Summary

Weed Management in Corn 2022.

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Weeds remain a constant challenge in Virginia corn production. In an effort to provide research-based information on the most effective herbicides and other weed management techniques, 22 treatments were evaluated. Accordingly, the Virginia Cooperative Extension Pest Management Guide for Field Crops (http://pubs.ext.vt.edu/456/456-016/456-016.html) and the Mid-Atlantic Field Crop Weed Management Guide (http://extension.udel.edu/ag/weed-science/weed-management-guides/) were updated with the latest findings from herbicide evaluation research conducted in the Mid-Atlantic region. Additionally, Dr. Flessner's extension program delivered 20 presentations reaching an audience of >850 were delivered in 2022 that included information obtained through Virginia Corn Board sponsored research to producers, agronomists, industry groups, and other stakeholders, in addition to site visits and personal communications.

In addition to herbicides, experiments also evaluated corn "planted green" into cover crops to better understand potential weed management benefits of delayed weed emergence and better weed suppression from greater cover crop biomass compared to "planting brown" (after cover crop termination). Cover crop biomass increased as termination timing was delayed in all cases. Later terminated cover crop reduced soil moisture during May, when little to no rainfall occurred, which influenced results. Weed response varied, but generally improved as termination timing was delayed. Corn yield was poor mostly due to the drought, but also varied with treatment and termination timing, but generally, yield was greatest with hairy vetch terminated at planting.

Initial testing of harvest weed seed control was completed via preliminary assessment of combine metrics. Both an iHSD on a John Deere S770 and a Redekop Seed Control Unit on a John Deere S680 increased engine capacity compared to conventional harvest, which required extra fuel. Despite this, travel speed of the combine was not reduced in any field these configurations indicating that both combines had sufficient engine capacity to operate without slowing harvest. Weed seed capture and grain loss samples were collected to understand how effective harvest weed seed control might be in corn, but processing is still on-going at this time. Results are expected by March 2023.

VIRGINIA CORN BOARD
PROJECT REPORT – 2022

Weed Management in Corn 2022

Objectives:

1) Evaluate various preemergent and postemergent herbicides and programs for weed control.
2) Planting green into cover crops.
3) Preliminary analysis of a seed impact mill in corn.

Objective 1: Evaluate various preemergent and postemergent herbicides and programs for weed control.

Background:

The Weed Science Society of America considered corn yield in the US from 2007 to 2013 in the absence of herbicides. Without effective herbicides, they estimated that weeds would cause a 52% corn yield loss (https://doi.org/10.1614/WT-D-16-00046.1). In 1992, it was estimated that weeds caused a 1 to 15% loss in corn yield (http://www.jstor.org/stable/4045287). Among the most problematic weeds are those which are herbicide resistant. Clearly, effective weed management is necessary to maximize corn yield (https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/PPWS/ppws-101/PPWS-101.pdf). Notably, these include glyphosate (group 9) and ALS-inhibiting herbicide (group 2) resistant Palmer amaranth and common ragweed.

In an effort to provide research-based information on the most effective herbicides, the Virginia Cooperative Extension Pest Management Guide for Field Crops (http://pubs.ext.vt.edu/456/456-016/456-016.html) and the Mid-Atlantic Field Crop Weed Management Guide (http://extension.udel.edu/ag/weed-science/weed-management-guides/) are updated annually with the latest findings from herbicide evaluation research conducted in the Mid-Atlantic region. Additionally, Dr. Flessner's extension program delivers over 30 presentations per year to various stakeholder groups across Virginia. As new herbicides are introduced to the market and weeds' response to herbicides changes as resistance develops to existing herbicides, research must be conducted to evaluate and corroborate information provided in the guide. Therefore, this proposal is for research directly tied to providing the latest research-based information to corn producers.

Procedures:

In May 2022, experiments were established at Kentland farm in Blacksburg, Virginia. The experimental area had endemic populations of pitted and ivy leaf morningglory (*Ipomoea lacunosa* and *Ipomoea hederacea*, respectively), giant foxtail (*Setaria faberi*), redroot pigweed (*Amaranthus retroflexus*) and common lambsquarters (*Chenopodium album*). Prior to planting field corn, the area was tilled with a disk harrow followed by a roto-tiller and fertilized with 56 kg ha^{-1} of each nitrogen, phosphorus and potassium. Gramoxone was applied at 840 g ai ha^{-1} with 1% crop oil concentrate by volume prior to planting. Field corn was planted in early May 72,376 seeds ha^{-1} using a 2-row plot planter with 76.2 cm row spacing. An additional 112 kg ha^{-1} of nitrogen was applied when the corn was at growth stage V4.

Each experiment was a randomized complete block design with four replications. Herbicide treatments were made using handheld spray equipment and four TeeJet 11002XR (Spraying Systems Co.; Wheaton, IL) nozzles for all treatments. Spray equipment was calibrated to apply 140 L ha^{-1} (15 GPA) at 207 kPa. All preemergence (PRE) herbicides were applied immediately after planting. Postemergence (POST) herbicides were applied when corn was 30 cm tall. For all experiments in this objective, the area was weed free at planting.

Subsequent data collected included: visual crop injury on a scale from 0 – 100% relative to the untreated check, where 0 means no visible crop injury and 100 means complete plant necrosis; weed control by species on a scale from 0 – 100% relative to the untreated check, where 0 means the treatment neither injured the weed nor reduced its pressure and 100 means the treatment killed all weeds present; and grain yield, where grain weight in grams per plot was transformed to metric tons per hectare (Mg ha^{-1}) by dimensional analysis, accounting for plot size and grain moisture. Visible crop injury and weed control data were taken 2 and 4 weeks after PRE herbicide application and 2, 4, and 6 weeks after POST herbicide application. Grain yield was measured at the end of the season.

Results:

Experiment 1: Corn weed control using Acuron Flexi, Acuron GT, Impact Core, and other herbicides in a two-pass system.

Table 1. Treatments for experiment 1, where application A was made at planting on May 4, 2022 and application B was made June 1.

No.	Name	Rate	Unit	Application Code
1	Untreated Check			
2	Bicep II Magnum	2.5	qt/a	A
	Acuron GT	3.75	pt/a	B
	N-Pak AMS	2.5	% v/v	B
	NIS	0.25	% v/v	B
3	Bicep II Magnum	2.5	qt/a	A
	Halex GT	4	pt/a	B
	N-Pak AMS	2.5	% v/v	B
	NIS	0.25	% v/v	B
4	Lumaz EZ	2.25	qt/a	A
	Acuron GT	3.75	pt/a	B
	N-Pak AMS	2.5	% v/v	B
	NIS	0.25	% v/v	B
5	Lumaz EZ	2.25	qt/a	A
	Halex GT	4	pt/a	B
	N-Pak AMS	2.5	% v/v	B
	NIS	0.25	% v/v	B
6	Acuron Flexi	1.75	qt/a	A
	Roundup Powermax	32	fl oz/a	B
	N-Pak AMS	2.5	% v/v	B
	NIS	0.25	% v/v	B
7	Acuron Flexi	1.75	qt/a	A
	Zidua SC	1.85	fl oz/a	A
	Roundup Powermax	32	fl oz/a	B
	N-Pak AMS	2.5	% v/v	B
	NIS	0.25	% v/v	B
8	Acuron Flexi	1.75	qt/a	A

9	Acuron Flexi	1.75	qt/a	A
	Zidua SC	1.85	fl oz/a	A
10	Acuron	1.5	qt/a	A
	Princep	1	qt/a	A
	Acuron	1.5	qt/a	B
	Roundup Powermax	32	fl oz/a	B
	N-Pak AMS	2.5	% v/v	B
	NIS	0.25	% v/v	B
11	Bicep II Magnum	1.8	qt/a	A
	Halex GT	3.6	pt/a	B
	Aatrex	1	pt/a	B
12	Impact Core	20	fl oz/a	B
	Aatrex	1	pt/a	B
	Roundup Powermax	28.4	fl oz/a	B
	MSO	1	% v/v	B
	AMS	2.5	lb/a	B
13	Dual II Magnum	1.5	pt/a	A
	Impact Core	20	fl oz/a	B
	Aatrex	1	pt/a	B
	MSO	1	% v/v	B
	AMS	2.5	lb/a	B
14	Dual II Magnum	1.5	pt/a	A
	Impact	1	fl oz/a	B
	Aatrex	1	pt/a	B
	MSO	1	% v/v	B
	AMS	2.5	lb/a	B

Figure 1.

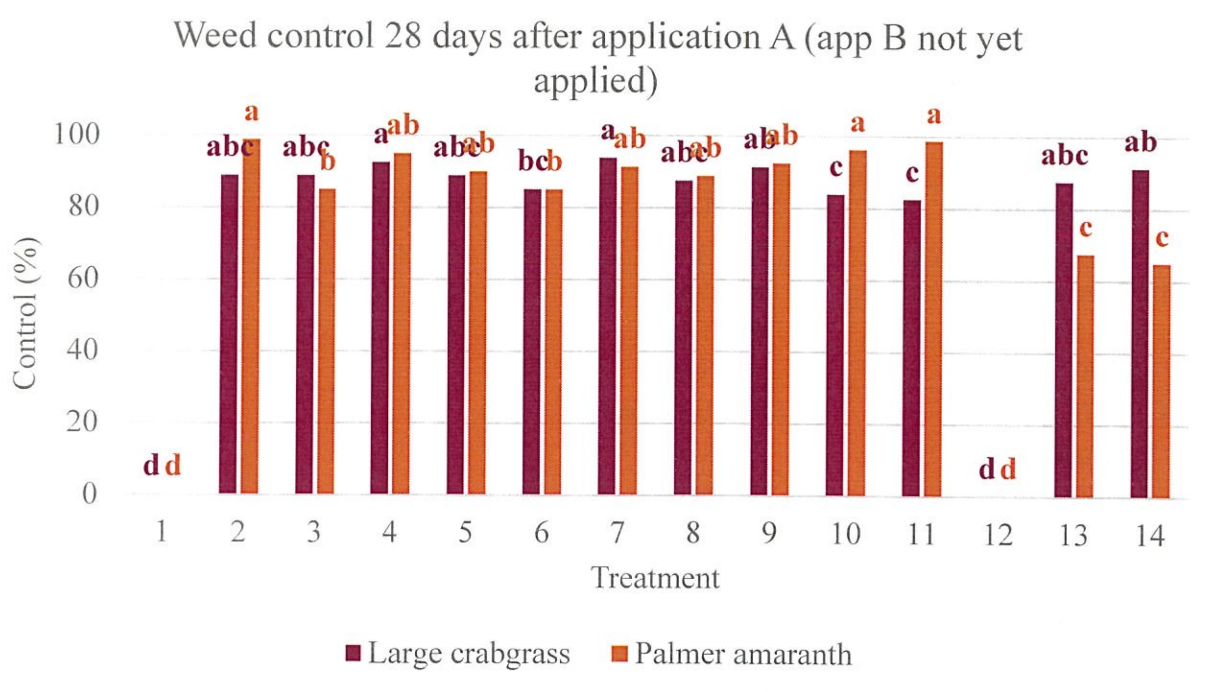
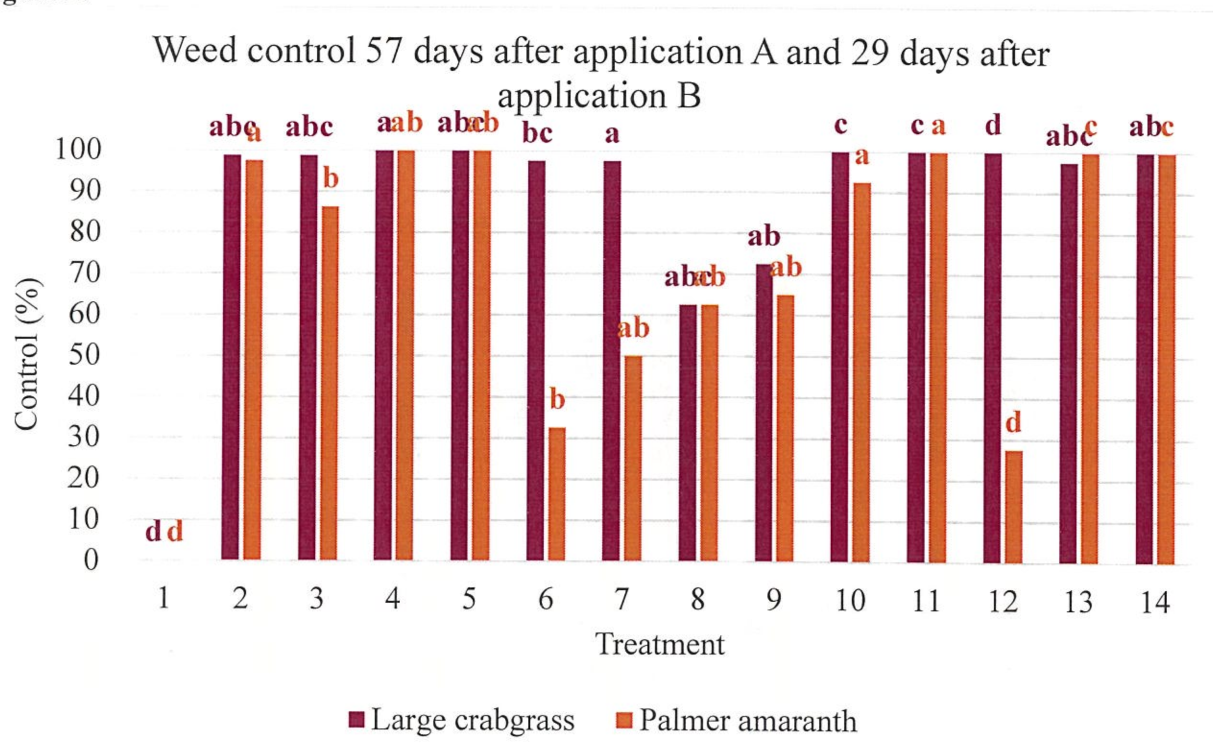


Figure 2.



Experiment 2: Preplant herbicidal control of cover crops and common weeds.

Table 2. Treatments for Experiment 2.

No.	Name	Rate	Unit
1	Untreated check		
2	Roundup Powermax 3	30	fl oz/a
	2,4-D LV4	16	fl oz/a
3	Gramoxone 2SL	48	fl oz/a
	COC	1	% v/v
4	Gramoxone 2SL	48	fl oz/a
	2,4-D LV4	16	fl oz/a
	COC	1	% v/v
5	AMS	8.5	lb/100 gal
	Sharpen	1	fl oz/a
	MSO	1	% v/v
	Roundup Powermax 3	20	fl oz/a
6	AMS	3	lb/a
	Interline	32	fl oz/a
7	Leadoff	1.5	oz wt/a
	Roundup Powermax 3	20	fl oz/a
8	AMS	8.5	lb/100 gal
	Sharpen	1	fl oz/a
	MSO	1	% v/v
	Leadoff	1.5	oz wt/a

Figure 3.

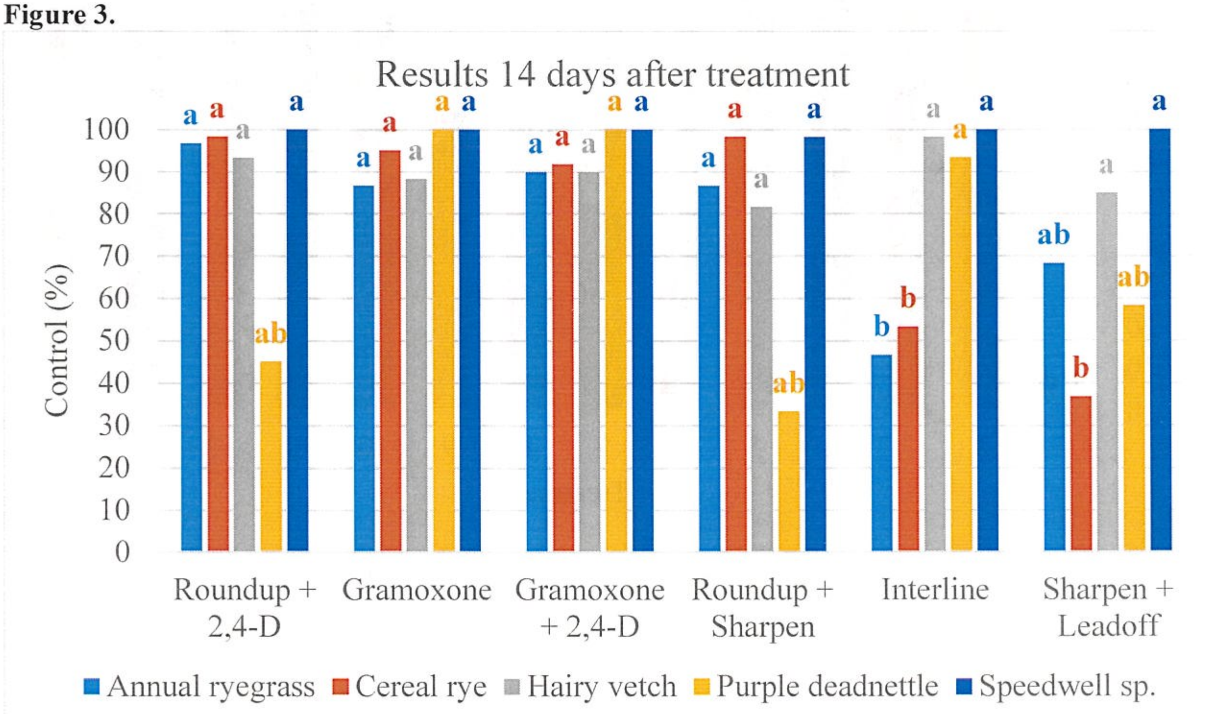
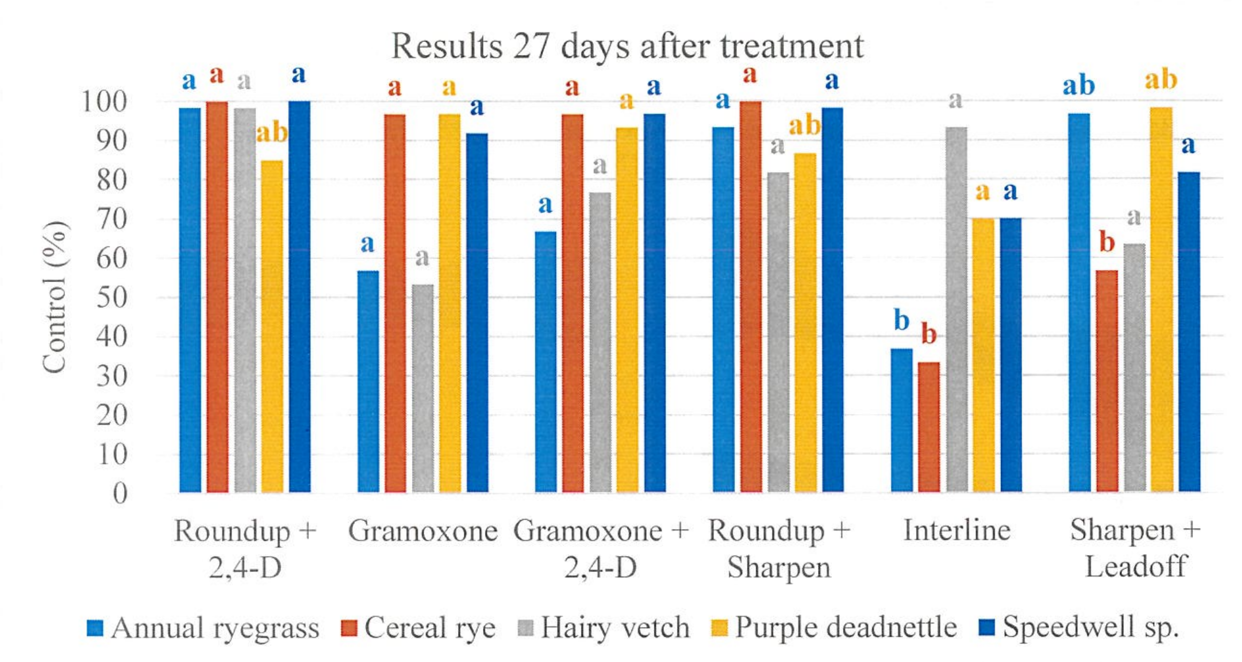


Figure 4.



Objective 2: Planting green into cover crops.

Background:

One way to help manage herbicide resistant weeds is through the use of cover crops, which have been shown to reduce summer annual weeds (https://doi.org/10.1017/S0890037X00040859). Research previously funded by the Virginia Corn Board indicates that approximately 7500 lbs of cover crop biomass per acre can result in 75% weed suppression for approximately 6 weeks after cover crop termination. This level of biomass means farmers must maximize cover crop biomass, which generally does not occur until approximately May 1. Since most grain corn is planted in April, corn farmers are not able to fully utilize cover crops for weed management. Planting into actively growing cover crops, known as "planting green," allows cover crop to continue to grow and acquire additional biomass until terminated by herbicides. Thus, weed suppression from cover crop residue should increase relative to termination prior to corn planting. Research funded by the Virginia Corn Board in 2020 indicated exactly that- by delaying termination of cover crops from 2 weeks prior to planting until at or 2 weeks after planting, cover crop biomass increased resulting in improved weed suppression while, importantly, maintaining corn yield. There are potential drawbacks to planting green, the most obviously of which is the cover crop competing with corn in the sensitive early establishment phase. Therefore, more research needs to be conducted to fully vet this system.

Procedures:

A factorial experiment of cover crop (none, hairy vetch, or cereal rye + hairy vetch) and termination timing (2 weeks before corn planting, 1 week before planting, at planting, 1 week after planting, and 2 weeks after planting) was initiated in two locations (Blacksburg and Blackstone, VA) in the fall of 2020 that was planted into corn starting in April 2021. Cover crops were terminated with glyphosate (Roundup at 1 qt/a) + glufosinate (Liberty at 1 qt/a). At each termination timing, a subsample of aboveground cover crop biomass was collected. Palmer amaranth density was evaluated 4 weeks after planting. All weeds were controlled 4 weeks after planting with Halex GT at 3.5 pt/a. Corn yield was evaluated. Standard agronomic practices were used including N fertility, hybrids, planting rates, no-till, etc.

Results:

Figure 5. Cover Crop biomass by site-year from termination timings 2 weeks before (-2), 1 week before (-1), at planting (0), 1 week after (1), and 2 weeks after (2) planting.

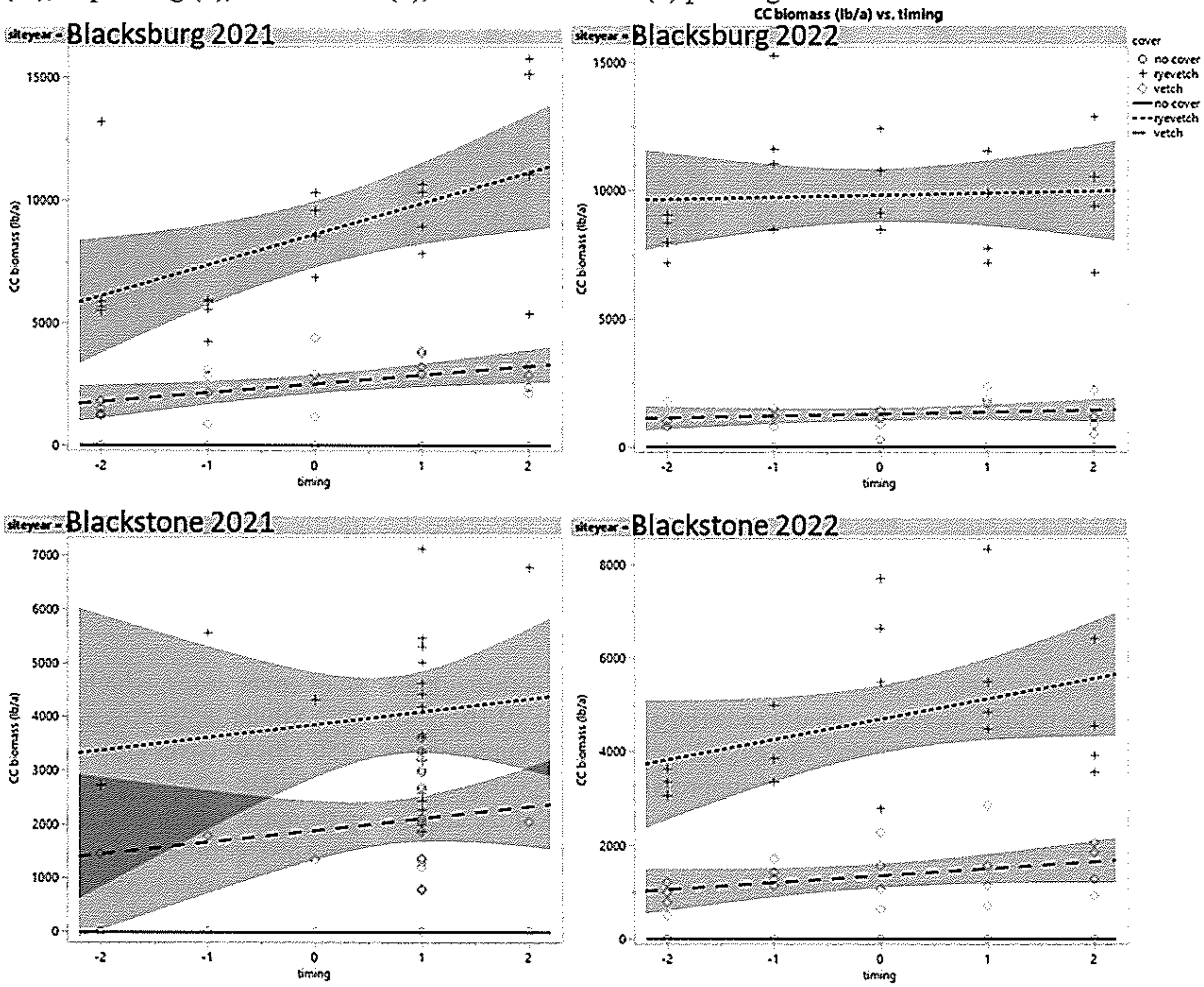


Figure 6. Palmer amaranth density (plants per square meter) by site-year from termination timings 2 weeks before (-2), 1 week before (-1), at planting (0), 1 week after (1), and 2 weeks after (2) planting.

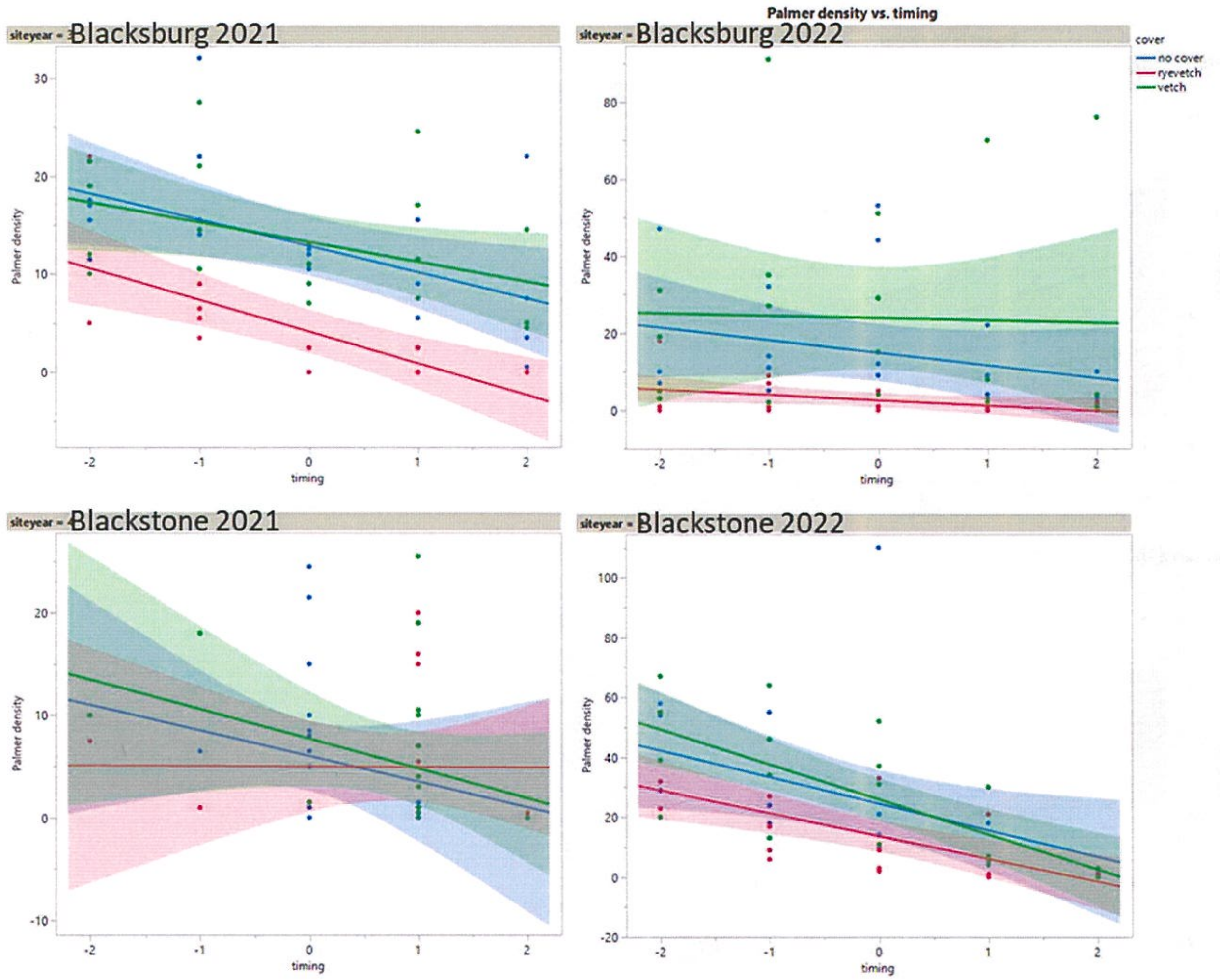


Figure 7. Palmer amaranth height (inches) by site-year from termination timings 2 weeks before (-2), 1 week before (-1), at planting (0), 1 week after (1), and 2 weeks after (2) planting.

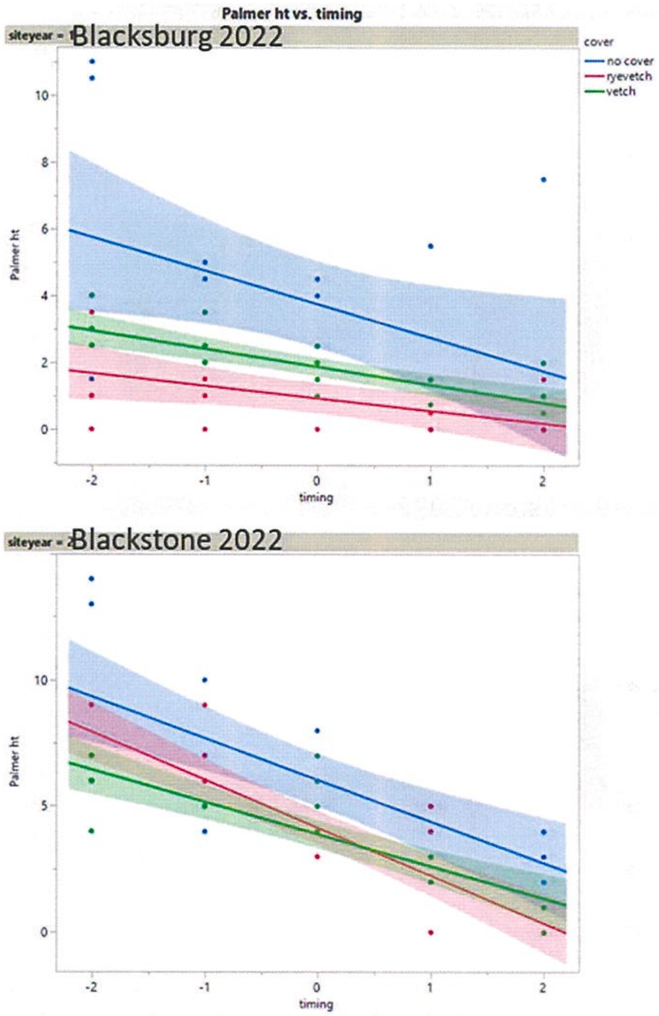


Figure 8. Corn yield (bu/a)) by site-year from termination timings 2 weeks before (-2), 1 week before (-1), at planting (0), 1 week after (1), and 2 weeks after (2) planting.

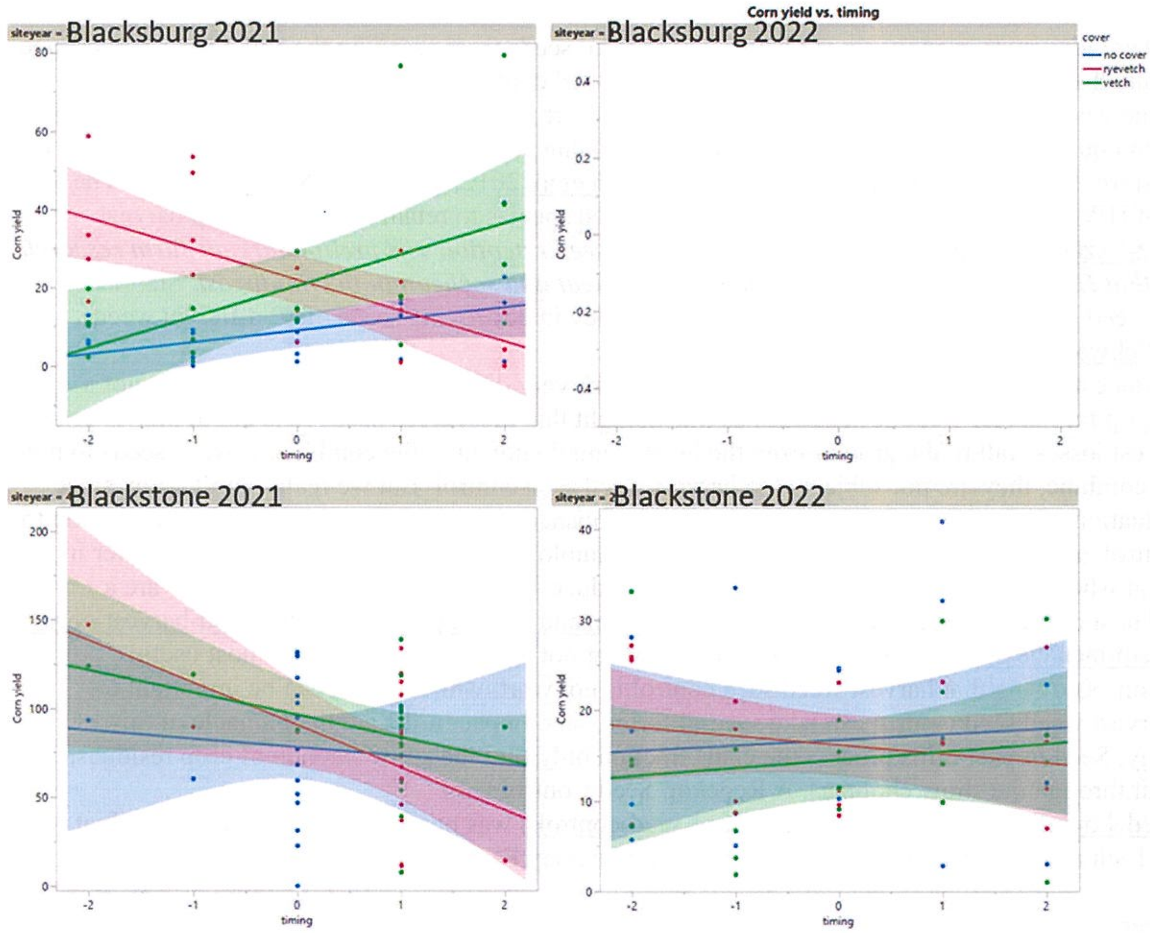


Figure 9. Pictures from the Blackstone, Virginia 2022 site.

Increase of ~15 lbs N/a per week in vetch containing cover crops

Objective 3: Preliminary analysis of a seed impact mill in corn.

Background:

Another way to manage weeds is to prevent weed seeds from reaching the soil during harvest and thus deplete the soil seed bank. So-called harvest weed seed control systems destroy, capture, or concentrate weed seeds as they exit the combine, in an effort to use the combine as a weed control tool. These techniques have proven to be efficacious in Australian crop production for crops harvested with a grain/platform header (i.e. wheat, barley, canola) (Walsh et al. 2012; Walsh and Newman 2007). The success of HWSC relies on the propensity of annual weed species to retain seeds until crop harvest (Schwartz-Lazaro et al. 2017, Walsh et al. 2018). ***Both seed retention and preliminary on-farm research indicate that HWSC holds tremendous potential for wheat and soybean in the Southeast.*** Stationary testing of seed impact mills has shown about 98% efficacy in destroying seeds of 10 different weed species (Schwartz-Lazaro et al. 2017).

Since a corn head and a grain/platform head work very different, it may be that corn is not a suitable crop for harvest weed seed control as it is thought that most weed seeds (and about half of grain corn harvest losses) fall to the ground from the header and do not enter the combine. If weed seeds to not enter the combine, they are not subjected to harvest weed seed control. But we really don't know since little evaluation of harvest weed seed control and no published results are available in corn. In addition to weed control, an additional potential benefits of this technology is reduced volunteer corn (whether in subsequent wheat or soybean crops), which may also reduce sudden death syndrome as these are a preferred host of the pathogen (https://crops.extension.iastate.edu/cropnews/2010/09/good-harvest-corn-should-help-manage-soybean-sds). Lastly, knowing what not to do is sometimes the most useful information. Knowing that harvest weed seed control is not worthwhile in corn can be important to. While harvest weed seed control can take several forms, seed impact mills are the pinnacle of this technology. Seed impact mills process the chaff fraction only (not the straw fraction of crop residues, which exit through the straw chopper). A Redekop Seed Control Unit (https://redekopmfg.com/products/harvest-weed-seed-control/) was purchased by the Flessner Lab at Virginia Tech and installed on a John Deere S680 at Shockley Farms, near Cape Charles, VA.

Procedures:

Header grain and weed seed loss quantification. We compared weed seed capture between a standard corn header (no modifications) and a 360 Yield Saver modified header. The 360 Yield Saver modification was designed to reduce corn grain loss through the gathering chains on the header by attaching brushes to the gathering chains (Figure 10). We believed this would also increase weed seed capture during harvest, resulting in weed seeds reaching the seed impact mill at the rear of the combine where they would be killed.

Figure 10. Mesh bags installed to capture chaff, straw, grain, and weed seeds exiting to the combine during harvest while providing adequate airflow.

To evaluate weed seed capture from these two header types, we have acquired and installed the modifications on a combine prior to corn harvest in 2022. At harvest, we moved weeds from weedy corn fields or nearby areas to the corn field prior to harvest. This approach mimicked a weed that grew in the field all season while providing a uniform weed seed quantity to evaluate, which was quantified prior to harvest. The field was free of the weed species we "transplanted". Weeds evaluated with a standard header on-farm included redroot pigweed, morningglory spp., and jimsonweed. Weed species evaluated and compared between standard and 360 yield saver modified header included Johnsongrass, jimsonweed, and redroot pigweed. Plots will be the width of one header. There were five replications.

We captured all weed seeds exiting the combine in the chaff fraction, which is the fraction that enters seed impact mills where seeds are destroyed (Figure 10). We also separately collected the straw fraction. By quantifying weed seed available to enter the combine and weed seed that exits the combine, we can calculate the weed seed lost at the header. Weed seed that may end up in the grain would be the same for all treatments and thus will not be quantified. We also documented any grain corn lost in the chaff and straw fractions. Grain corn on the ground after harvest is header loss as we collected all residues exiting the combine. We quantified header loss using tarps between corn rows surrounding the "transplanted" weeds. The two header types were compared using a Fisher's Protected LSD means separation for each species and end point (chaff, straw, or header loss).

Results: Processing of samples is currently ongoing after corn harvest in September. Results are expected to be available my March 2023.

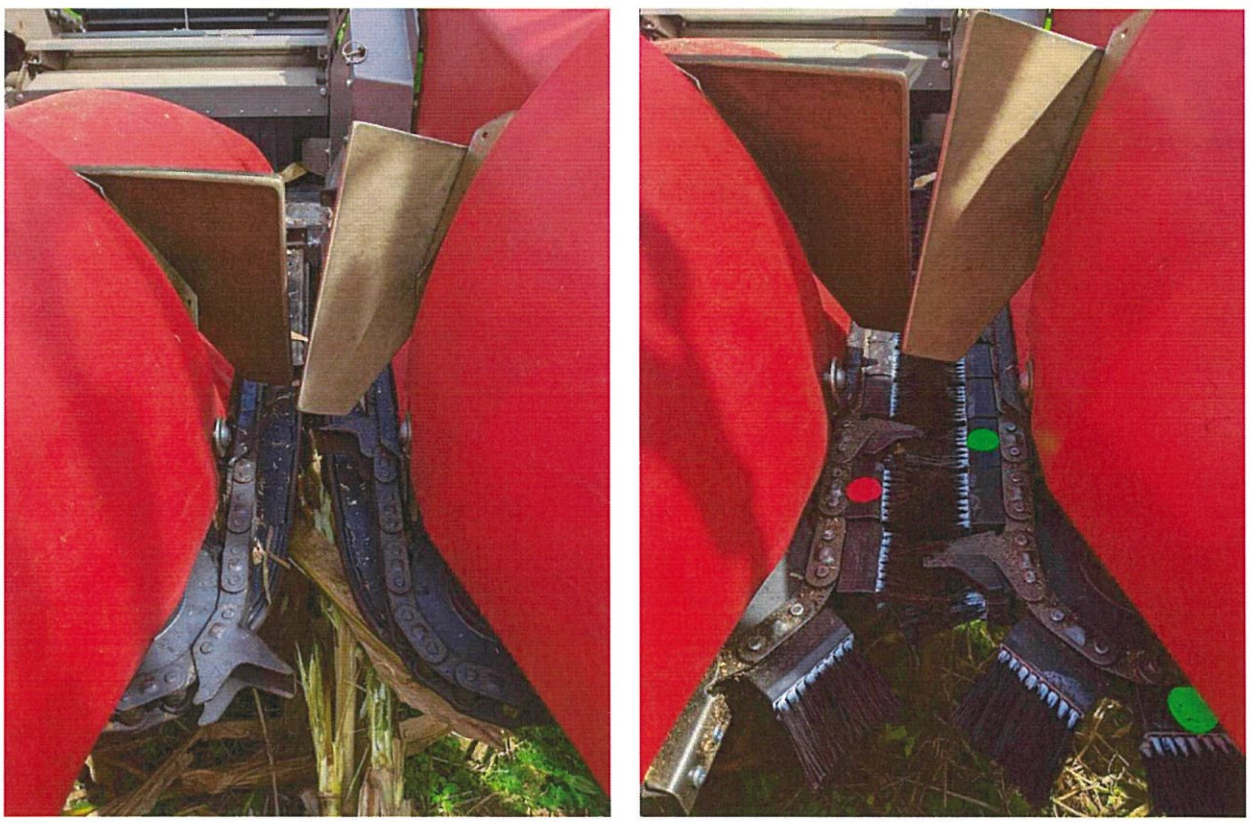
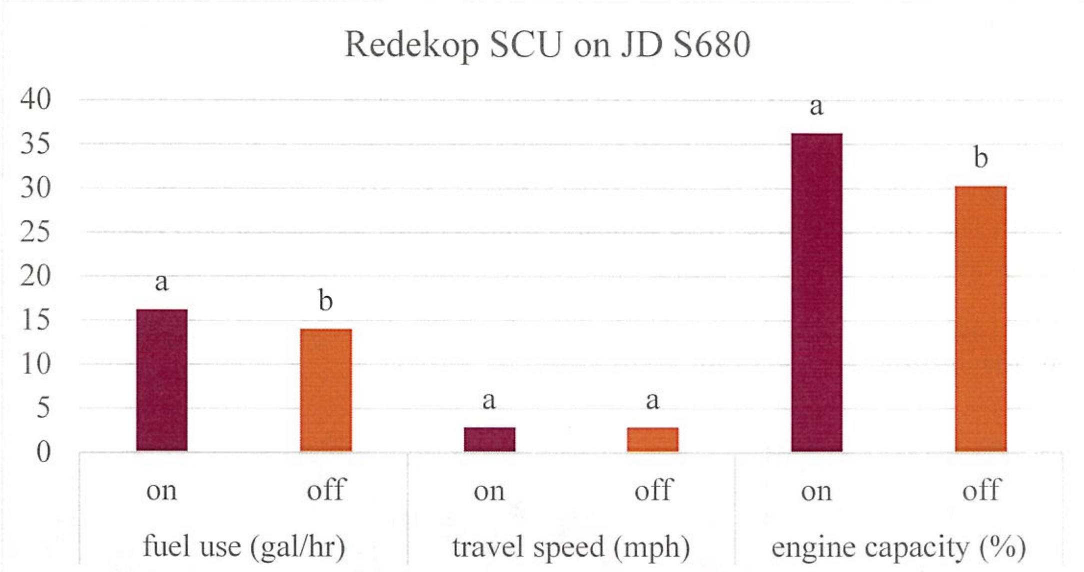


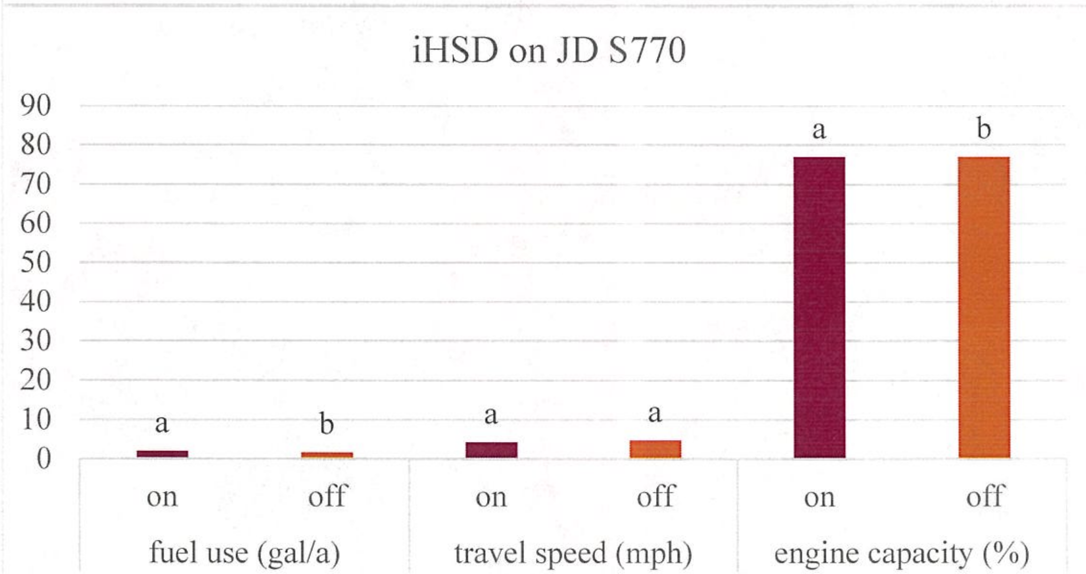
Figure 11. Comparison of a standard corn header row unit (left) to a 360 Yield Saver modified row unit (right). Note the brushes on the modified header designed to reduce corn grain losses, which we expect to increase weed seed capture as well.

<u>Operation costs of the Redekop Seed Control Unit.</u> One feature of the Redekop SCU is that it can be turned on or off as desired. This feature allows for the ideal testing of additional operational requirements as they can be compared with the exact same combine. Farmers are keenly interested to know if they must slow down to operate a seed impact mill and how much horsepower the mill takes from the combine. Modern combines track fuel use (gal/hour), travel speed (MPH), engine capacity (%), and other

parameters. We will record these values while the mill is running and compare these to when the mill is off.

Results:





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Outcomes: Data generated were used to update the 2023 Virginia Pest Management Guide: Field Crops and the Mid-Atlantic Field Crop Weed Management Guide as well as delivered to stakeholders through Extension presentations throughout Virginia. Dr. Flessner delivers over 30 presentations to producers, agronomists, industry groups, and other stakeholders every year, in addition to site visits and personal communications.

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