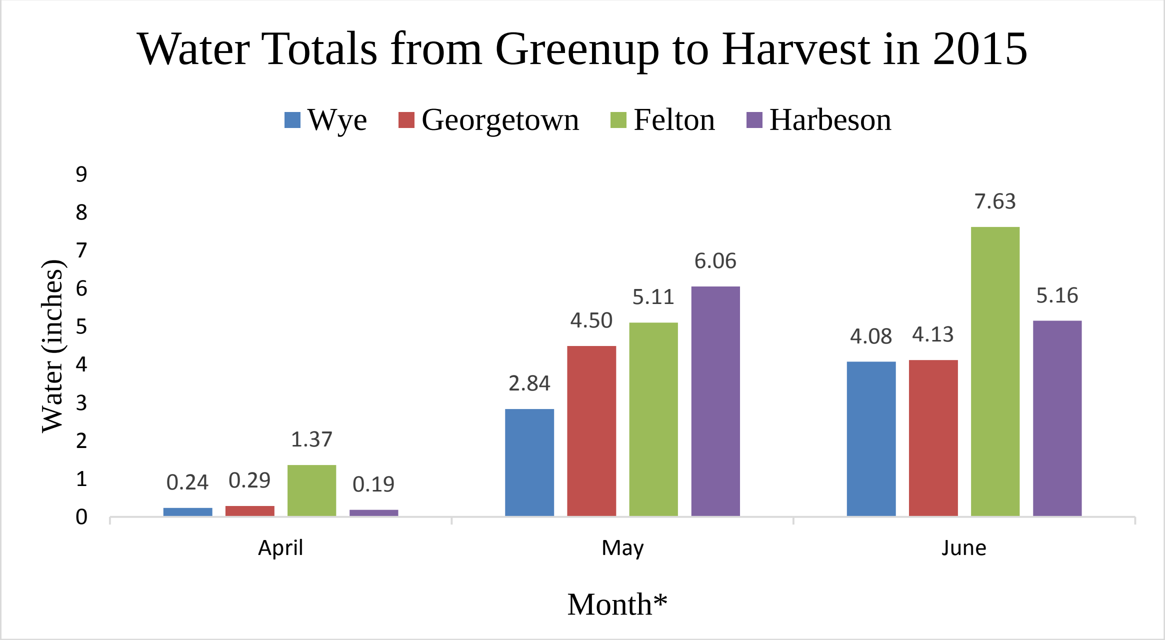
Experimental sites in 2015 included the Carvel Research and Education Center located in Georgetown, Delaware, the Warrington Irrigation farm in Harbeson, Delaware, a field owned by Co-PI Sylvester in Felton, Delaware, and the Wye Research and Education Center in Queenstown, Maryland. The wheat variety FS 815 [Growmark FS] was planted at all locations in October 2014 (**Table 1**). Georgetown and Felton were seeded with a 10' Great Plains no-till drill in rows spaced 7" apart while Harbeson and Wye were seeded with a 15' Great Plans no-till drill in rows spaced 7.5" apart. Vertical tillage implements were utilized to size residue prior to seeding plots at Georgetown, Harbeson, and Felton while a disk was used at the Wye. Stand counts and residue measurements were taken December 2014.

Table 1. Planting date, final plant stand, and percent residue at all locations. Target seeding rate was 1.8 million seeds/A.

Location	Planting Date	Final Plant Stand (plants/A)	Percent Residue
Georgetown	October 8, 2014	1.23 million	74%
Harbeson	October 27, 2014	1.43 million	79%
Felton	October 29, 2014	1.19 million	73%
Wye	October 20, 2014	1.27 million	40%

The experimental design at each plot was a randomized complete block with six replications of each treatment. Plots measured 4.67' by 23' at Georgetown and Felton and 5' by 23' at the Harbeson and Wye locations. Spreader rows were utilized to facilitate even disease development and minimize plot to plot fungicide drift. The sites at Georgetown, Felton, and Harbeson were irrigated at different levels to supplement rain in the droughty 2015 growing season. Data logging rain gauges were installed to capture both rainfall at all locations and irrigation totals at Georgetown, Harbeson, and Felton (**Figure 1**). Rainfall data from the DEOS network was also utilized in conjunction with the data logging rain gauges. Water totals were higher in May at Georgetown, Harbeson, and Felton because of supplemental irrigation.

Figure 1. Total water (rainfall plus irrigation) at all locations.



*Data collection began on April 17 at Felton and April 22 at Georgetown, Harbeson, and Wye. Data collection ended day of harvest (Georgetown on June 23, Harbeson on June 25, Wye on June 25, and Felton on July 1).

The fungicide application programs were evaluated using the fungicides Tilt® (Propiconazole), Quilt Xcel® (Azoxystrobin + Propiconazole), Priaxor® (Fluoxapyroxad + Pyraclostrobin), Stratego YLD® (Prothioconazole + Trifloxystrobin), and Prosaro® (Prothioconazole+Tebuconazole), applied according to **Table 2**. An untreated control was included for comparison. Tilt® was selected because propiconazole fungicides are cheap and often used at greenup (FGS 5) as part of a split-application fungicide program. Quilt Xcel®, Stratego YLD®, and Priaxor® are dual mode of action fungicides that are commonly used in fungicide programs in the region and include strobilurin (Group 11) fungicides, which are touted to improve yields in the absence of significant disease pressure or under stressful conditions, such as drought. Prosaro is the industry standard for suppression of Fusarium head blight. All fungicides were applied with a CO_2 backpack sprayer equipped with Twinjet Flat Fan 8002 nozzles at a pressure of 34 psi in 20 gallons of water per acre.

Table 2. Treatments used in the study.

Treatment	**Product**[1]	**Timing**[2] **(FGS)**	**Program**	**Rate (oz/A)**
1	Control-No Fungicide	n/a	n/a	n/a
2	Tilt	8	Standard solo	4
3	Tilt	5+8	Standard split	2+4
4	Tilt fb Prosaro	5+10.51	Late split	2+6.5
5	Quilt Xcel	8	Standard solo	10.5
6	Quilt Xcel	5+8	Standard split	7+10.5
7	Quilt Xcel fb Prosaro	5+10.51	Late split	7+6.5
8	Priaxor	8	Standard solo	4
9	Priaxor	5+8	Standard split	2+4
10	Priaxor fb Prosaro	5+10.51	Late split	2+6.5
11	Stratego YLD	8	Standard solo	4
12	Stratego YLD	5+8	Standard split	2+4
13	Stratego YLD fb Prosaro	5+10.51	Late split	2+6.5
14	Prosaro	10.51	Late solo	6.5

[1] fb=followed by

[2] The FGS scale is used to describe wheat growth stages. FGS 5 is greenup or psuedostem erection, FGS 8 is flag leaf emergence, and FGS 10.51 is beginning flower. + indicates applied sequentially with a half rate at F5 and a full rate at F8.

To determine the potential net returns of various fungicide programs, yields relative to untreated controls were compared across a range of grain prices and application costs typical for the region. Local agriculture businesses were surveyed for input costs, mainly fungicide costs and custom application costs during the growing season.

Disease severity ratings were collected when disease symptoms were detected on the lower leaves after beginning flower. Initial ratings utilized a leaf position dependent scale described in Table 3**.** Leaf position dependent ratings were collected twice before switching to percent severity assessed on the flag leaf at each location. Initial disease severity ratings began at full flower (FGS 10.53) and final ratings were taken at soft dough (FGS 11). The leaf position dependent and disease severity ratings were combined to calculate the area under the disease progress curve (AUDPC) which describes disease progress up the plant over time. In addition to disease severity, Normalized Difference Vegetation Index Value (NDVI) data was recorded using a handheld GreenSeeker [Trimble]. The handheld device was held waist high at a normal walking pace over each plot. A greater reflectance returned a higher value indicative of a greener or healthier plant.

Plots were harvested using research plot combines and yield data was adjusted to 13.5% moisture. Data from all sites were combined and analyzed using a random effects mixed model in JMP. Treatment means were compared using the student's –t test at the 5% probability level.

Selected Results

Effect of Treatment Timing on Yields

All treatment timings yielded higher than the untreated control {P(F)=0.01}. Yield was numerically greatest for the early application at F5 followed by Prosaro at FGS 10.5.1 program (83.4 bu/A), but this not significantly different from the other tested program timings (**Figure 2**). FGS 5 did not improve yield compared to the standard, solo applications at FGS 8 or at FGS 10.5.1. Furthermore, FGS 10.5.1 applications and standard, FGS 8 treatments resulted in similar yields.

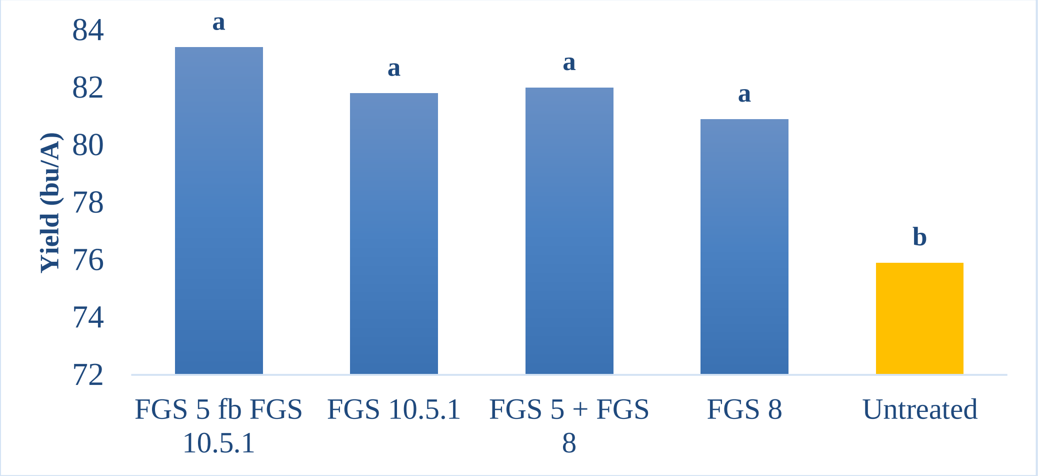


Figure 2. All fungicide program timings significantly impacted yield. Treatments are listed by timing of application which is denoted by FGS 5 (greenup) followed by (fb) FGS 10.5.1. (flowering), FGS 5 (greenup) plus FGS 8 (flag leaf) , solo application at FGS 8 (flag leaf) or solo application at beginning flower (FGS 10.5.1). Treatment means followed by the same letter are not significantly different. Means were separated using Fishers Protected LSD (α=0.05).

Effect of Treatment Timing on Foliar Disease Control

Fungicide program timing significantly impacted foliar disease control {P(*F*)=0.009}. All fungicide program timings significantly reduced disease compared to the untreated control (**Figure 3a**). The addition of an FGS 5 application did not reduce disease severity compared to standard applications at FGS 8 or at FGS 10.5.1. The solo application at FGS 10.5.1 provided the same level of disease control relative to the solo application at FGS 8. Furthermore, fungicide program timing significantly impacted disease progress {P(*F*)<.0001}. All timings reduced the progress of disease compared to the untreated control. Program treatments consisting of a FGS 5 + FGS 8, FGS 5 fb FGS 10.5.1, reduced disease progress to the same extent as the standard FGS 8 applications (**Figure 3b**).

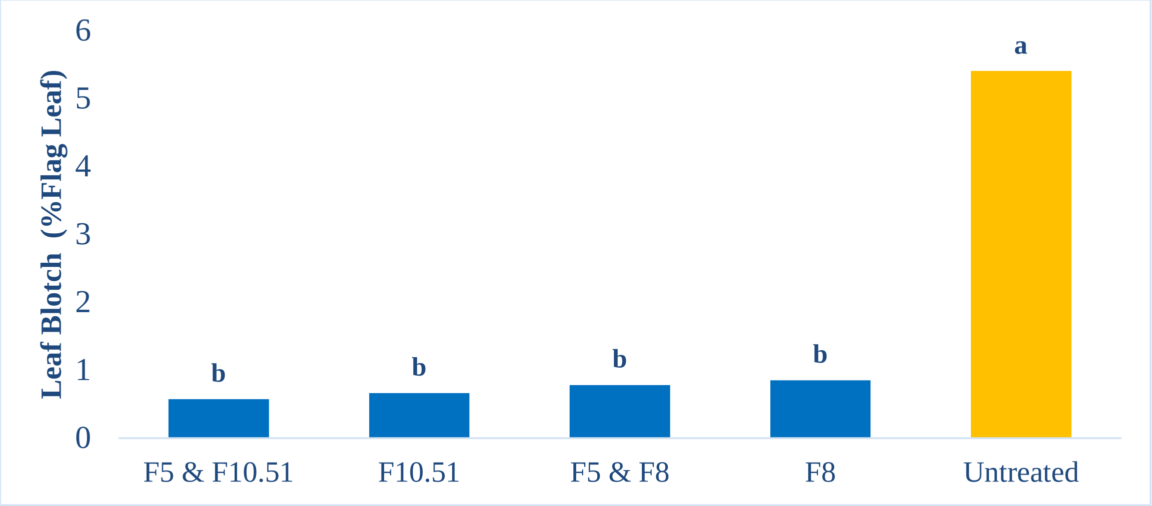


Figure 3a. Fungicide program timing had a significant impact on disease severity. Timing means followed by the same letter are not significantly different. Means were separated using Fishers Protected LSD (α=0.05).

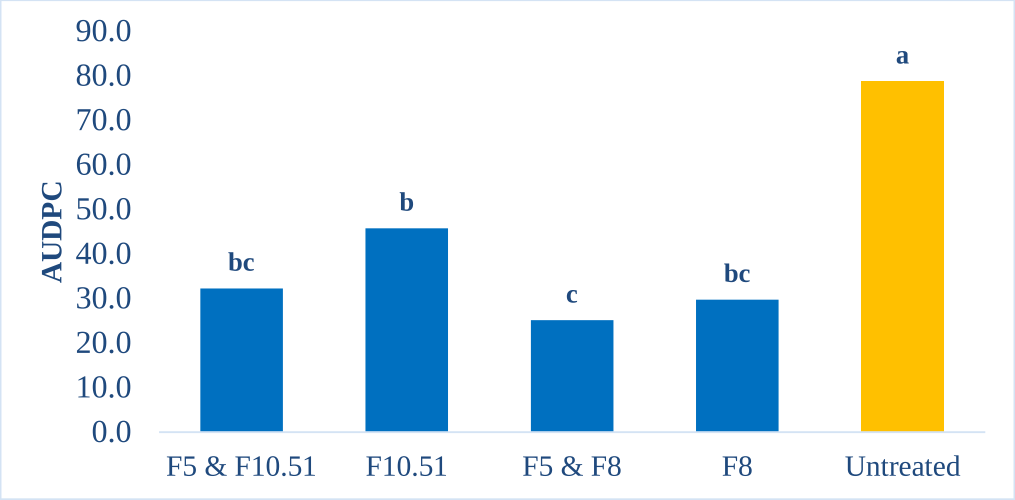


Figure 3b. Fungicide program timing had a significant impact on disease progress. Disease progress was tracked over time using the leaf-position dependent scores to calculate the area under the disease progress curve (AUDPC). Higher numbers indicate disease progressed further up the plant over time. Timing means followed by the same letter are not significantly different. Means were separated using Fishers Protected LSD (α=0.05).

Effect of Treatment Timing on Plant "Health"

Fungicide program timing had a significant effect on plant "health" {P(*F*)<.0001}. Overall, readings were 15% higher in fungicide treatments compared to the untreated control (**Figure 4**). The addition of an early application to the FGS 8 program did not increase readings. No differences in greenness were detected between the solo application at FGS 10.5.1. and the standard solo application at FGS 8.

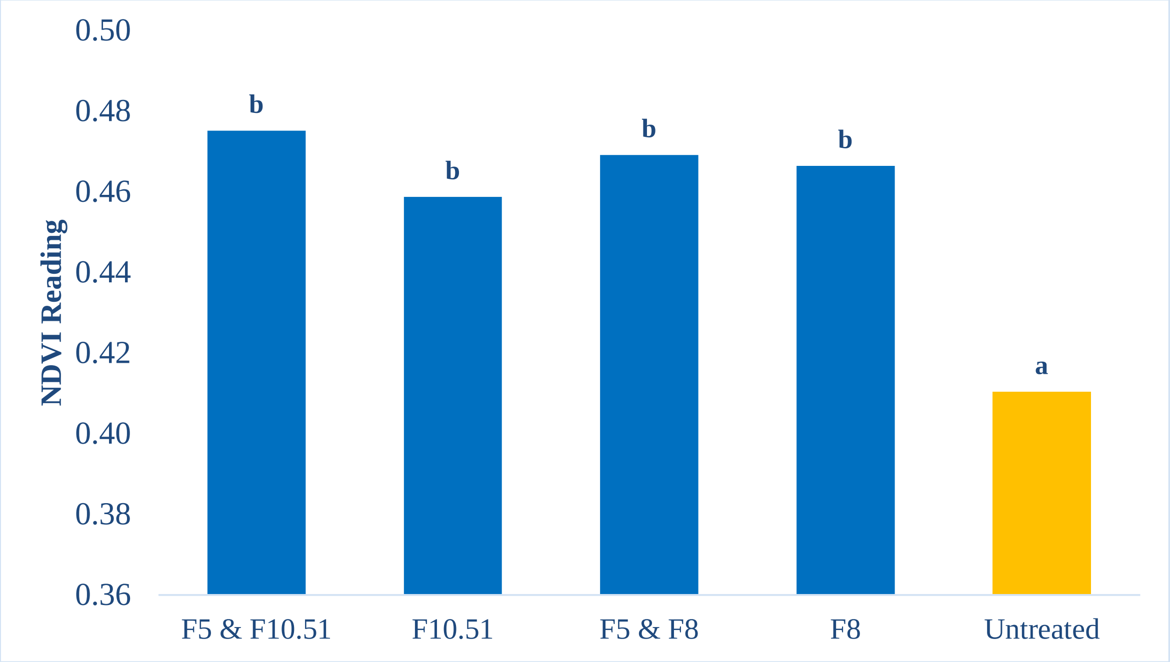


Figure 4. Fungicide program timing had a significant impact on NDVI readings {P(F)<.0001}. Timing means followed by the same letter are not significantly different. Means were separated using Fishers Protected LSD (α=0.05).

Preliminary Economic Analysis

Results indicated that returns can be either positive or negative depending on program and commodity price. All but one program resulted in a positive net return when wheat is $5.00/bu and all treatments resulted in a net return when wheat is $6.00/bu. The net returns for program timings indicated either a negative or a very small net return when wheat is $4.00/bu or less (**Table 5**). All timings resulted in a positive net return once wheat reached $5.00 or $6.00/bu.

Table 5. Net Return of each treatment compared to untreated control.

		Net Return at Price/Bu		
Treatment	**Application cost (total)**	**$4.00**	**$5.00**	**$6.00**
FGS 8	$21.56	-$1.16	$3.94	$9.04
FGS 5 + FGS 8	$29.15	-$4.39	$1.80	$7.99
FGS 5 fb FGS 10.51	$30.20	$0.20	$7.80	$15.40
FGS 10.51	$22.43	$1.57	$7.57	$13.57

Even though programs may average a positive net return over all locations, results may vary each time a fungicide program is utilized. Therefore, the percentage of time a program exceeded breakeven was calculated to describe the frequency a program is successful. Treatments exceeded breakeven 33% to 63% of the time at $4.00/bu wheat (**Table 5**). FGS5 + FGS 8 treatments exceeded breakeven only 41% of the time when wheat was $4.00/bu (**Table 6)**. The solo application at FGS 8, FGS 5 + FGS 10.51, and the solo application at FGS 10.51 was just above 50% at $4.00/bu wheat. Programs with later fungicide timings typically had a higher percentage to cover application costs. At $6.00/bu wheat, the same programs increased to 68% and 58% success.

Table 6. Percentage of time program timings exceeded breakeven.

	Price received per bushel		
Treatments Timings	**$ 4.00**	**$ 5.00**	**$ 6.00**
F8	51	58	61
F5+F8	41	49	56
F5 fb F10.51	53	60	68
F10.51	54	58	58

Summary of Important Findings

Data generated from the first year of this study provide insight to the potential impacts and profitability of commonly used fungicide programs in Delaware and Maryland. Results indicate fungicide programs can be profitable in Mid-Atlantic wheat production systems, though the greatest chance of realizing a return is when disease pressure is moderate to high and wheat price is above $5.00/bu. Early season fungicide applications at FGS 5 did not significantly improve disease control or yield relative to the solo applications at FGS 8 and FGS 10.5.1 and could result in lower net returns due to additional application costs. Late season applications at FGS 10.5.1 were as efficacious as solo applications at FGS 8 and resulted in similar yields and net returns. This suggests growers targeting Fusarium head blight with fungicide applications at flowering could also control late season foliar diseases such as Leaf blotch complex and potentially further increase net returns. The study will be replicated in 2016 on an additional seven sites across DE, MD, VA, and PA to build a more robust dataset and generate models and decision tools to assist growers in making profitable fungicide application decisions to winter wheat. A Metaanalysis will be conducted for the dataset to generate a fungicide profitability tool to assist growers in making profitable fungicide decisions.

Corn

Corn yields averaged 192 bu/A on 164,000 harvested acres. Overall grain production was estimated at 31,488,000 bu. Approximately 4000 acres were planted for silage, yielding 20 tons/A. Seedling disease caused minimal losses of stand in most fields, due to dry conditions at planting. Late season rains impacted foliar diseases such as Northern Corn Leaf Blight and Grey Leaf Spot in many areas, and Grey leaf spot arrived earlier than typical in many fields, resulting in yield reductions. Anthracnose was fairly common throughout the state and observed in corn at the vegetative growth stage. However, top dieback and anthracnose stalk rot was not an issue. Dry weather after ear set increased stalk rots, with charcoal rot, red root rot, and fusarium root/stalk rots common in many areas. Diplodia ear rots were reported in several fields.

Field Corn (*Zea mays*) 'Dynagro D49VC88')

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Evaluation of headline and integral in furrow applications on corn in Delaware.

The experiment was conducted at the University of Delaware's Carvel Research and Education Center, Thurmond Adams Research Farm in Georgetown. The experiment consisted of four fungicide treatments and an untreated control arranged in a randomized complete block design with four replications. Plots consisted of 4 rows spaced 30 in. apart and 40 ft in length. The plots were seeded into minimally tilled corn residue on 27 Apr at a population of 32,000 plants/A with a Kinzie planter set up for in furrow chemical applications. In furrow applications were made at planting at 3 gal/A and applied directly on top of the seed prior to furrow closure. Plots were managed for nutrients and weeds according to Delaware extension guidelines, although the second nitrogen application occurred later than ideal, likely impacting overall yields. Seedling emergence was rated on 14 Apr and 20 Apr on 12 ft row per plot. The center two rows of each plot were harvested on 9 Sep using a small plot combine. Yields were adjusted to 15.5% moisture. Data were analyzed to ensure normality and statistically analyzed using the GLM procedure of JMP v12.

Temperatures were within the historical average but dry, with the location receiving only 11.7 in. of rainfall throughout the course of this study. Northern corn leaf blight and gray leaf spot arrived near R1, but were not rated. No effects of in furrow application were observed for disease, seedling emergence, or yield.

Treatment and rate/acre	Seedling emergence 14 Apr[z]	Seedling emergence 20 Apr	Yield (bu/a)
Headline EC, 3 fl oz	30	31	113
Headline EC, 6 fl oz	29	30	109
Integral, 0.6 fl oz + Headline EC, 3 fl oz	30	32	115
Integral, 1.2 fl oz + Headline EC, 6 fl oz	29	30	110
Untreated control	29	31	113
P(*F*)	ns	ns	ns

[z] Means within a column followed by the same letter are not significantly different according Fisher's Protected LSD test (α=0.05).

Field Corn (*Zea mays*) 'Dynagro D49VC88')

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Evaluation of in furrow pesticide applications and pop up fertilizer on corn in Delaware.

The experiment was conducted at the University of Delaware's Carvel Research and Education Center, Thurmond Adams Research Farm in Georgetown. The experiment consisted of four fungicide treatments and an untreated control arranged in a randomized complete block design with four replications. Plots consisted of 4 rows spaced 30 in. apart and 40 ft in length. The plots were seeded into minimally tilled corn residue on 27 Apr at a population of 32,000 plants/A with a Kinzie planter set up for in furrow chemical applications. In furrow applications were made at planting at 3 gal/A and applied directly on top of the seed prior to furrow closure. Plots were managed for nutrients and weeds according to Delaware extension guidelines. Seedling emergence was rated on 14 Apr and 20 Apr on 12 ft row per plot. The center two rows of each plot were harvested on 9 Sep using a small plot combine. Yields were adjusted to 15.5% moisture. Data were analyzed to ensure normality and statistically analyzed using the GLM procedure of JMP v12.

Temperatures were within the historical average but dry, with the location receiving only 11.7 in. of rainfall throughout the course of this study. Northern corn leaf blight and gray leaf spot arrived near R1, but were not rated. In furrow applications of fertilizer the three way treatment containing Headline, Capture, and Fertilizer increased yields compared to untreated controls. The Three way mixture also significantly improved test weights compared to all other treatments except the Capture only treatment.

		Seedling Emergence					
	Treatment	14-May	20-May	**TWT**		**Yield**	
1	Untreated control	28	30	51.6	b[z]	158.3	b
2	Headline EC	30	31	51.7	b	166.6	ab
3	Capture LFR	30	32	52.0	ab	167.8	ab
4	Starter fertilizer	30	31	51.6	b	170.7	a
5	Headline EC + Starter fertilizer	29	31	51.5	b	167.1	ab
6	Headline EC + Capture LFR + Starter fertilizer	30	31	52.3	a	174.3	a
	P(*F*)	0.73	0.76	0.0027		0.0057	

[z] Means within a column followed by the same letter are not significantly different according Fisher's Protected LSD test (α=0.05).

Field Corn (*Zea mays*) 'Dynagro D49VC88')
Northern corn leaf blight; *Exserohilium turcicum*
Grey leaf spot; *Cercospora zeae-maydis*

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Evaluation of foliar fungicides for management of foliar diseases of field corn in Delaware.

The experiment was conducted at the University of Delaware's Carvel Research and Education Center, Thurmond Adams Research Farm in Georgetown, Delaware. The experiment consisted of 12 fungicide treatments and an untreated control arranged in a randomized complete block design with four replications. Plots consisted of 4 rows spaced 30 in. apart and 30 ft. in length. The two inner rows were used as treatment rows and the two outer rows were used as a buffer between adjacent treatments. The plots were seeded into minimally tilled corn residue on 28 Apr at a population of 32,000 plants / A. Plots were managed for nutrients and weeds according to Delaware extension guidelines. Fungicides were applied to the center two rows at V5 on 22 May with a CO_2 backpack sprayer that delivered 20 gpa at 35 psi. The sprayer was equipped with a 6 ft. boom with TeeJet® 80V02 nozzles spaced 18 inches apart set in a directed spray pattern. Fungicides were also applied at R1 on 6 Jul using a back sprayer fitted with a telescoping boom with specifications identical to those previously described. Whole plot ratings of percent disease severity were made at ear leaf level on 6 Aug, 13 Aug, and 19 Aug. Whole plot ratings were used to calculate the Area Under the Disease Progress Curve (AUDPC) using trapezoidal integration. In addition, six leaves were selected from the inner two rows per plot at random and rated for percent disease on the leaf immediately below the ear leaf (Ear -1) on 13 Aug and the ear leaf on 19 Aug. Plots were trimmed to 25 feet in length and the inner two rows harvested on 9 Sep using a small plot combine. Yields were adjusted to 15% moisture. Data were analyzed to ensure normality and statistically analyzed using the GLM procedure of JMP v12.

Temperatures were within the historical average but dry, with the location receiving only 11.7 in of rainfall throughout the course of this study. No effects of early season fungicide treatments on stem diameter or vitality were observed. Diseases observed included Grey leaf spot and Northern corn leaf blight at relatively equal amounts just after dent in mid-August. Anthracnose was observed sporadically early in the season, but not at levels sufficient to rate. Significant treatment effects (P(*F*) = 0.0008) were observed for foliar disease ratings conducted on the ear-1 leaves, but not the ear leaf. Foliar disease was greatest on the ear-1 leaves in untreated controls and treatments only receiving a fungicide at V5. Trivapro, Affiance, and Priaxor applied at R1 provided the greatest disease suppression on ear-1 leaves. Similar results were observed for the AUDPC (P(F) = <0.0001); however, Priaxor applied at R1 provided significantly greater plot level disease suppression compared to all other treatments. No significant impact of treatments on yield were detected, although all R1 applications except Domark resulted in numerically greater yields than the untreated control.

Treatment and rate/acre (crop growth stage at application)	Disease severity ear -1 (%)[z]	AUDPC [y]	Yield (bu/A)
Affiance 1.50SC 10.0 fl oz (V5)	14.5 ab	365.2 abc	191.4
Affiance 1.50SC 10.0 fl oz (R1)	6.4 c	258.6 cd	186.9
Aproach Prima 2.34SC 6.8 fl oz (R1)	11.4 bc	265.0 d	195.4
Domark 230ME 4 fl oz (V5)	14.2 ab	433.6 a	201.8
Domark 230ME 4 fl oz (R1)	9.6 bc	262.2 d	199.0
Priaxor 4.17SC 8 fl oz (R1)	4.6 c	135.1 e	182.4
Trivapro SC 14.6 fl oz (V5)	16.3 ab	358.2 abc	194.7
Trivapro SC 14.6 fl oz (R1)	5.1 c	226.3 d	195.1
Stratego YLD 4.18 SC 2 fl oz (V5)	19.1 a	415.0 a	198.3
Stratego YLD 4.18 SC 4 fl oz (V5)	18.3 a	414.1 a	205.0
Stratego YLD 4.18 SC 4 fl oz (R1)	12.1 ab	297.6 bcd	182.1
Stratego YLD 500SC 2.0 fl oz (V5) FB[x] Stratego YLD 500SC 4.0 fl oz (R1)	8.0 bc	295.5 bcd	199.8
Untreated control	17.7 a	1.9 a	199.2
P(*F*)	<0.001	<0.0001	ns
R^2	0.73	0.79	

[z] Means within a column followed by the same letter are not significantly different according Fisher’s Protected LSD test (α=0.05).

[y] Area Under the Disease Progress Curve

[x] FB = Followed by

Soybean

Soybean yields averaged 40 bu/A in 2014 on 163,000 harvested acres. Overall production was estimated at 6,920,000 bu. Seedling diseases occurred in full season diseases at low/moderate levels. Predominant issues included Fusarium spp. Soybean cyst nematode, as usual, was the largest issue in soybean production. Root knot nematode was also observed at damaging levels in some soybean fields. Soybean vein necrosis virus was abundant and moderate in severity. Foliar diseases such as downy mildew appeared early, but increasing temperatures resulted in little to no yield impacts. Charcoal rot was present in many fields. Issues with green stem and Dectes stem borer impacted harvest in many fields. The most common foliar disease was Septoria leaf spot; however, the disease was not detected in upper portions of the canopy and therefore likely resulted in minimal yield losses.

SOYBEAN (*Glycine Max* ‘Dynagrow S29RY65’)
Brown Spot; *Septoria glycines*

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University of Delaware

Evaluation of foliar fungicides for management of brown spot of soybean in Delaware, 2015.

The experiment was conducted at the University of Delaware’s Carvel Research and Education Center in Georgetown. The study consisted of 14 fungicide treatments arranged in a spatially balanced randomized complete block design with four replications. Soybeans were planted into no till soybean residue on 21 May at 150,000 seeds / A. Plots consisted of four 30-in. spaced rows, 20 ft long and 10 ft wide with 5-ft alleys between plots. Standard soybean production practices as described by the University of Delaware Cooperative Extension Service were followed. Fungicides were applied to the center two rows at a rate of 20 gal/A with a CO_2 backpack sprayer equipped with a 6 ft boom with TeeJet® 80V02 fan nozzles angled forward 20 degrees. Fungicides were applied on 3 Jul (V5) 14 Jul (R1) and 13 Aug (R3). Natural sources of pathogen inoculum were relied upon for disease. Disease was evaluated on 25 Aug and 2 Sep by visually assessing leaf disease severity. Briefly, a total of six trifoliate leaves were randomly picked from the lower 1/3 canopy of the middle two rows for each plot. Each trifoliate was rated for percent of leaf area infected. The center two rows of each plot were harvested 14 Oct using a small plot combine. Yields were corrected to 13% moisture. All disease and yield data were assessed for normality and analyzed using a mixed model analysis of variance and means were separated using Fisher’s least significant difference (*P*=0.05).

Average temperatures were 76.2^{o}F, 73.9^{o}F, and 71.2^{o}F for Jul, Aug, and Sep, respectively. The growing season was dry, with rainfall of 2.95 in., 3.25 in., and 3.37 in. during Jul, Aug, and Sep, respectively. Plants were planted later than typical, and this in combination with dry weather resulted in slow growth rates. Consequently, canopies never completely closed between plot rows and disease developed later than typical for brown spot in Delaware. Treatments significantly impacted disease severity at both rating times. On 25 Aug, Priaxor was the only treatment to reduce disease compared to untreated controls when applied at V5. All other treatments applied at either R1 or R3 significantly reduced disease relative to controls except Domark applied at R1. On 2 Sep, all treatments except Stratego YLD applied at V5 significantly reduced foliar disease relative to controls. Both Priaxor and Trivapro applied at R3 provided significantly greater disease control than all Stratego YLD treatments and Domark applied at R1. Stratego YLD, Domark, Trivapro, and Priaxor applied at R3 improved yield relative to untreated controls. No effects were detected for test weight.

Treatment, Rate/A, Timing	Disease Severity (%) 25 Aug	Disease Severity (%) 2 Sep	TWT[y] (lb/bu)	Yield (bu/A)
Affiance, 10 fl oz, R1	3.3 d	6.0 de	55.0	28.0bcde
Affiance, 10 fl oz, R3	3.0 d	6.8 de	55.1	28.5bcde
Aproach Prima, 6.8 fl oz, R3	3.8 cd	7.3 cde	55.0	28.8abcde
Domark 230ME, 4 fl oz, R1	7.0 ab	9.0 bcd	54.5	25.9de
Domark 230ME, 4 fl oz, R3	4.5 cd	7.3 cde	54.7	29.3abcd
Priaxor, 4 fl oz, V5	3.5 d	8.3 bcde	54.8	28.5bcde
Priaxor, 4 fl oz, R3	3.3 d	5.0 e	55.3	32.0abcd
Proline, 3 fl oz, R1	3.5 d	7.3 cde	55.2	26.8cde
Stratego YLD, 2 fl oz, V5	9.0 a	10.5 abc	55.6	26.5cde
Stratego YLD, 4 fl oz, V5	9.0 a	11.8 ab	54.8	26.0cde
Stratego YLD, 4 fl oz, R3	3.0 d	9.5 bcd	55.5	29.3abcd
Trivapro, 14.6 fl oz, V5	6.0 bc	6.3 de	55.2	28.3bcde
Trivapro, 14.6 fl oz, R3	4.0 cd	4.8 e	54.9	31.1abcd
Untreated check	9.0 a[x]	13.8 a	55.0	25.7e
P(*F*)	<0.0001	<0.0005	NS	<0.01
R^2	0.73	0.59		0.69

[w] NS = not significant.

[x] column numbers followed by the same letter are not significantly different at P=0.05 as determined by Fischer’s LSD test.

[y] TWT = test weight.

SOYBEAN (*Glycine Max* ‘Asgrow AG45231’) A. A. Kness, C. D. Ramage, and N.M. Kleczewski

Soybean cyst nematode (*Heterodera glycenes*) University of Delaware

Evaluation of seed treatments for soybean cyst nematode control of soybean in Delaware, 2015.

The experiment was conducted at the University of Delaware’s Carvel Research and Education Center in Georgetown. The study consisted of 5 seed treatments and a untreated control run through the treatment process arranged in randomized complete block design with seven replications. Soybeans were planted into no till soybean residue on 25 May at 150,000 seeds / A in a field heavily infested with Race 1,4 of Soybean cyst nematode. Plots consisted of four 30-in. spaced rows, 20 ft long and 10 ft wide with 5-ft alleys between plots. Standard soybean production practices as described by the University of Delaware Cooperative Extension Service were followed. Seed treatments were applied by the industry and applied using a Monosem planter. Initial SCN egg numbers were collected immediately following planting from the center 5-ft of each plot by collecting 8, 0.5in. x 8-in. soil cores per plot, followed by egg/cyst extraction and enumeration using standard protocols. Egg samples were samples on 25-Jun and 24 Jul, and the difference between final and initial egg numbers used to determine product effect on SCN reproduction. Emergence was rated from the center 2 rows of each plot on 5-Jun, and 6 seedlings from the inner 2 rows were randomly harvested and dried to consistent mass. Plots were harvested on 26-Octover and yields corrected to 13.4% moisture. All disease and yield data were assessed for normality and analyzed using a mixed model analysis of variance and means were separated using Fisher’s least significant difference (*P*=0.05).

Average temperatures were 76.2°F, 73.9°F, and 71.2°F for Jul, Aug, and Sep, respectively. The growing season was dry, with rainfall of 2.95 in., 3.25 in., and 3.37 in. during Jul, Aug, and Sep, respectively. No significant effects were detected for any seed treatment in comparison to controls for any measured variable. However, emergence, drymass, and yields were numerically lower for controls when compared to all tested seed treatments.

Treatment	Pf/Pi[w] 1st	Pf/Pi 2nd	Emergence (%)	Drymass (g)	Yield (bu/A)
untreated	0.34	1.67	87	0.084	30.5
Clariva complete	0.39	1.59	94	0.087	35.9
CruiserMaxx Vibrance	0.34	1.63	87	0.087	34.2
Clariva complete + Mertect	0.31	1.72	93	0.087	34.2
Acceleron + Poncho Votivo	0.44	1.51	92	0.093	36.7
P(F)	NS[x]	NS	NS	NS	NS

[w] Final SCN egg count dived by initial SCN egg count

[x] NS = not significant

Impacts of Soybean Vein Necrosis Disease on Delaware Soybeans

Final report for 2015 Season

Funded by the Delaware Soybean Board

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Introduction

In 2011, a new virus causing Soybean Vein Necrosis disease (SVNd) was identified in Maryland and Delaware soybean fields. Soybean Vein Necrosis Virus is acquired by Soybean thrips during the first two larval stages and transmitted in a persistent, propagative manner. Symptoms of SVNd include vein clearing or necrosis, which can spread over the entire foliar surface over time. Increased SVNd has been associated with reduced grain quality in Midwestern soybean production regions; however, the significance of SVNd on Mid-Atlantic soybean production remains unclear.

There were two main **objectives** to the 2015 DSB project on SVNd:

1. Document SVNd occurrence and severity in Delaware soybeans planted in full and double crop production systems for a second consecutive season
2. Examine the effects of SVNd on soybean yield using replicated, small plot studies

To address these objectives, a survey, predominantly funded by USDA NIFA, and small plot research studies funded by DSB were conducted in Delaware during the 2015 growing season.

Methods

Survey

In 2015, we surveyed 30 full season and 20 double crop fields in Delaware. Fields were each surveyed twice to target early (vegetative or early reproductive) and late (mid-to late pod fill) stages in development (**Figure 1**). Within each field, twenty sites consisting of 3 row feet were haphazardly selected and assessed for the presence of plants with SVNd. Symptomatic trifoliates were collected, placed on ice, and shipped overnight for confirmation of the virus through Enzyme Linked Immunosorbant Assays (Agdia, Inc.). Data were analyzed using repeated measures ANOVA (JMP 12.0). DSB funds were used for confirmation of SVNV through Agdia, as explained in the initial proposal.

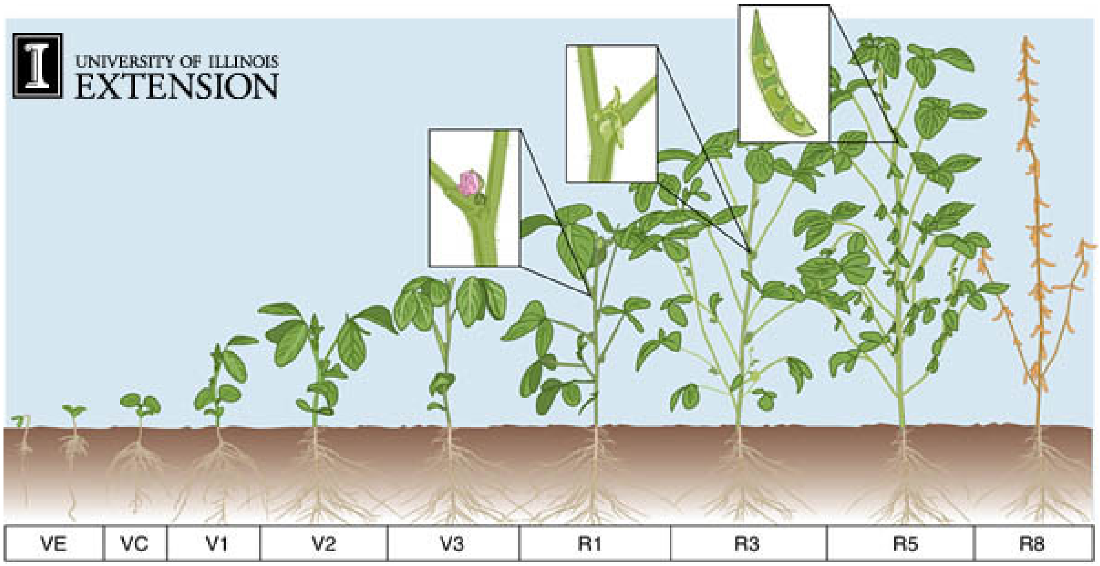

Figure 1. The stages of soybean growth and development. A plant at R6 would have at least one green pod on the upper four nodes filled to capacity.

Trial 1 Effects of Thrips on SVNd and Yield

Two trials were conducted to examine the impact of thrips numbers on SVNd and yield. The first trial was planted as full season and the second as double crop. Thrips numbers were manipulated through application of a neonicotinoid seed treatment and sequential foliar insecticide applications. The design was a randomized complete block with six reps per treatment. Treatments included: 1) untreated control, 2) neonicotinoid (Gaucho 2 oz./hundred weight) seed treatment (s), 3) S + V5 foliar application of spinosad (Blackhawk; 2 oz./A); 4) S+V5 + R1, 5) S+V5 + R1 + R3, and 6) S + V5 + R1 + R3 + R5. Plots were 10 ft. x 23 ft., with soybean cultivar SS 3914NS R2 planted on 30' rows at a target population of 171,000 plants / A. Treatments were applied to plots at 40 PSI with a CO_2 pressurized backpack sprayer. Blackhawk was chosen as it has been shown to have good thrips activity in other systems. Thrips were monitored every 7-14 days until a week after R5. At R6, SVNd severity was determined from 10 plants at the center of each plot. Twenty trifoliates were haphazardly selected from the upper 1/3 of the canopy and rated for percent foliar severity. Disease index was calculated using the formula index = (Incidence x severity) x 100. Plots were harvested and yields adjusted to 13% moisture. Virus was confirmed in symptomatic tissue by Agdia, Inc. Thrips data were analyzed using repeated measures ANOVA. Yield and total thrips data were analyzed using a random mixed model analysis of variance (JMP 12.0).

Trial 2 Effects of variety and planting date on SVNd

A third study was conducted due to serendipity, as SVNd was severely and evenly distributed in one of the UMD soybean variety trials. The 2015 UMD soybean variety trial was used to assess the impacts of variety and cropping system on SVNd severity and yield. All cultivars were planted in a full season and double crop production system at the Wye Research and Education center located in Queenstown, MD in a random complete block design with three reps per variety. Ten cultivars were selected from the variety trials based on arbitrary categorization to symptom expression level (low, medium, high). SVNd index was calculated as described in Trial 1 at R6. Plots were harvested and yields adjusted to 13% moisture. Data were analyzed using a random mixed model analysis of variance (JMP 12.0).

Results

Survey

Survey results indicated that 72% of fields had detectable levels of disease by R5-R6, with 69% of full season and 93% of double crop fields affected. The within field severity ranged from 41% to 53% in full season vs double crop fields, respectively (**Table 1**). Statistical analyses indicated significant effects of evaluation time and cropping system on SVNd severity [Cropping System x Stage at Rating P (*F*) = 0.014]. SVNd developed earlier and to a greater degree in double crop soybeans compared to full season soybeans (**Figure 2**). In the full season fields, SVNd incidence at the reproductive stage was similar to the vegetative stage in double crop systems. This is similar to what was observed in the 2014 SVNV survey.

Table 1. Overall survey data showing indicating the location, cropping system, as well as overall levels of symptomatic plants in Delaware, 2015.

Cropping system	**County (# fields)**	**Fields with SVNd**	**Average Within Field Incidence**[y]
Full Season	Newcastle (8)	75%	38%
	Kent (12)	82%	39%
	Sussex (10)	50%	45%
Double Crop	Newcastle (9)	100%	76%
	Kent (6)	100%	50%
	Sussex (5)	80%	34%

[Y] Incidence is the percent of infected plants within an infected field

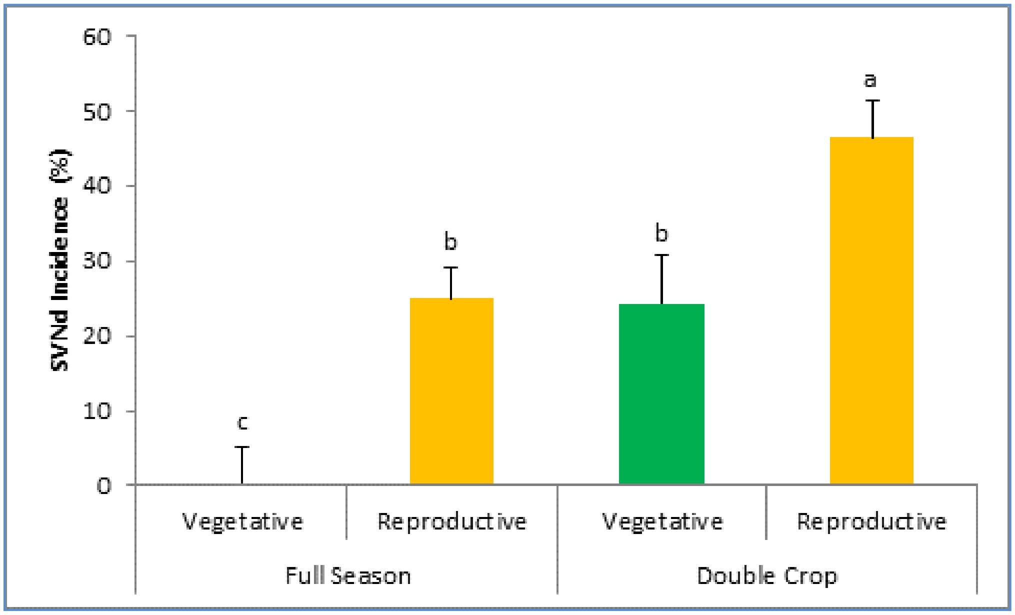

Figure 2. The effects of stage at rating and cropping system on SVNd incidence. Statistical analysis indicated that SVNd incidence was significantly impacted by the cropping system and that infection started earlier in double crop systems. Different letters indicate significant differences using Fisher's Protected LSD (α = 0.05).

Trial 1- Effects of Thrips on SVNd and Yield

Unfortunately technical issues prevented us from utilizing data from the full season study. . In the double crop planting, insecticide treatments significantly reduced thrips up to seven days after treatment on three of the six assessment dates [Time x Treatment; P(*F*) <0.0001] . Plants receiving three or four foliar insecticide applications had significantly lower total numbers of thrips than other treatments (**Table 2**). However, thrips reduction did not impact SVNd index or yield (**Table 2**). Overall, SVNd levels for this trial were very low.

Table 2. Effects of sequential applications of Blackhawk insecticide (2 oz./A) and seed Gaucho treatment on thrips numbers, SVNd severity, and yield.

	No. Thrips per 20 Leaflets						**Total Thrips**	**SVNd Index**	**Yield (bu/A)**
Treatment	**3-Aug**	**10-Aug**	**17-Aug**	**25-Aug**	**11-Sep**	**15-Sep**			
control[x]	3	12 a[y]	7	26	22 a	10 ab	80 a	0.035	33
Seed treatment (S)	5	11 a	6	24	15 bc	11 a	71 ab	0.069	36
S+V4	5	6 b	9	28	15 bcd	9 abc	72 ab	0.037	35
S+V4+R1	5	5 bc	7	22	19 ab	9 ab	66 b	0.051	36
S+V4+R1+R3	3	2 c	6	23	13 cd	7 bc	54 c	0.055	35
S+V4+R1+R3+R5	5	6 bc	6	20	10 d	6 c	52 c	0.068	35
P(*F*)	NS	<0.0001	NS	NS	<0.001	0.028	<0.001	NS	NS

[x] Planted on 7/15/2015; Foliar applications of Blackhawk (2 oz. /A) occurred on 8/6, 8/18. 8/27, and 9/8 2015.

[y] Treatment means not sharing the same letter are significantly different using Fishers LSD (α=0.05)

Trial 2 Effects of variety and planting date on SVNd

Overall, full season beans out-yielded double crop beans (78.8 vs 56.7 bu /A). SVNd index was 250% greater in double crop beans when compared to full season beans (5.5 vs 2.2%). Variety significantly impacted both yield and SVNd index within both systems [Variety P(*F*) <0.0001]. SVNd index was lowest for cultivar 74B42R in both cropping systems (**Figure 3A**). For a given cultivar, SVNd index was greater for the double crop system when compared to the corresponding full season system in seven of the ten cultivars rated (**Figure 3B**). Across all varieties and systems we detected a moderate, but significant negative linear relationship between log SVNd index and yield [P(*F*) <0.0001; **Figure 4**].

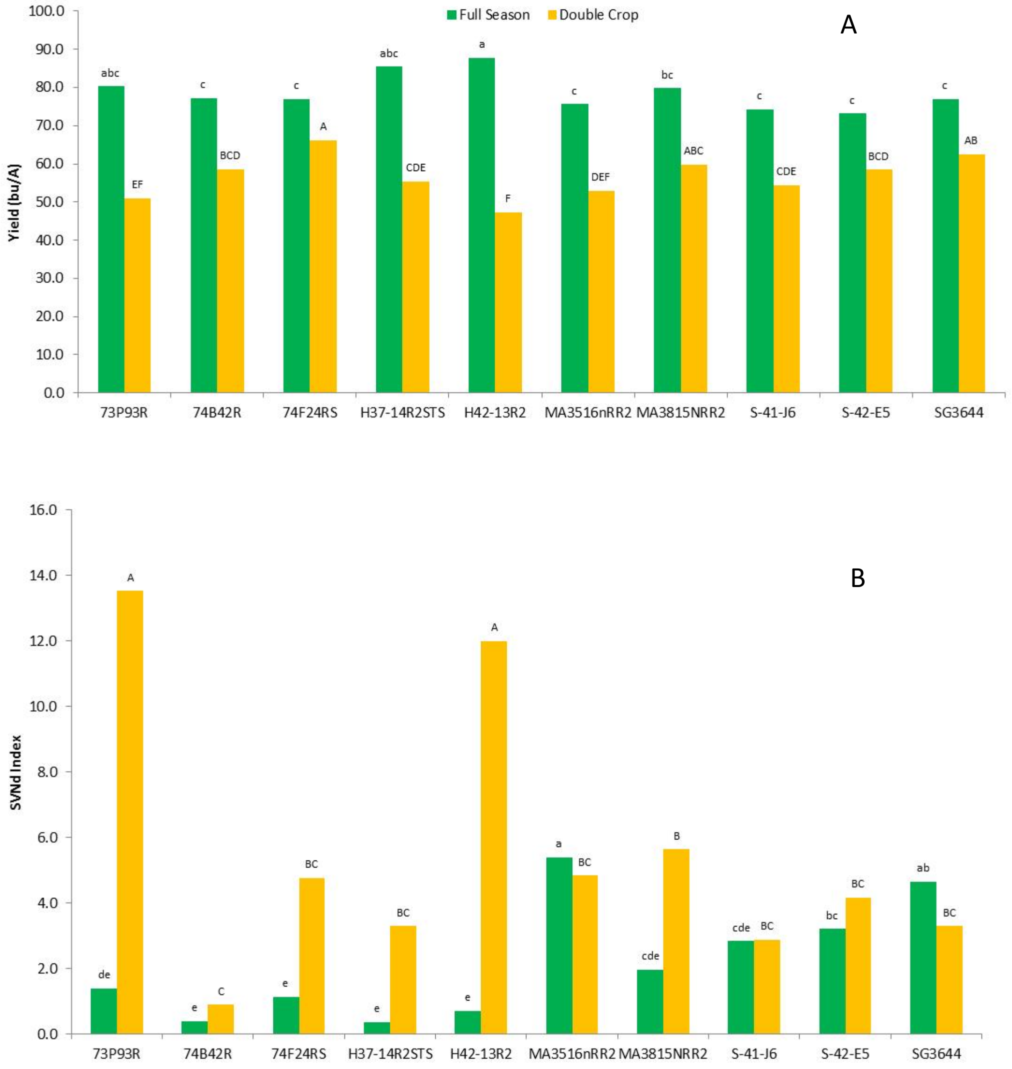

Figure 3A-B. Yield and SVNd Response of ten soybean cultivars planted in full season and double cropping systems in 2015. A) Yields significantly differed between cultivars, with full season yielding better than double crop, as expected. B) Cultivars significantly differed in SVNd response. In general, SVNd was lower for most cultivars in full season plantings when compared to double crop plantings. The cultivar 74B429 contained significantly less SVNd in both full season and double crop plantings. Treatment means within the same capitalization scheme not sharing the same letter are significantly different using Fishers LSD (α=0.05).

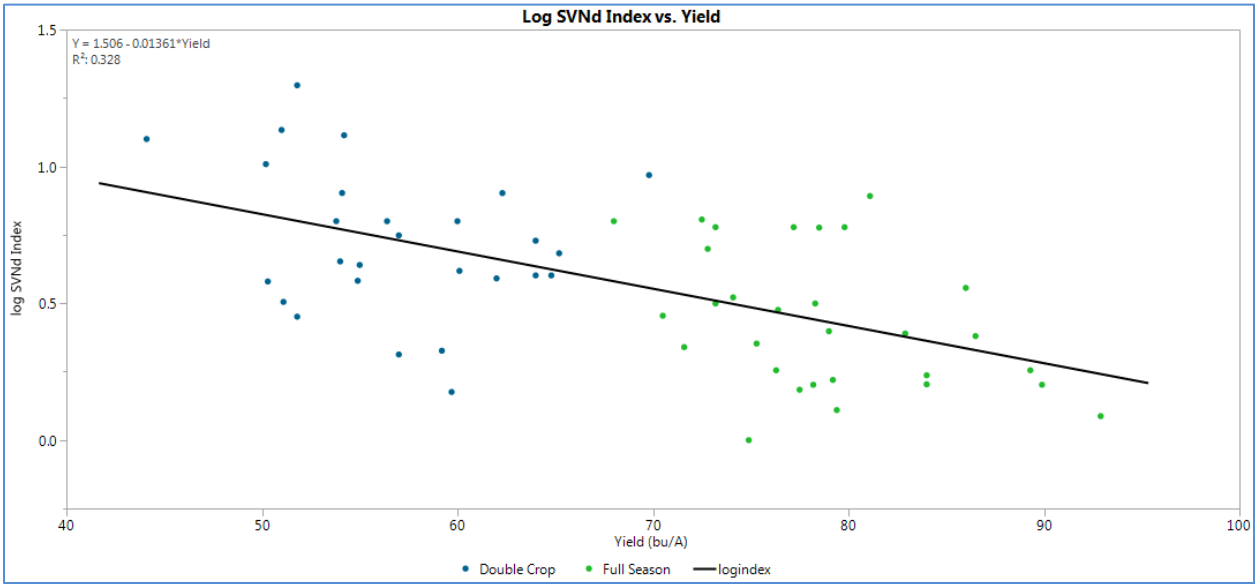

Figure 4. A significant negative, linear relationship was detected between log SVNd index and yield for ten soybean varieties planted in full season and double crop systems.

Discussion

For the second consecutive season, we have documented SVNd to be a prevalent viral disease in both full season and double crop soybeans grown in Delaware. Survey and research plot trials support the hypothesis that double crop soybeans may be impacted by SVNd to a greater degree than full season beans. Double crop beans are planted later in the growing season, which may result in exposure to greater numbers of thrips carrying SVNV and therefore increased SVNd earlier in plant development. Our results show that soybean cultivars may vary significantly in disease expression. Of the ten cultivars examined, foliar disease expression was consistently and significantly lower in cultivar 74B42R when compared to other tested cultivars. Our data showed a moderate, but significant relationship between logarithmic relationship between SVNd index and yield. To our knowledge, this is the first report of a negative yield impact associated with SVNd. It must be noted that the correlation between index and yield was conducted across a range of cultivars with different SVNd expression levels. Variation in response to SVNd by a particular variety can occur as a result of variety level responses. Thus, the correlation observed here may be stronger if expression patterns of various varieties are taken into account. Unfortunately, such analysis is beyond the scope of the present study but may be considered in future years.

Preliminary data from replicated trials conducted across the United States indicate that SVNd symptomology may be associated with changes in bean quality, particularly oil (Paper under review). Although beans were harvested for quality analysis in Trial 2, data are not expected until 2016. Shifts in oil content may be important to growers planting high oleic soybeans because the purchase of these beans and associated premiums may not be realized if oleic oil content falls below a stated level. A better understanding of the responses of high oleic soybeans to SVNd may be an appropriate avenue to explore in the near future.

Although insecticides did reduce thrips numbers, the reduction was not sufficient to reduce SVNd. Great effort was taken to ensure adequate coverage of the foliage with Blackhawk insecticide; however, we were able to detect living thrips on foliage, regardless of when tissue was assessed in relation to treatment application. Edge effect, plant growth in between applications, and coverage may have contributed to these results. It is important to remember that the virus is transmitted persistently (throughout the lifespan of the insect after the acquisition phase) and sufficient disease transmission may be achieved in the presence of relatively low numbers of infected insects. Untreated areas can serve as reservoirs allowing reestablishment of the insect. Trial 2 was bordered by woods to facilitate infestation by thrips. Although this may have helped establish SVDd, it also may have provided a means for thrips to rapidly reestablish on untreated tissues and plots following a treatment. Regardless, the purpose of Trial 2 was not to test the effectiveness of Blackhawk or seed treatment insecticides for managing thrips. Rather, the goal was to generate a range of thrips pressure that would create a gradient of SVNd symptoms within a single soybean variety. We were unable to achieve this goal in Trial 2. The role of insecticides for thrips / SVNd management remains unclear.

Our results indicate that SVNd is prevalent across Delaware and that it may be associated with reductions in yield in some instances. Although we do not currently have any recommendations for management because the factors associated with yield loss need to be better defined, planting date and variety will likely play a significant role in managing SVNd if the need arises in the future. The methods for rating described in this report are simple, repeatable, and should allow breeders, variety trial coordinators, plant pathologists, and other industry to assess varieties for SVNd and provide these data to growers in technical and extension publications.

Future Directions

There are many aspects of SVNd that we do not understand. For example, we do not know which species of thrips may transmit the virus in soybeans grown in Delaware. Research indicates that soybean thrips are a vector, but are there other thrips in our region that may contribute to the disease? Where are these thrips overwintering? Although there are preliminary data on host range in the literature, we do not know what weeds or cultivated species important to Delaware may serve as alternate hosts for the virus. A better understanding of these factors will improve our knowledge of this soybean virus and its potential management in future years.

Vegetables

WATERMELON (*Citrullus lanatus* ‘Sugar Baby’)
Fusarium wilt; *Fusarium oxysporum* f. sp. *niveum*

K. L. Everts and R. C. Korir
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Evaluation of fungicides for management of foliar diseases on watermelon, 2015.

The experiment was conducted at the University of Maryland’s Lower Eastern Shore Research and Education Center, Salisbury, as a randomized complete block design with six fungicide treatments and four replications. Plots consisted of one raised bed, 40 ft long, on 7-ft centers using 1.25-mil plastic and one line of 8-in. emitter spaced drip tape. The beds were shaped and covered with plastic in a one pass operation on 22 May. Four-week-old seedlings were removed from the greenhouse to begin hardening off on 21 May. They were transplanted into the field 36 in. apart with a 20-20-20 (N-P-K) (2.5 lb/150 gal water) starter solution on 29 May. Soil moisture was maintained by drip and overhead sprinkler irrigation as needed. Fungicide applications began 24 Jun, when the vines met in the row, and were applied weekly until 13 Aug. Fungicides were applied with a tractor-mounted sprayer that delivered 45 gal/A at 43 psi through six D4-45 hollow-cone nozzles mounted in a directed pattern. The percent severity of Cercospora leaf spot, gummy stem blight and downy mildew were evaluated on 31 Jul. Defoliation due to all diseases, including downy mildew, was evaluated as the percent necrotic tissue on a whole plot basis on 17 Aug, when individual symptoms could not be distinguished. All mature and marketable fruit from each plot were harvested, counted, and weighed on 3 Aug. A final harvest was made on 10 Aug by removing all remaining marketable and nonmarketable fruit, which were counted and weighed. Percent brix was evaluated for three random fruit per plot on each harvest date.

Cercospora leaf spot, gummy stem blight, and downy mildew occurred in all plots during the season. All fungicide schedules reduced Cercospora leaf spot, gummy stem blight and downy mildew severity as compared to the non-treated plots on 31 Jul when disease severity was low. By 17 Aug, gummy stem blight and downy mildew had progressed and caused severe necrosis in the non-treated plots. Plots sprayed with either Aprovia Top at the high rate and Inspire Super, or with Luna Experience had the least foliar necrosis, which was significantly lower than when Aprovia Top at the low rate was used or the non-treated plots. There were no statistically significant differences in % brix (data not shown) or yield among treatments. No phytotoxicity was observed.

Treatment and rate/A	Application dates[z]	Cercospora leaf spot (%) 31 Jul	Gummy stem blight (%) 31 Jul	Downy mildew severity (%) 31 Jul	Foliar necrosis (%) 17 Aug	Yield lb/plot
Bravo Weather Stik 6SC 24 fl oz;	1,2,3,6,8					
Aprovia Top EC 8.5fl oz	4,5,7	1.2 b[y]	2.2 b	0.00 c	18.3 b	185 a
Bravo Weather Stik 6SC 32 fl oz;	1,2,3,6,8					
Aprovia Top EC 10.5fl oz	4,5,7	0.9 bc	1.3 b	0.25 bc	14.3 bc	213 a
Bravo Weather Stik 6SC 32 fl oz;	1,2,3,6					
Aprovia Top EC 10.5 fl oz	4,7					
Inspire Super 2.82SC 20 fl oz	5,8	1.0 bc	1.7 b	0.00 c	13.3 c	226 a
Bravo Weather Stik 6SC 32 fl oz;	1,2,3,6					
Aprovia Top EC 10.5 fl oz;	5,8					
Inspire Super 2.82SC 20fl oz	4,7	0.2 c	1.5 b	0.03 bc	13.8 c	211 a
Bravo Weather Stik 6SC 32fl oz;	1,2,3,6,8					
Luna Experience SC 17fl oz	4,5,7	0.7 bc	1.6 b	0.46 b	11.3 c	214 a
Non-treated		4.3 a	7.2 a	3.64 a	81.3 a	220 a
P value[x]		0.0008	0.0002	0.0001	0.0001	0.4217

[z] Application dates were 1=24 Jun, 2=1 Jul, 3=8 Jul, 4=15 Jul, 5=23 Jul, 6=29 Jul, 7=5 Aug, and 8=13 Aug.

[y] Mean values in each column followed by the same letter do not significantly differ according to Fisher's protected LSD ($P = 0.05$).

[x] P values ≤ 0.05 indicate significant differences are likely to exist among treatments.

WATERMELON (*Citrullus lanatus* ‘Sugar Baby’)
Fusarium wilt; *Fusarium oxysporum* f. sp. *niveum*

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Evaluation of Proline and Topsin M fungicides for management of Fusarium wilt on watermelon, 2015.

The experiment was conducted at the University of Maryland’s Lower Eastern Shore Research and Education Center, Salisbury, as a randomized complete block design with six fungicide treatments and four replications. Plots consisted of one raised bed, 80 ft long, on 7-ft centers using 1.25-mil plastic and one line of 8-in. emitter spaced drip tape. The beds were shaped and covered with plastic in a one pass operation on 13 May. Four-week-old seedlings were removed from the greenhouse to begin hardening off on 24 May. They were transplanted into the field 36 in. apart with a 20-20-20 (N-P-K) (2.5 lb/150 gal water) starter solution on 29 May. Soil moisture was maintained by drip irrigation as needed. Fungicide applications began on 2 Jun, and were applied weekly until 22 Jul. Fungicides were applied through the drip irrigation or as a foliar spray by a tractor-mounted sprayer that delivered 45 gal/A at 43 psi through six D4-45 hollow-cone nozzles mounted in a directed pattern. Individual vines were measured from four plants from each plot on 19 Jun. On 29 Jun, the percent of plants per row that were wilted was determined and the percentage of wilted foliage was evaluated on 7 and 22 Jul. The percent of foliage that demonstrated phytotoxicity symptoms of leaf margin necrosis was rated on a whole plot basis on 1 Aug. Gummy stem blight severity was also evaluated on the whole plot on 1 Aug. All mature and marketable fruits from each plot were harvested, counted, and weighed on 4 Aug. A total of five plants were collected from each plot, and fresh and dry weights were taken on 4 and 11 Aug, respectively.

Proline applied three times through the drip reduced Fusarium wilt severity on July 22 as compared to both the non-treated plots and plots treated with Topsin M. Proline applied once through the drip on 2 Jun or on 17 Jun and followed by foliar applications also reduced Fusarium wilt compared to the non-treated control. Vines were longest in plots where Proline was applied through the drip just after transplant. Gummy stem blight remained low throughout the season, and there were no statistically significant differences among treatments (data not shown). Due to high Fusarium wilt, which caused plant stunting, wilting and death, yield was extremely low in the field. There were no differences in total fruit weight or fruit number among treatments. In addition, no differences were observed in fresh or dry vine weight. A low level of phytotoxicity (less than 2%) was observed in plots where Proline was applied once through drip and then applied to the foliage on 24 June and 15 July.

Treatment and rate/A	Application timing[z]		% Fusarium wilt[y]			Vine length (in.)
	Drip	Foliar	29 Jun	7 Jul	22 Jul	19 Jun
Proline 480SC, 5.7 fl. oz	1,2,4		11.4 a[x]	27.0 a	60.0 c	17.2 a
Topsin M 4.5FL, 10 fl. oz	1,2,4		32.2 a	48.8 a	77.5 ab	13.0 c
Proline 480SC, 5.7 fl. oz	1	3,6	15.7 a	23.8 a	66.3 bc	17.3 a
Proline 480SC, 5.7 fl. oz	1	5,6	26.6 a	43.8 a	72.5 abc	16.5 ab
Proline 480SC, 5.7 fl. oz	2	5,7	21.6 a	32.0 a	66.3 bc	13.2 c
Non-treated	-	-	32.3 a	42.0 a	88.8 a	13.7 bc
P value[w]			0.0962	0.1174	0.0252	0.0183

[z] Application dates were 1=2 Jun; 2=17 Jun; 3=24 Jun; 4=1 Jul; 5=2 Jul; 6=15 Jul; 7=22 Jul.

[y] Percent wilt incidence on 29 Jun was evaluated as the percent of plants within a row that were wilted; on 7 and 22 Jul the severity of Fusarium wilt was rated as the percent of wilted vines and overall stunting.

[x] Mean values within each column followed by the same letter are not significantly different at *P*=0.05 according to Fisher's protected LSD.

[w] *P* values $\leq$ 0.05 indicate significant differences are likely to exist among treatments.

MUSKMELON (*Cucumis melo* 'Sivan')
Manganese toxicity

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Field evaluation of rescue treatments for manganese toxicity in muskmelon production in Maryland, 2015.

Manganese toxicity is a frequent problem in muskmelon grown in low pH sandy soils, as commonly used starter solutions (i.e. ammonium nitrate, urea, or urea-ammonium nitrate) acidify the soil. Leaf symptoms usually appear when fruit begin to net and are often misdiagnosed as a foliar plant disease. Currently, little can be done to correct manganese toxicity during the season. The experiment was conducted at the University of Maryland's Lower Eastern Shore Research and Education Center, Salisbury. The field of Fort Mott loamy sand soil had been previously planted with corn and received no lime application after harvest. Soil pH was 6.0 on 11 Dec 2014. The experiment was conducted as a randomized complete block design with three replicates. Rescue treatments included: Botanicare's SilicaBlast, Growth Products' 0-0-25 solution, and General Hydroponics' pH Up. Non-treated plots served as a control. Plots consisted of single row raised beds, 90 feet long with 33 plants on 7-ft centers, with 1.25 mil black plastic mulch and drip irrigation. The field was fertilized with a 16-03-15 (N-P-K) (650 lb/A) starter solution before the plastic was laid on 27 May. Muskmelon seedlings were treated with AdmirePro (8 oz/A) on 9 Jun and transplanted into the field on 12 Jun; plants were 32 in. apart in the row. Weed management relied on rototilling and hand-weeding. Insects were managed with: Entrust (6 oz/A) applied on 26 Jun, 29 Jul and 24 Aug; and PyGanic (32 oz/A) applied on 9 Jul, and 7 and 13 Aug. Foliar diseases were controlled with applications of copper fungicides (Champ at 22 oz/A on 29 Jul and 7 Aug; and Nordox at 1 lb/A on 6, 13 and 19 Aug). Soil pH was 4.4 on 29 Jun 2015. Rescue treatments for manganese toxicity were initiated after onset of foliar symptoms and were applied for 1 hr through the drip (0.67 gal/A) on 21 and 29 Jul, and 13 and 19 Aug. Muskmelon foliage from 11 plants per treatment per replicate was evaluated for symptoms of manganese toxicity using a 1-5 scale (anchored by 1=no symptoms and 5=severe symptoms). Foliar manganese concentration was calculated from samples consisting of 19 young, fully mature leaves (no petioles) per treatment per replicate; analysis by A&L Eastern Laboratories in Richmond, VA. Soil pH under the plastic mulch was measured with composite soil samples consisting of seven surface (0-8 inch) soil cores per treatment per replicate; analysis by the University of Delaware Soil Testing Laboratory in Newark. Mature fruit were weighed and assessed for soluble sugars on 3, 8, 12, 18 and 24 Aug. Foliar toxicity ratings, manganese concentration, soil pH, and harvest data were analyzed using JMP version 10, and means separated using Student's t-test (*p*=0.05).

Rainfall in Jun, Jul and Aug was 9.1, 4.3 and 4.0 in., respectively. However, no precipitation was recorded within 24 hours of any treatment application. No rescue treatment significantly reduced foliar symptoms or improved soil pH under the plastic mulch. Although plants treated with SilicaBlast had significantly lower foliar concentrations of manganese at the end of the season than plants treated with the 0-0-25 solution or the non-treated control, the concentration exceeded the normal healthy range (50-250 ppm) for the vegetable crop. Plants treated with SilicaBlast and pH Up had significantly larger average fruit weights, as compared to the non-treated control. However, soluble sugars were not significantly different among treatments. All plants (including the non-treated control) had total yields within two standard deviations of the mean (272±20) (data not shown).

			Mn toxicity rating[z]				Weight	Brix
Treatment[y]	**Manufacturer**	**Active ingredient[x]**	**17 Jul**	**27 Jul**	**3 Aug**	**8 Aug**	**(lb)[v]**	**(%)[u]**
Control			3.09	3.48	4.24	4.64	1.45 b	11.4 a
SilicaBlast	Botanicare	2% Si, 0.5% K_2SiO_3	3.67	3.97	4.36	4.24	1.66 a	11.6 a
0-0-25 solution	Growth Products	25% K_2CO_3	3.52	3.76	3.97	4.30	1.60 ab	11.3 a
pH Up	General Hydroponics	10-30% K_2CO_3	3.36	3.97	4.36	4.21	1.66 a	11.8 a

[z] Data based on foliar ratings of 11 plants per treatment per replicate using a 1-5 scale, where 1=no symptoms, 2=minimal symptoms (less than 10%), 3=moderate symptoms (10-25%), 4=enhanced moderate symptoms (25-50%) and 5=severe symptoms (more than 50%).

[y] Treatments did not differ by date (17 Jul *p*=0.175; 27 Jul *p*=0.258; 3 Aug *p*=0.206; and 8 Aug *p*=0.160).

[x] Abbreviations: Mn = manganese; Si = silicon, K_2SiO_3 = potassium silicate; K_2CO_3 = potassium carbonate.

[v] Up to six mature fruit weighed individually on each evaluation date per treatment per replicate. Average fruit weight was significantly different between the control and rescue treatments (*p*=0.022). Mean separation by Student's t-test (*p*=0.05).

[u] Brix (percent soluble sugars) determined for 19 fruit per treatment per replicate, staggered across harvest dates. Brix was not significantly different among treatments (*p*=0.325).

	Foliar Mn concentration (ppm)^{z}			**Soil pH^{w}**	
Treatment	**20 Jul** (0 applications)	**3 Aug** (2 applications)	**26 Aug^{y}** (4 applications)	**3 Aug** (2 applications)	**26 Aug** (4 applications)
Control	1543	1029	454 a	4.3	4.1
SilicaBlast	1363	888	322 c	4.4	4.3
0-0-25 solution	1553	888	440 ab	4.3	4.3
pH Up	1353	937	382 bc	4.2	4.3

Number in parentheses indicates number of rescue treatment applications prior to foliage or soil collection.

[z] Data based on foliar samples of 19 young, fully mature leaves per treatment per replicate. Normal Mn range is 50-250 ppm.

[y] Mn concentration was significantly different by treatment on 26 Aug (*p*=0.009), but not on 20 Jul (*p*=0.741) or 3 Aug (*p*=0.790). Mean separation by Student’s t-test (*p*=0.05).

[w] Data based on composite samples of seven soil cores collected under the plastic mulch per treatment per replicate. Recommended soil pH for muskmelon production is between 6.0 and 6.5. Soil pH was not significantly different by treatment (*p*=0.130) or date (*p*=0.421).

Summary squash (*Cucurbita pepo* ‘Gentry F1’)
Powdery mildew; *Podosphaera xanthii*

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Evaluation of fungicides for management of powdery mildew on squash, 2015.

The experiment was conducted at the University of Maryland’s Lower Eastern Shore Research and Education Center, Salisbury, as a randomized complete block design with thirteen fungicide treatments and four replications. Plots consisted of one raised bed, 30 ft long, on 7-ft centers using 1.25-mil plastic and one line of 8-in. emitter spaced drip tape. The beds were shaped and covered with plastic in a one pass operation on 22 May. Seeds were sown in the field 36 in. apart with a 20-20-20 (N-P-K) (2.5 lb/150 gal water) starter solution on 8 Jun. Soil moisture was maintained by drip and overhead sprinkler irrigation as needed. Fungicide applications began 14 Jul and were applied weekly until 4 Aug. Fungicides were applied with a tractor-mounted sprayer that delivered 45 gal/A at 43 psi through six D4-45 hollow-cone nozzles mounted in a directed pattern. Percent powdery mildew severity in each plot was assessed on 31 Jul and 13 Aug. The percent sporulation was estimated on the lower and upper surface of three random leaves positioned in the middle of the canopy. All mature and marketable fruit from each plot were harvested, counted, and weighed on 13, 15, 17, 20, 23, 29, 31 Jul and 3 Aug. A final harvest was made on 6 Aug by removing all remaining marketable and nonmarketable fruit, which were counted and weighed.

On 31 Jul all programs reduced powdery mildew severity on the upper leaf surface, and there were no differences among programs. However, on the lower leaf surface, Torino, Quintec, Aprovia Top and Luna Experience at 16 fl oz/A alternated with Procure; Torino alternated with Proline; and Luna Experience alone resulted in the greatest reduction of powdery mildew. Fontelis alternated with Torino, Aprovia Top alternated with Bravo, and a program where Torino and Procure were applied with the first spray delayed until 22 Jul all significantly reduced powdery mildew on the lower leaf surface as compared to the non-treated plots, but did not perform as well on 31 Jul as the top tier treatments. OSO alternated with Procure reduced powdery mildew as compared to the control, but OSO alone did not. On 13 Aug, Luna Experience alternated with Procure and Quintec applied twice followed by Procure resulted in the lowest numerical severity on both the upper and lower leaf surface, and Aprovia Top alternated with Bravo Weatherstik performed well on the upper leaf surface. In programs using Procure and/or Torino: Proline alternated with Torino, and Aprovia Top alternated with Procure and Luna Experience alone were intermediate. There were no statistically significant differences in yield. Quintec, which is not registered on summer squash, resulted in phytotoxicity (data not shown).

	Application dates[z]	Powdery Mildew (%)				Yield lb/plot
Treatment and rate/A		31 Jul		13 Aug		
		Upper Leaves	Lower Leaves	Upper Leaves	Lower Leaves	
OSO SC 6.5 fl oz	1-4	5.33 b	17.53 a	65.38 ab	82.61 ab	30.40 a
OSO SC 6.5 fl oz; Procure SC 8 fl oz	1,3 2,4	1.04 b	7.74 b	22.86 cd	44.03 cde	39.64 a
Aprovia Top EC 10.5 fl oz; Bravo Weatherstik SC 3pt	1,3 2.4	1.63 b	3.02 c	3.85 ef	57.25 bcd	35.21 a
Luna Experience SC 6 fl oz	1-4	0.17 b	0.60 de	16.49 c-f	28.84 de	33.89 a
Fontelis SC 1pt; Torino SC 3.4 oz	1,3 2.4	1.04 b	1.81 cd	40.24 bc	66.45 bc	32.20 a
Luna Experience SC 16 fl oz; Procure SC 8 fl oz	1,3 2,4	0.08 b	0.19 e	2.97 f	4.95 f	29.21 a
Aprovia Top EC 10.5 oz; Procure SC 8 fl oz	1,3 2,4	0.04 b	0.71 de	13.58 def	18.23 ef	29.51 a
Proline SC 5.7 oz; Torino SC 3.4 fl oz	1,3 2,4	0.00 b	0.12 e	22.85 cd	28.99 de	33.25 a
Quintec SC 6 fl oz; Procure SC 8 fl oz	1,2 3,4	0.00 b	0.07 e	3.30 ef	2.60 f	38.58 a
Procure SC 8 fl oz; Torino SC 3.4 fl oz	1,2 3,4	0.08 b	0.22 e	18.29 cde	27.52 de	34.20 a
Procure SC 8 fl oz; Torino SC 3.4 fl oz	1,3 2,4	0.08 b	0.11 e	14.79 def	18.13 ef	37.90 a
Torino SC 3.4 fl oz: Procure SC 8 fl oz	2 3,4	1.38 b	2.70 c	10.91 def	17.47 ef	29.94 a
Non-treated		23.50 a	31.57 a	82.13 a	96.06 a	33.99 a
P value[x]		0.0001	0.0001	0.0001	0.0001	0.7603

[z] Application dates were 1=14 Jul; 2=22 Jul; 3=28 Jul; 4=4 Aug.

[y] Mean values in each column followed by the same letter do not significantly differ according to Fisher's protected LSD (*P* = 0.05).

[x] *P* values ≤ 0.05 indicate significant differences are likely to exist among treatments.

LIMA BEAN (*Phaseolus lunatus* ‘Cypress’)
Downy mildew; *Phytophthora phaseoli*

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Evaluation of the residual activity of fungicides on downy mildew of lima bean in Delaware, 2015.

The experiment was conducted at the University of Delaware’s Carvel Research and Education Center, Thurmond Adams Research Farm in Georgetown. The experiment had nine fungicide treatments arranged in a randomized complete block design with four replications. Plots consisted of 4 rows spaced 30 in. apart and 20 ft in length. The two inner rows were used as treatment rows and the two outer rows were used as a buffer between adjacent plots. Lima beans were direct seeded into conventionally tilled ground on 16 Jun using a four-row Monosem planter at four seeds per ft of row. Plots were managed according to extension guidelines and irrigated with an overhead sprinkler system as needed. Fungicides were applied at late bloom on 7 Aug with a CO_2 backpack sprayer that delivered 20 gpa at 35 psi. The sprayer was equipped with a 6 ft boom with TeeJet® 80V02 nozzles spaced 18 in. apart set in a directed spray pattern. Plots were inoculated at dusk on 11 Aug by spraying pods located in the treatment rows with a liquid sporangial suspension of *P. phaseoli* using a hand-pressurized backpack sprayer. Inoculum was prepared by growing *P. phaseoli* on lima bean seedlings (cultivar Fordhook 242) in a controlled dew chamber at the University of Delaware’s Fischer Greenhouse in Newark. Briefly, tissue infected with *P. phaseoli* was harvested from previously prepared lima bean plants, finely chopped, and applied to 3-day old lima bean seedlings growing in 4 in. square pots and placed in a dew chamber for one week. The process was repeated weekly until a total of 4 flats of lima beans were harvested for inoculation. Infected plant material was harvested and placed in a bucket of water, agitated, then sieved into a 30 over 60 mesh screen into the sprayer and applied to the plots to ensure adequate pod coverage. Downy mildew incidence was rated on 20 Aug by counting the number of infected pods and the total number of pods from six randomly selected plants from the center two rows of each plot. Yield data was collected on 4 Sep by measuring the total amount of marketable shelled beans from the inner two rows of each plot.

A thunderstorm brought 1.17 in. of rain on 11 Aug that immediately preceded inoculation, which was then followed by an additional 0.06 in. of rain on the morning of 12 Aug. Rainfall, coupled with an average daytime temperature of $74.9^{o}F$ provided ideal conditions for disease. Downy mildew was most severe in the untreated control treatment. Forum, Tanos, and Prophyt did not significantly reduce disease severity compared to the untreated control. Ridomil Gold Copper, V10208, and Presidio were intermediate in their reduction of downy mildew compared to the untreated control. Orondis (A20942D) + chlorothalonil, and Orondis (A20941A) + Revus, provided the greatest reduction of downy mildew in the trial. There was a strong correlation between disease severity and yield (R^2=0.58, P<0.0001), plots treated with Orondis (A20941A) + Revus yielded the most marketable beans, and the untreated control yielded the least. No phytotoxicity was observed in any of the plots.

Treatment and rate/A	Downy mildew incidence (%)	Marketable yield (lb/A)
V10208 8 fl oz	13.87 c[z]	1803 bc
Forum 4SC 6 fl oz	30.20 d	1796 bc
Orondis (A20942D) + chlorothalonil 2.14 pt	5.03 ab	2276 ab
Orondis (A20941A) + Revus 2.05 fl oz & 6.8 fl oz	2.97 a	2416 a
Presidio 4SC 4 fl oz	11.76 c	1918 abc
Prophyt 4 pt	32.97 d	1507 cd
Ridomil Gold Copper WP 2 lb	8.61 bc	2143 ab
Tanos 50DF 8 oz	27.30 d	1583 cd
Non-treated	38.04 d	1199 d
P [y]>*F*	0.0001	0.0014

[z] Means within a column followed by the same letter are not significantly different according Fisher’s Protected LSD test (α=0.05).

[y] *P* values ≤ 0.05 indicate significant treatment differences.

2015 UD Nematode Assay Service Summary

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The University of Delaware Nematode Assay Service ran a total of 38 samples for the 2015 calendar year on vegetable and field crop samples. Thirty-five samples originated from Delaware and three samples were from Kent County Maryland. Twenty-nine of the samples originated from Sussex County, Delaware. Six samples were submitted from Kent County Delaware. Over 80% of the samples were submitted by private consultants or Agribusiness (ex: Pioneer, Syngenta). The remaining samples were submitted by University of Delaware extension agents, except for one sample that was submitted directly by a grower. Overall the service was not directly used by growers in Delaware, which is consistent with past growing seasons.

All samples requested a troubleshooting assay, with 19 of the samples also requesting soybean cyst nematode egg counts. Soybean cyst juveniles were detected in 12 of the 38 samples (32%). Lesion nematodes were the most common plant pathogenic nematode, occurring in 68% of the samples. Spiral nematodes were the second most common, occurring in 55% of the samples. Stunt and lance nematodes were found in 32% and 29% of samples, respectively. Root knot nematode was detected in 24% of samples. Stubby root and dagger were the least common nematodes detected in the assays, at 16% and 8%, respectively. Two samples had low numbers of ring nematode. The majority of samples (68%) had low levels of nematodes that would likely not affect crop production.

Overall, nematodes, with the exception of root knot, soybean cyst, and occasionally lesion, did not occur at levels that would significantly impact crop production in most Delaware crops. This is consistent with observations and past assay results. Other nematodes detected in the assays, although characterized as being pathogenic, do not often cause sufficient damage to impact yields or their numbers are not consistently tied to plant damage.