Online Proceedings of the 2021 Wisconsin Agribusiness Classic

January 11-14, 2021 (Virtual)

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Appreciation is expressed to the Wisconsin fertilizer industry for the support provided through the Wisconsin Fertilizer Research Fund for research conducted by faculty within the University of Wisconsin System.

2021 Wisconsin Agri-Business Association Distinguished Service Awards

Distinguished Organization Award
Rosen's Inc.
{For Exemplary Industry Professionalism}

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Cyndi Wentland (International Leaders)
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Outstanding Service to Industry
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2020 – 2021
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NUTRIENT MANAGEMENT AND ECONOMICS

COVER CROPS AS AN INTEGRATED MANAGEMENT STRATEGY AGAINST TROUBLESOME WEEDS IN KANSAS

By Greg Martinelli [1/]

Abstract

Cover crops are a promising integrated management strategy for Palmer amaranth and other troublesome weed species. Multiple factors contribute to weed control associated with cover crops. This presentation will review data describing the impact of cover crops on weed suppression in field crop production systems with an emphasis on Palmer amaranth and other troublesome species that occur in Kansas. Studies conducted between 2017 and 2020 in corn, soybean, and grain sorghum at various locations in Kansas will be discussed, as well as supporting data from other locations. When considered collectively, the data suggest that the primary factors influencing weed control by cover crops in Kansas are timing of weed emergence and cover crop biomass production.

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ADVANCING AGRICULTURAL RESEARCH USING ARTIFICIAL INTELLIGENCE ALGORITHMS

Spyros Mourtzinis[1], Paul Esker[2], James Specht[3], and Shawn Conley[4*]

Field trials are commonly used to estimate the effect of different factors on crop yield. To date, evaluating the effectiveness of management practices to increase yield has been restricted to specific soil types and weather conditions (i.e., environments) and background management cropping systems. Thus, results of such experiments cannot be safely generalized to farms with diverse soil types and background management. Currently, a method that evaluates and predicts the effectiveness of tens of thousands of possible cropping system interactions to increase yield in each specific field across the US does not exist. We have developed a novel approach to perform such evaluation by aggregating data from thousands of experiments across the US by leveraging the power of artificial intelligence algorithms. Our approach and algorithms can help accelerate agricultural research by generating accurate yield estimates for thousands of cropping systems and environments for specific fields. The result of this work can allow individual farmers to identify the most appropriate cropping system (i.e., practice adoption) for their specific environment and ultimately increase yield and/or profitability.

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CORN-SOYBEAN ROTATION, TILLAGE, AND FOLIAR FUNGICIDES: IMACTS ON YIELD AND SOIL FUNGI

Lindsay A. Chamberlain, Thea Whitman, Jean-Michel Ané, Thierno Diallo, John M. Gaska, Joseph G. Lauer, Spyridon Mourtzinis, and Shawn P. Conley [1/]

Fungal diseases can have a detrimental impact on soybean and corn yield. Foliar fungicides are used to manage fungal diseases and minimize yield loss, along with cultural practices like tillage and crop rotation. Prophylactic foliar fungicide use does not consistently increase yield for corn and soybean, especially when disease pressures are low. Also, there are concerns about the impact of fungicides on non-target organisms, including fungi living in the soil. We tested the effects of tillage, crop rotation, and foliar fungicide use on corn grain and soybean seed yield over three growing seasons. For both crops, rotation was key to achieving high yields, although there was an interaction of tillage × crop rotation for soybean and crop rotation × fungicide for corn. For soybean seed yield, both foliar fungicide treatments showed a small yield increase over untreated plots. Additionally, we assessed bulk soil fungal communities in a subset of treatments (crop rotation and fungicide treatments in no-till plots), using ITS sequencing and PLFA-FAME. We observed distinct fungal communities in the continuously cropped treatments, while annually rotated communities were very similar. There was also greater overall microbial biomass and a higher relative abundance of arbuscular mycorrhizae fungi associated with continuous corn. There were no differences in soil fungal communities or microbial biomass associated with foliar fungicide treatments. Based on our findings, we recommend that farmers use integrated pest management strategies to manage fungal diseases, which may include fungicide applications, if they are justified by economic disease thresholds or prediction tools.

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Wheel traffic in alfalfa: How much of the field is impacted by machines and what does that mean for yield?

Parker Williams[1], Brian D. Luck[1], Francisco J. Arriaga[2], and Dennis W. Hancock[3]

Alfalfa is unique from other crops as it requires a variety of machines to harvest. Whether it is being harvested for silage or hay, alfalfa harvest can require up to five different pieces of equipment per cutting. With this many machines travelling through a field during a single harvest, a significant portion of production field can be affected by machine traffic. Specific machines involved in alfalfa harvest include a mower, merger or rake, tedder, forage harvester or baler and multiple different types of transport vehicles. In the United States, over 6.7 million hectares of alfalfa were harvested in 2019, worth over $9 billion (USDA/NASS, 2019) with some of this area seeing multiple passes of machinery traffic. This substantial amount of production in the US shows the impact machine traffic could have.

In 2019 and 2020 all machines involved in alfalfa harvest were monitored using GNSS receivers to determine their paths through the field (Figure 1). The area impacted by the tires was subtracted from the total field area (Figure 2). Results showed that on average, 49% of the field area had tires pass over it (Table 1).

Research plots were assessed at the Arlington Agricultural Research Station with 7 different treatments (Table 2). Figure 3 shows yield results for 2019 and 2020. Wheel traffic applied to the alfalfa plots showed statistically different results for the no-till (P-value = 0.17 and 0.007 respectively) and medium tillage (P-value = 0.01 and 0.11 respectively). Heavy tillage showed no statistically different results due to external factors in the field. Average yield reduction was shown to be 0.68 ton/ac.

Reducing wheel traffic in alfalfa production systems has the potential to increase yield and reduce plant damage and compaction. Future research will investigate ways to reduce wheel traffic and identify methods of reducing the impact of machinery traffic on alfalfa.

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Figure 1. Machine paths during alfalfa haylage harvest including mowing, merging, and harvest operations

Figure 2. Area of field covered (green) by wheel traffic based on machinery footprints.

Table 1. Percentage of field coverage by wheel traffic during alfalfa haylage harvest in 2019 and 2020.

Year	Cutting	Field Size (ha)	Area Covered (ha)	Percent covered
2019	1st	30.90	16.85	55%
2019	2nd	30.90	18.79	61%
2019	3rd	30.90	14.63	47%
2020	1st	30.90	17.59	57%
2020	3rd	30.90	13.35	43%
2020	4th	30.90	10.43	34%
			Average	**49%**
			Standard Deviation	9%

Table 2. Wheel traffic treatments applied to the research plots at the Arlington Agricultural Research Station.

Treatment	Name	Description
1	Single Pass Silage	One application of compaction immediately after harvest covering the entire plot.
2	Three Pass Silage	Three applications of compaction. One immediately after harvest, one 24 hours after harvest and one 26 hours after harvest. Full plot application.
3	Five Pass Silage	Five applications of compaction. One immediately after harvest, two passes 24 hours after harvest, and two passes 26 hours after harvest. Full plot application.
4	Simulated Silage	Two wheel tracks applied within the plot. One pass immediately after harvest, one pass 24 hours after harvest, and two passes 26 hour after harvest.
5	Three Pass Hay	Three applications of compaction. One immediately after harvest, one 48 hours after harvest and one 72 hours after harvest. Full plot application.
6	Five Pass Hay	Five applications of compaction. One immediately after harvest, two passes 48 hours after harvest, and two passes 72 hours after harvest. Full plot application.
7	Zero Compaction (control)	No machine traffic applied.

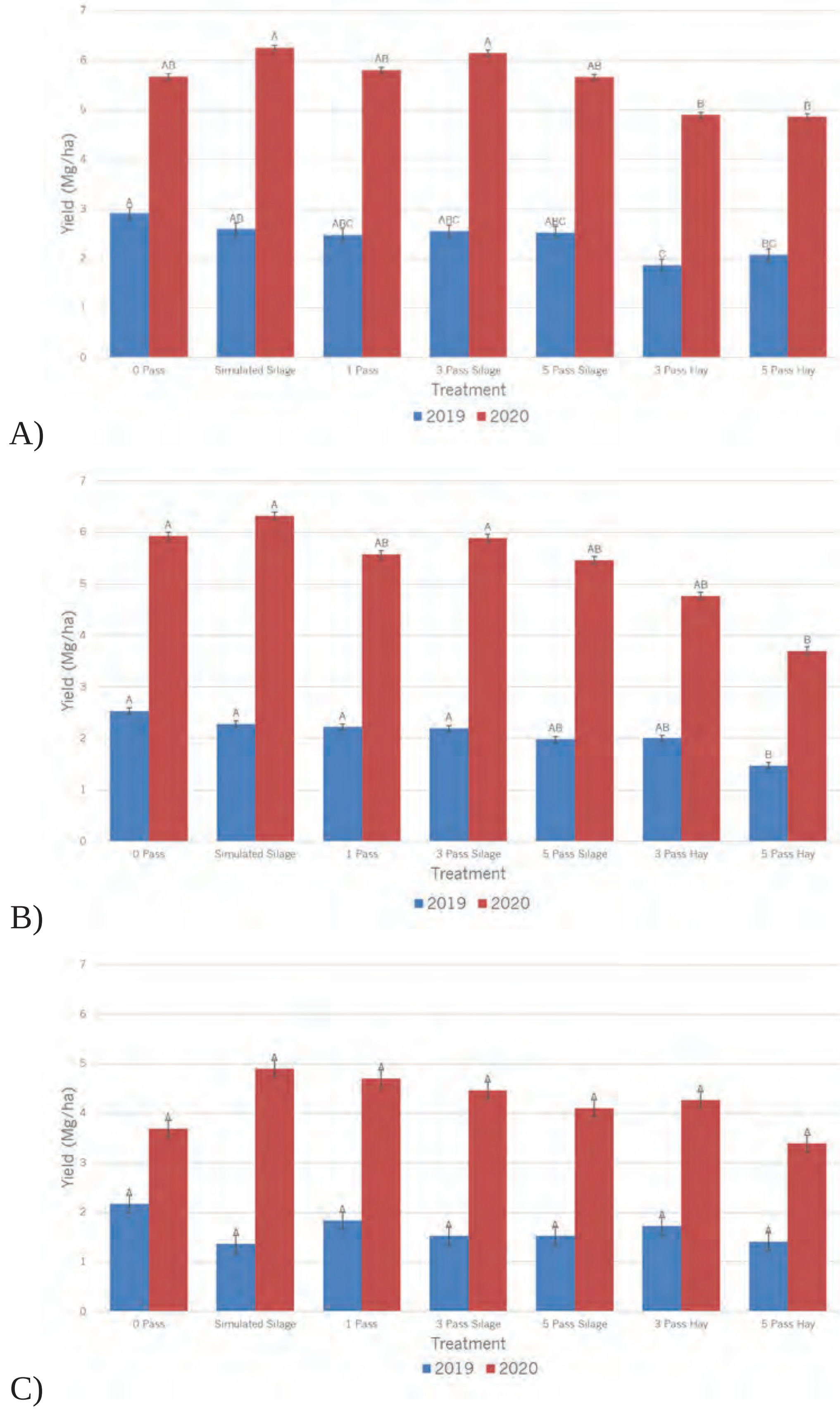


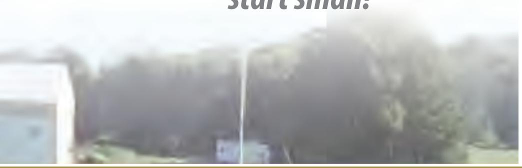
Figure 3. Yield results in 2019 and 2020 due to traffic treatments within the various tillage scenarios. No-tillage (A), spring tillage only (B), and fall and spring tillage (C) were considered for this study.

Interseeding alfalfa into silage corn

CURRENT RECOMMENDATIONS

Extension
UNIVERSITY OF WISCONSIN–MADISON

When trying new practices, it's always a good idea to start small!



Over the last decade, scientists at the USDA-Agricultural Research Service, the University of Wisconsin, Michigan State University and Penn State University have been developing reliable methods for establishing alfalfa in high yielding silage corn. Based on this work, the following represents our current recommendations for implementing this practice on farms. Establishment of alfalfa by interseeding into corn has:

BENEFITS

- Up to 2-fold greater 1st year alfalfa yield compared to conventional spring-seeded alfalfa and greater overall forage production from corn silage-alfalfa rotations
- Profitability of corn silage-alfalfa rotations increased by 7–15% under typical production conditions
- Soil and nutrient loss from cropland decreased by 37–87% due to greater soil cover provided by interseeded alfalfa

CHALLENGES

- Competition from interseeded alfalfa seedlings can reduce corn silage yield by 0–15%
- Wet soil conditions during corn silage harvest can damage alfalfa stands
- 1–3 extra passes are required for agrichemical application to ensure establishment of alfalfa

Field characteristics and soil fertility

Good establishment of both crops is essential

- The site must be suitable for good alfalfa production:
  - ✓ Soil pH of 6.6 or greater with good drainage
  - ✓ Smooth, firm seedbed, free of excessive residues
  - ✓ Not routinely wet or easily rutted during corn silage harvest
- To ensure good corn production:
  - ✓ Apply phosphorus, potassium, boron and sulfur (based on soil test results) to meet nutrient needs of both corn silage and seeding-year alfalfa
  - ✓ Apply a starter fertilizer (40-20-20 lb/acre of N, P_2O_5 and K_2O) at planting in a 2x2 placement
  - ✓ Total N rate from fertilizer and manure should be at the upper end of Extension recommendations for corn silage

Proper timing

Balancing competition between corn and alfalfa is important, consider soil temperature, soil moisture and planting timing

- If corn is planted early under cool conditions (minimum soil temperatures are below 50°F), delay interseeding until the corn V1 stage to lessen competition from alfalfa.
- Warmer conditions favor late-planted corn growth, so alfalfa should be interseeded within 3 days to allow sufficient growth before corn canopy closure.
- Corn & interseeded alfalfa can compete for moisture early in the growing season:
  - ✓ If the soil profile is extremely dry and rainfall is not expected after planting, either irrigate after interseeding or do not interseed
  - ✓ Interseeded alfalfa improves water infiltration into soil, so dry mid- or late season conditions usually have little impact on alfalfa establishment or corn silage yield

Corn hybrid, seeding rate and harvest considerations

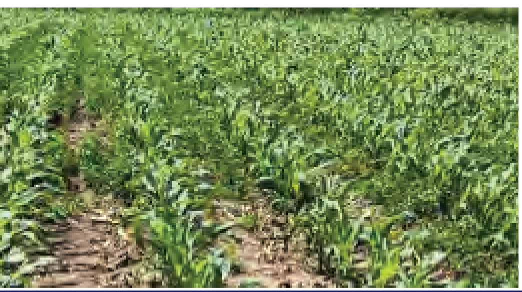
Hybrid selection and plant populations are important

- Use an early to mid-season hybrid for an anticipated harvest by early to mid-September to allow interseeded alfalfa adequate time to prepare for winter.
- To provide a good balance between satisfactory alfalfa establishment and good corn silage yields, plant corn to provide a final population of 28,000–32,000 plants/acre.
- Harvest corn at the proper moisture for ensiling.
  - ✓ Avoid harvesting if fields are wet and easily rutted; follow Extension recommendations to minimize soil compaction

Alfalfa establishment

Varieties vary in their performance in interseeded systems

Previous studies in Wisconsin have shown good success with the following alfalfa varieties: 55H94, 55H96, 315LH, Magnagraze II, Magnum Salt, Hybriforce 3400, Hybriforce 3420, 54Q14, 55V50, FSG403LR, FSG329, Spredor 5, WL359RR.LH, RR Vamoose, 431RRLH, and FSG430RR.LH



- Alfalfa varieties vary considerably in performance in this system, make sure you plant a variety that is documented to be effective.
  - ✓ Alfalfa varieties with high resistance to Aphanomyces races common in your area should be used
  - ✓ Low lignin or 'high quality' alfalfa varieties have not performed well in this system
- A drill with press wheels should be used to plant 16 lb/acre of alfalfa on a live seed basis at a ¼–½ inch depth in the corn inter-row area.
  - ✓ Row spacing for alfalfa should not exceed 10 inches
  - ✓ Do not use seeders that use only corrugated rollers to incorporate surface broadcast seed into soil
  - ✓ If interseeded within 2 days of corn planting, alfalfa can also be drilled over or across corn rows
- The plant growth regulator Kudos® can help with alfalfa establishment in corn.
  - ✓ This product is registered for this use in Pennsylvania and Wisconsin where drop nozzles direct Kudos® to alfalfa foliage when it is 5–15 inches tall

Pest management

Good pest management is key to establishing alfalfa

Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the USDA and does not imply its approval to the exclusion of other products that may also be suitable.

- **PRE Emergence herbicide:** Apply acetochlor (Warrant®) after planting, just after alfalfa emergence.
- **POST Emergence herbicide:**
  - ✓ For Roundup® Ready systems, glyphosate is highly effective when weeds are 4–6 inches tall
  - ✓ For conventional alfalfa or corn, bromoxynil (Moxy 2E®) applied when broadleaf weeds are 1–2 inches tall and after alfalfa has 4 trifoliate leaves is recommended
- **Fungicide and Insecticide:** High incidence of foliar disease and potato leafhoppers can impact alfalfa survival. Applications of a fungicide and an insecticide has been shown improve survival when these pests are present.

Looking ahead! In future articles, we will discuss more results that optimize agrichemical application rates and timings for interseeded alfalfa. In ongoing work, we will identify corn hybrids that are best suited for interseeding and will further refine management practices to ensure interseeded alfalfa production systems will be reliable, high yielding and profitable for farmers.

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COVER CROP AND 4R NITROGEN MANAGEMENT IMPACTS ON CORN NITROGEN NUTRITION AND YIELD

Shalamar Armstrong [1/]

Introduction: Cereal rye has become the most commonly selected option for cover cropping because it is well suited for the growing environment of the UMRB region, due to its winter hardiness and wide planting date window that allows for establishment after cash crop harvest. However, a barrier to adopting cereal rye is that it has been found to reduce corn yields due to immobilization of soil available inorganic N. This reduction in available soil inorganic N has been attributed to early season soil N depletion from the soil profile due to N scavenging of cereal rye and N immobilization by the microbial community due to carbon release into the soil profile following cereal rye residue decomposition. Thus, there is a critical need to develop "Next Generation Cover Crop Management" that optimizes N use efficiency, cash crop production and nutrient loss reductions.

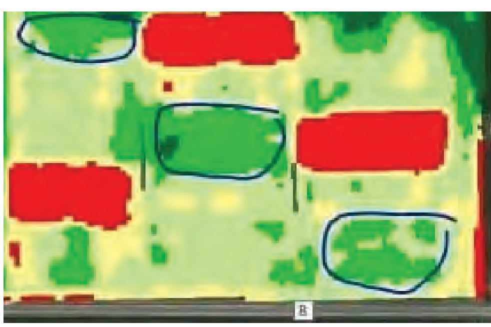
Objectives: The goal of this presentation is to share published and preliminary results from studies where "Next Generation" cover crop and N fertilizer management were employed for corn production.

Description of 2020 Nitrogen Management Treatments and resulted Corn N uptake at R6 and Corn Grain Yield.

2020 Nitrogen Management Treatments, Corn N Uptake and Yield

Treatment	Zero Control	Regional Control*	Regional Control + CC	Adaptive 1 (Late N)**	Adaptive 2 (Late N +)***
			(lbs A^{-1})		
Fall Anhydrous Ammonia		120	120	120	120
Starter N at Planing (28% UAN)		5	5	5	5
Sidedress at V4-V6 (28% UAN)		100	100	0	85
Y Drop at V8-V10 (28% UAN)				100	75
Total N Applied	*0*	*225*	*225*	*225*	*285*
Corn N Uptake at R6 (lbs N/A)	**54**	**264**	**248**	**178**	**293**
Corn Yield (bu/A)	**116**	**223**	**215**	**209**	**227**
Nitrate Loss vis Tile-Drainage (lbs N/A)	**6**	**24**	**14**	**15**	**15**

*Nitrogen Management common to the region, split timing of N application between fall and spring.
**Adaptive N management that moved the V6 sidedress application to V10 assuming that soil derived N would suffice. ***Adaptive N management that sustained a sidedress application and applied an additional 60lbs of N at V10 to compensate for cover crop scavenged N.



Blue circles and green squares represent the location of Adaptive 2 treatment in late Oct.

Results from study 1: In 2020, a late application of N fertilizer, equivalent to the mass of N scavenged by the Cereal Rye (CR) cover crop, mitigated the usual yield lag for corn planted into Cereal Rye residue. On average, approximately 60 lbs A^{-1} of N is scavenged in the CR above-ground biomass and only 10% of that biomass N is used by the subsequent cash crop, leaving the corn N deficient, according to our 15N research findings. Additionally, in past corn years, we observed a reduction in N uptake for corn planted in CR residue, as the plant is transitioning into reproduction growth, relative to the no cover crop Regional Control. Therefore, we made a significant adaptation to the Regional Control N management to compensate for N scavenged by the CR cover crop. The adaption consisted of applying an additional 60 lbs A^{-1} of fertilizer N at the V10 growth stage using a Y-Drop applicator.

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Relative to the Regional Control, the additional 60 lbs A^{-1} of N late resulted in a 10% increase in corn N uptake and an increase of 4 bu A^{-1}. This difference in grain yield is not significantly different; however, it demonstrated significant agronomic improvement for corn following CR adoption compared to the other CR treatment. For instance, the Adaptive 2 Late N treatment yielded similarly to the non-CR Regional Control but resulted in 12 and 19 more bu A^{-1} relative to the Regional Control + CC and Adaptive 1 Late N treatments, respectively. Furthermore, the late season additional N for the Adaptive 2 Late N treatment resulted in 45-115 lbs A-1 N taken up by the corn plant relative the other CR treatments.

Additional critical agronomic observations from the 2020 growing season were (1) late applications of fertilizer N must be in addition to sidedress at the V6 growth stage. We assumed that soil derived N would satisfy the N demanded of the plant at V6, but we observed that shifting the sidedress N from V6 to V10, resulted in a reduction of N uptake and yield. In an average precipitation year, soil mineralization rates possible could have sustained the crop N demand, but the 2020 growing season was considered to be dry relative to the 30-average precipitation. Furthermore, (2) to generate competitive corn grain yield following CR termination, the N scavenged by CR cover crop cannot be ignored and should be applied late in the growing season as the plant is transitioning to reproduction growth. Corn Uptake data analysis from the past 3 corn years suggest that N depletion in corn planted behind CR occurs between VT and R3. Economically, we must examine if the additional in the CR treatment paid off relative to the non-CR Regional Control. Assuming, a corn price of 4.95/bu and a N price of 0.39/bu, we determined that the 4 bu increase from the additional N only absorbed 84% of its total cost.

Results from this study indicate the potential to produce competitive corn grain yield following cereal rye termination through late season N fertilizer supplementation.

FALL COVER CROPS AND FALL MANURE

Matt Ruark [1/]

The abundance of late summer-harvested corn silage in Wisconsin means that there are many acres where manure can be applied between late summer and later fall. Current nutrient management guidelines estimate manure N availability based on animal source, solids content, and application method, but no adjustments are made regarding application timing. A Wisconsin Fertilizer Research program-funded research project evaluated how fall grass cover crops affect the amount of N in the fall applied manure will be available to a subsequent corn crop. Results of this research have shown that cover crop biomass influences the amount of N in the manure that will remain for the next corn crop. If there is greater than 2,000 lb/ac of dry matter biomass, the cover crop will have used all the N from the manure, while if there is less than 1,000 lb/ac of dry matter biomass, the effect on the manure N credit is minimal.

Table 3 in Cover crops, manure, and nitrogen management (https://learningstore.extension.wisc.edu/products/cover-crops-manure-and-nitrogen-management).

Cover crop biomass (lb/ac)	Estimated N uptake (lb/ac)	Amount to adjust manure N credit (lb/ac)
<1,000	<25	No adjustments needed
1,000–2,000	25–45	Subtract 35 lb/ac from manure N credit if winter rye was used*
>2,000	>50	Do not take any manure N credit†

* There was no clear effect when winterkilled cover crops were used based on Wisconsin research (inset).
† This recommendation applies to manure N applications up to 100 lb/ac of available N.

(Adapted from the UW-Division of Extension publication “Cover crops, manure, and nitrogen management”; the full report can be found at: https://learningstore.extension.wisc.edu/products/cover-crops-manure-and-nitrogen-management)

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COLORADO POTATO BEETLE - EVIDENCE FOR THE EMERGENCE OF METABOLIC RESISTANCE[1/]

Dr. Russell L. Groves[2/] and Dr. Justin R. Clements[3/]

Management of agricultural crops relies on integrated pest management strategies to mitigate production losses due to insect infestation. Producers of field and vegetable crops depend on local and regional guidelines for pesticide applications to limit insect infestation and minimize associated damage (1). Within an agroecosystem, a producer may need to manage multiple insect, pathogen and plant species resulting in the application of several insecticide, fungicide and herbicide mode of action groups, respectively (2). Pesticide applications used for the same cropping system can vary among producers and can vary between different geographic regions. One pest of solanaceous crops which is often controlled using a diverse set of cultural and chemical management practices, is the Colorado potato beetle (*Leptinotarsa decemlineata* Say). If not properly managed, this specialist herbivore can cause significant defoliation of the potato canopy that can result in yield loss and economic injury for the producer. In addition to its ability to rapidly defoliate plants, *L. decemlineata* is considered a major pest species because of its ability to develop resistance to insecticides at a rapid rate (3).

Insecticide resistance develops and propagates within insect populations through the selection of individuals that possess genetic attributes that, when passed onto offspring, result in resistant phenotypes (4). Insecticide resistance can develop through multiple mechanisms, including enhanced metabolic breakdown of insecticides, reduced cuticular penetration, target site insensitivity, and behavioral resistance or avoidance (4). Previous *L. decemlineata* investigations have classified possible mechanisms of insecticide resistance within select populations, including the detoxification and removal of insecticides from the insect's body through phase 1 (detoxification through breakdown) and phase 2 (removal through excretion) enzymes (3, 6-8). These studies have examined the over-expression of transcripts corresponding to xenobiotic resistance mechanisms within select populations of *L. decemlineata* classified as insecticide resistant through traditional dose response bioassays. Crossley et al. 2017 examined short nucleotide polymorphisms and these studies suggest that a combination of detoxification and excretion enzymes play a significant role in insecticide resistance.

Defining the mechanisms of insecticide resistance development within *L. decemlineata* is difficult due to the differences observed between geographically distinct populations of the insect. *Leptinotarsa decemlineata* populations are found within all major potato production areas of the United States. However, insecticide resistance to common insecticide mode of action groups, has predominantly been associated with potato production areas on the East Coast and in the Midwest, but not in the Pacific Northwest region. While estimates of total insecticide applications (kg active ingredient ha^{-1}) are similar across the United States, the amount of other pesticides applied, including fungicides, differs dramatically in different geographies. Clements *et al*. (2018) hypothesized that the geographic disparity in insecticide resistance could partially be explained by the increased application of fungicides (8). The transcriptomic response and classification of the enzymatic detoxification mechanisms revealed that both insecticides and fungicides induced similar detoxification mechanisms within individuals from the same population. This result suggests that the geographic disparity in observed resistance levels can be partially explained by the development of cross-functional detoxification pathways driven by chronic exposure to both insecticides and fungicides (8).

Geographic location is often related to the patterns of pesticide management strategies and chemical inputs which are required for crop protection, and consequently may play a significant role in insecticide resistance development. Examining the patterns of transcript expression of previously classified detoxification mechanisms through targeted RNA sequencing provided insight into transcript regulation corresponding to putative insecticide resistance that were linked to geographic location.

[1/]Funding support through USDA NIFA, Agreement No. 58-5090-9-033
[2/]Professor and Department Chair, Department of Entomology, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706.
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Additionally, differences between the over-expression of detoxification mechanisms within resistant populations of *L. decemlineata* may suggest that insecticide resistance can develop in different ways. We investigated transcript expression of 38 previously classified detoxification enzymes induced by imidacloprid (an insecticide) and chlorothalonil (a fungicide) within 5 discrete populations of *L. decemlineata* obtained from areas in the U.S. representing eastern, midwestern and western production regions. We found unique patterns of transcript expression in different geographic locations, including overexpression of transcripts related to insecticide metabolism within insecticide resistant populations. The results suggest the genetic response of these populations may be partially linked to geographic location and corresponding management practices.

By examining the transcript expression of multiple populations of *L. decemlineata*, we determined the similarities and dissimilarities between transcript expression of known xenobiotic detoxification mechanisms. By establishing the response of populations to insecticides through LD50 estimates and examining transcript expression through targeted RNA sequencing, we determined that the two populations deemed as imidacloprid-resistant over-express unique detoxification mechanisms in different proportions. We further validated the previous induction studies conducted by Clements et al. (2018) in field populations (6,8). The experiments conducted within this study demonstrate a diverse set of transcripts that appear to be over-expressed within different field populations with different resistant phenotypes. The findings of this research further suggest that mechanisms of insecticide resistance in *L. decemlineata* most likely involve multiple metabolic resistance mechanisms, and further that these mechanisms differ among geographic region.

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[1/]Funding support through USDA NIFA, Agreement No. 58-5090-9-033

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WISCONSIN POTATO AND VEGETABLE WEED MANAGEMENT UPDATE

Jed Colquhoun, Daniel Heider, Richard Rittmeyer and Jordan Schuler[1]

Despite significant pandemic-related restrictions on research and our ability to do things like travel or hire student workers, 2020 was an extremely productive research season. We adjusted to the times, but thanks to hard work by the team we were able to accomplish all of our objectives. Here are a few highlights and where we're heading in our potato and vegetable program:

- In the herbicide evaluation program, we've conducted field studies on over two dozen crops in recent years, including significant efforts in potato and vegetables. We continue to support these activities in crops rotated with and around potatoes and vegetables to provide a holistic, multi-year weed management approach to reduce weed seedbanks and the risk of selecting for resistant weeds that will plague the land well beyond the potato and vegetable production years. This work in 2020 covered everything from direct-seeded cabbage to dry beans and horseradish.

  We continue to investigate the potential use of several herbicide active ingredients in potatoes and vegetables. This research is critical to generate several years of crop safety data that registrants and regulators require prior to adding crops to existing labels. With similar goals, we also conducted research in Hancock and Antigo to refine the use of three PPO-inhibitor herbicides in potato, focused on reducing rates to minimize crop injury risk while still controlling weeds.

  Our program continues to support the secondary herbicide uses in potato. For example, in the 2020 growing season we conducted a study to look at refined timings of 2,4-D application to enhance skin set and color in several fresh-market red-skinned varieties.

- We've spent much time in recent years investigating the effect of off-target herbicides, such as through tank contamination, on potato seed crops and commercial production in the year after exposure. In our most recent work in this area, we're finding that the mother plant exposure timing to off-target herbicides is extremely critical relative to the impact on daughter tuber (seed) growth next year. It appears that exposure to off-target herbicides within a couple days of tuber initiation has the most negative impact. We repeated this work for a second season this year to see if that observation holds up in differing environmental and growing conditions.

- We continued work in 2020 to study the use of plant growth regulators to hasten uniform potato and vegetable emergence and canopy development. The results of these preliminary studies were interesting, suggesting that early-season crop growth can be significantly altered by low rates of plant growth regulator application and that we can also alter weed emergence timings. In 2021, we'll

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continue this work by looking at both seed and early foliar treatments and will follow these through harvest to determine crop yield, size distribution and quality implications.

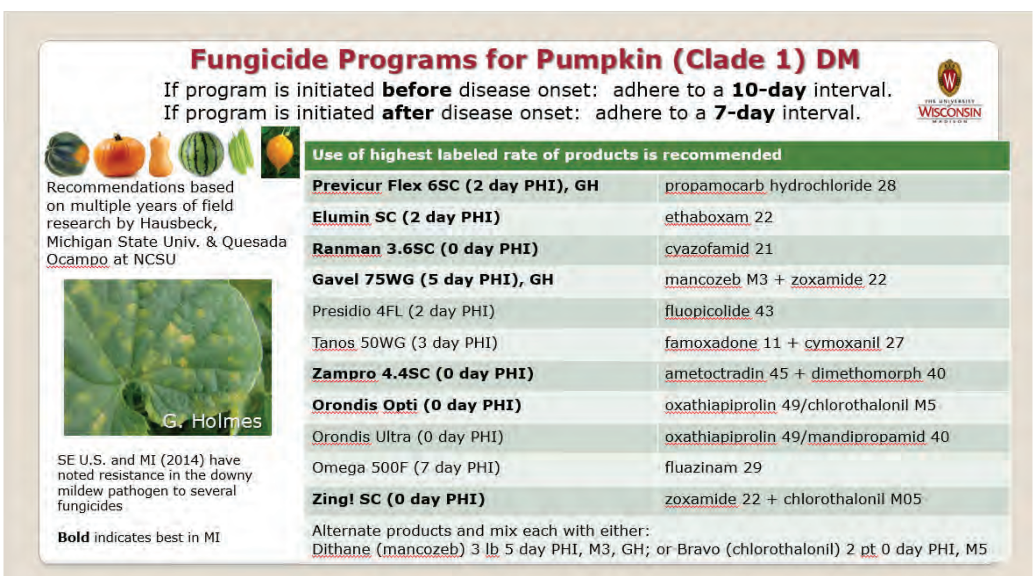
- We're also now investigating potential economically viable alternative crops that could further diversify Wisconsin's agricultural portfolio. In 2020, graduate student Jordan Schuler established four alternative crop study sites: at two central Wisconsin locations, at Antigo and at Arlington. For example, in Hancock we had good success in our first year growing Bambara groundnuts, a high-protein nut that is not only drought tolerant but also fixes nitrogen, reducing the needs for irrigation and fertilizer. We'll expand on this work in the 2021 season.

Pesticide labels change often. As always, read and follow the label prior to any pesticide use.

ADVANCES IN CUCURBIT DOWNY MILDEW
CHARACTERISTICS AND MANAGEMENT

Amanda Gevens [1/]

Cucurbit downy mildew caused by the oomycete pathogen *Pseudoperonospora cubensis* has been a sporadic disease concern in Wisconsin for many years. Since 2004, the United States has seen a novel introduction of a variant of the pathogen which overcomes the dm1 cucumber host resistance to downy mildew. The work of Drs. Lina Quesada Ocampo of North Carolina State University, and Mary Hausbeck of Michigan State University has greatly elevated our knowledge of cucurbit downy mildew in the US since 2005. The information that I provide in this piece comes from their work. Because Wisconsin sees sporadic and infrequent cases of cucurbit downy mildew, my fungicide recommendations typically reference the trial outcomes of Dr. Mary Hausbeck at Michigan State Univ. due to proximity to our production region. Currently, we have two groups of cucurbit downy mildew pathogens. One group, termed Clade 1 infects acorn squash, pumpkin, butternut squash, watermelon, bittermelon, and balsam apple. The second group, termed Clade 2 is the newly introduced strain and it infects cucumber, cantaloupe and Buffalo gourd. An additional notable difference between the clades is that Clade 2 very quickly becomes resistant to single site mode of action fungicides, rendering them useless. Monitoring of these clades has become critical in the southeastern US where both clades routinely are present. Clade 1 tends to arrive in NC fields later than Clade 2. Most cucumber varieties commercially available are resistant to Clade 1 (old strain), but there is no complete resistance available for Clade 2. For pickling cucumber, 'Citadel' and 'Peacemaker' from Seminis are tolerant to Clade 2. For slicing cucumber, SV3462CS and SV4142CL are tolerant to Clade 2. Greenhouse growers should use tolerant varieties since chemical options in a greenhouse are very limited and the risk of fungicide resistance is very high. Fungicide


Fungicide Programs for Pumpkin (Clade 1) DM

If program is initiated **before** disease onset: adhere to a **10-day** interval.
If program is initiated **after** disease onset: adhere to a **7-day** interval.

Recommendations based on multiple years of field research by Hausbeck, Michigan State Univ. & Quesada Ocampo at NCSU

Use of highest labeled rate of products is recommended	
Previcur Flex 6SC (2 day PHI), GH	propamocarb hydrochloride 28
Elumin SC (2 day PHI)	ethaboxam 22
Ranman 3.6SC (0 day PHI)	cyazofamid 21
Gavel 75WG (5 day PHI), GH	mancozeb M3 + zoxamide 22
Presidio 4FL (2 day PHI)	fluopicolide 43
Tanos 50WG (3 day PHI)	famoxadone 11 + cymoxanil 27
Zampro 4.4SC (0 day PHI)	ametoctradin 45 + dimethomorph 40
Orondis Opti (0 day PHI)	oxathiapiprolin 49/chlorothalonil M5
Orondis Ultra (0 day PHI)	oxathiapiprolin 49/mandipropamid 40
Omega 500F (7 day PHI)	fluazinam 29
Zing! SC (0 day PHI)	zoxamide 22 + chlorothalonil M05

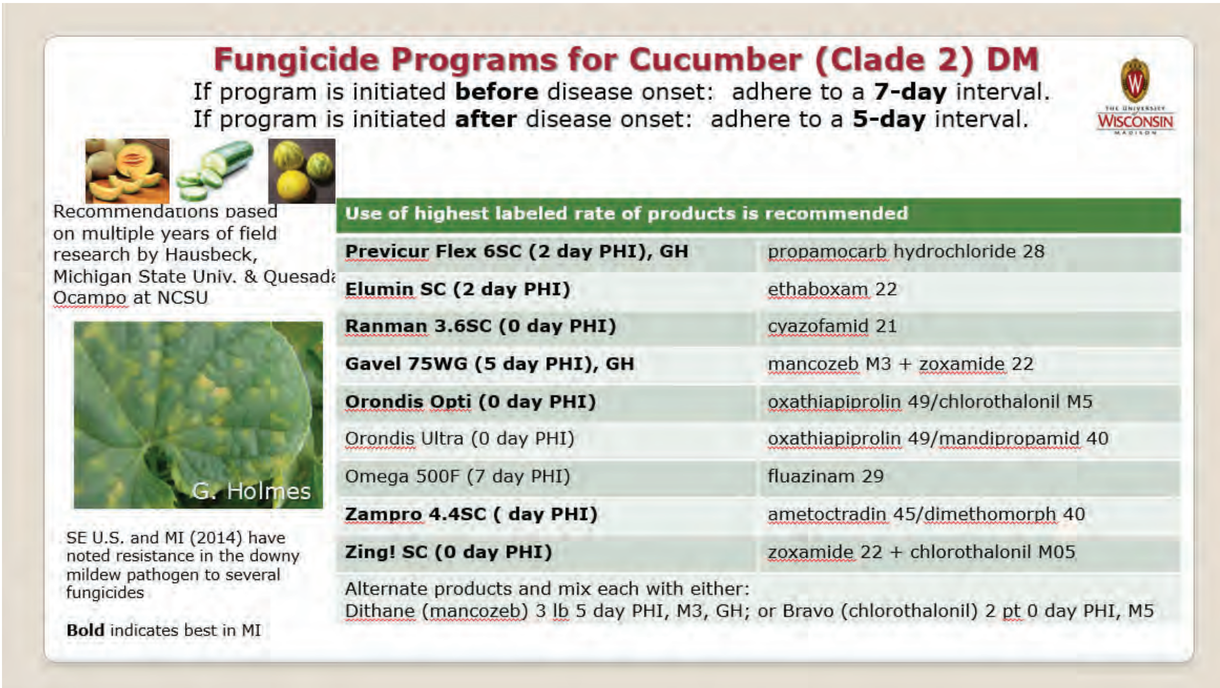
Alternate products and mix each with either:
Dithane (mancozeb) 3 lb 5 day PHI, M3, GH; or Bravo (chlorothalonil) 2 pt 0 day PHI, M5

SE U.S. and MI (2014) have noted resistance in the downy mildew pathogen to several fungicides

Bold indicates best in MI

management recommendations are provided in the two figures below.

[1/]Chair and Professor, Dept. of Plant Pathology – Univ. of Wisconsin Madison.



IRRIGATION AND NITROGEN MANAGEMENT OF DRY RED KIDNEY BEANS GROWN IN CENTRAL WISCONSIN

Yi Wang [1/]

The Central Sands region is the heart of Wisconsin's premier vegetable production with its coarse-textured soils and abundant groundwater. However, this region is also the epicenter of controversies over groundwater reduction during the summertime when water is being pumped for agricultural irrigation, and groundwater contamination by nitrate leached from highly cultivated fields. There is urgent need for research exploring **alternative vegetable crops and new farming strategies** to mitigate the groundwater quantity and quality issues, and improve vegetable production sustainability.

Previous research showed dark red kidney (DRK) beans use 30% less water than potatoes, and 25% less water than sweet corns. In addition, DRK beans can fix N_2, enrich soil health by leaving behind essential nutrients for the next crop, and thus reduce the need for chemical fertilizers compared to potatoes and sweet corns. On top of that, DRK beans are a vital source of plant-based proteins, and can be consumed as part of a healthy diet to prevent and help manage chronic diseases.

Currently most DRK beans are planted in the Northwestern part of Wisconsin, of which the growing season length and growing conditions (irrigated sandy soils) are similar to those of the Central Sands. In the 2020 season, we conducted a field study at the University of Wisconsin Hancock Agricultural Research Station to evaluate the impacts of three irrigation practices and four nitrogen rates on growth of five dark red kidney bean varieties.

The treatments and N rates are listed in Table 1.

[1/] Assistant Professor, Department of Horticulture, Univ. of Wisconsin-Madison

Table 1. Treatments and N rates.

<table>
<tr><th colspan="2">Irrigation Treatment</th><th colspan="2">N Treatment</th><th>Variety</th></tr>
<tr><td rowspan="2">Standard Irrigation</td><td rowspan="2">Starting irrigation 17 days after planting, irrigate with 0.3 – 0.4’’ per time every two days. Soil moisture was kept between 60% and 80% field capacity until desiccant application. This was recommended by the industry.</td><td>20 lb N/a</td><td>Only starter</td><td rowspan="4">Montcalm, Dynasty, Red Rover, Red Hawk, and Spire</td></tr>
<tr><td>80 lb N/a</td><td>20 N starter + 60 N when second trifoliate fully expanded</td></tr>
<tr><td>Deferred Irrigation</td><td>Started two weeks after the standard irrigation.</td><td>120 lb N/a</td><td>20 N starter + 60 N when second trifoliate fully expanded + 40 N when 90% of plants entering reproductive stage</td></tr>
<tr><td>Deficit Irrigation</td><td>Skipped every other standard irrigation event until flowering.</td><td>160 lb N/a</td><td>20 N starter + 60 N when second trifoliate fully expanded + 80 N when 90% of plants entering reproductive stage</td></tr>
</table>

ANOVA table of the treatment effects is shown in Table 2:

Treatment	Pr > F
Irri	0.194
N Rate	<0.0001***
Variety	0.059*
Irri*N Rate	0.948
Variety*N Rate	0.304
Variety*Irri	0.938
Variety*Irri*N Rate	0.847

We did not find any significant effects of the irrigation practices on yield, however, different varieties responded differently to varying N rates. From Figure 1, it is suggested that yield of Montcalm, Red Hawk and Spier kept increasing as the N rate increased, but Danasty reached its highest yield at 80 lb N/acre, and Red Rover reached its highest yield at 120 lb N/acre. For the highest yield potential, there was not any varietal difference.

We will repeat this study in the 2021 season to see if consistent results can be obtained.

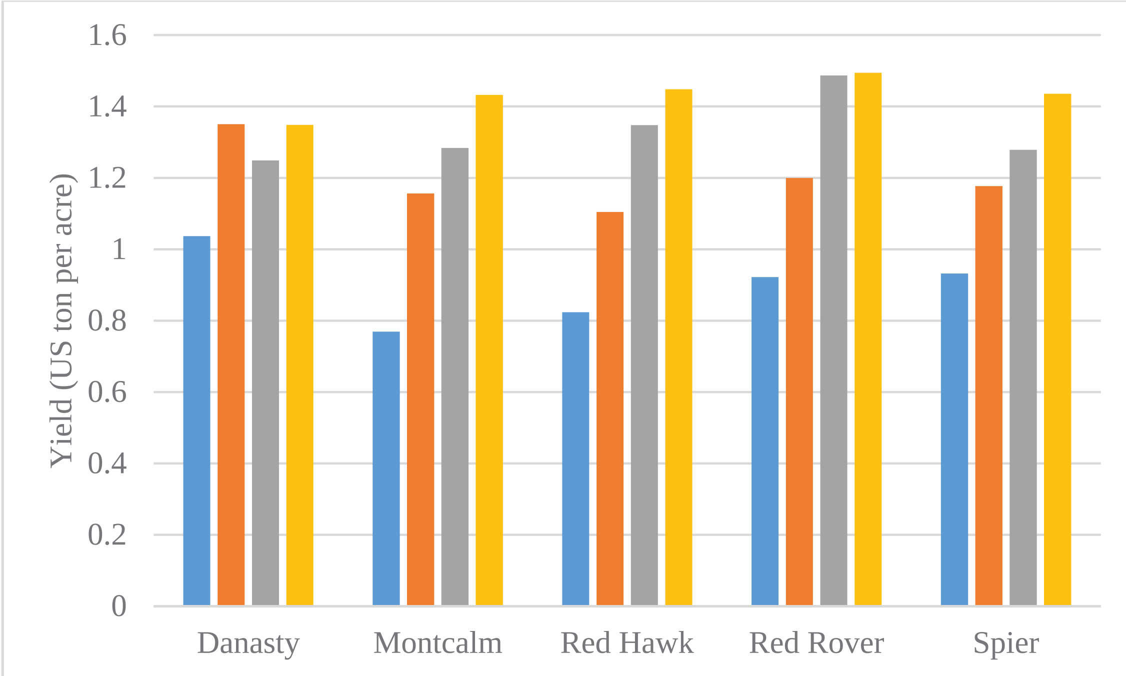


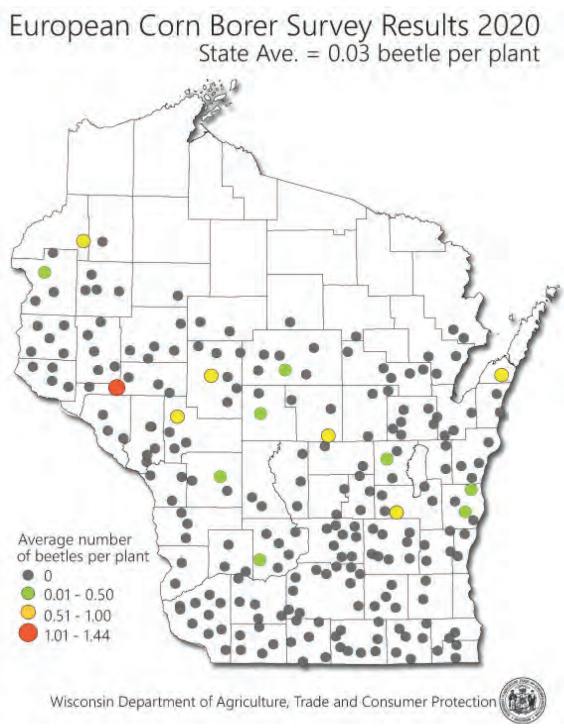
Figure 1. Yield of the five varieties under each of the four N rates.

A REVIEW OF DATCP'S INSECT SURVEY RESULTS FROM 2020

Krista L. Hamilton[1/]

European Corn Borer

Larval populations increased from historically low levels in 2018 to 2019 but remained extremely low overall. The state average count in 229 cornfields sampled this fall was 0.03 borer per plant, which is only marginally higher than the all-time low average of 0.01 per plant recorded during the two preceding seasons. All three of the state's southern agricultural districts showed averages less than or equal to 2019 levels, while negligible increases were noted in the central and northern areas. Larvae were absent from 90% of the fields sampled in September and October.



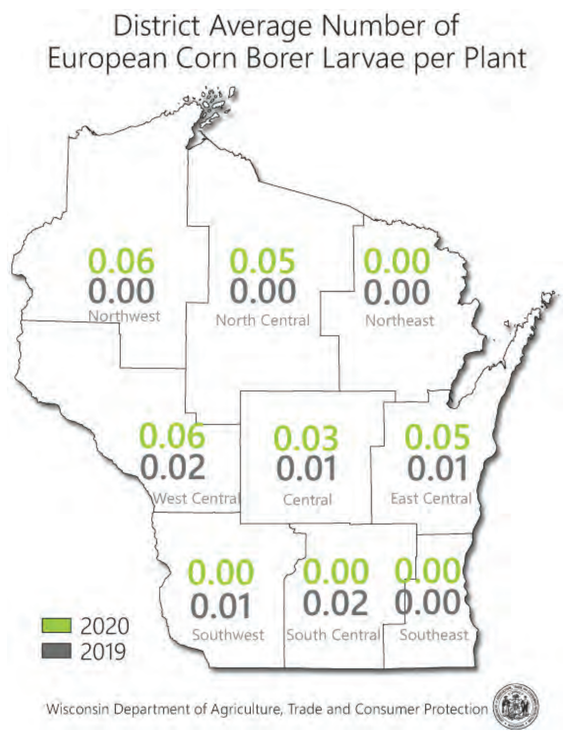


Table 1. European corn borer fall survey results 2011-2020 (Average no. borers per plant).

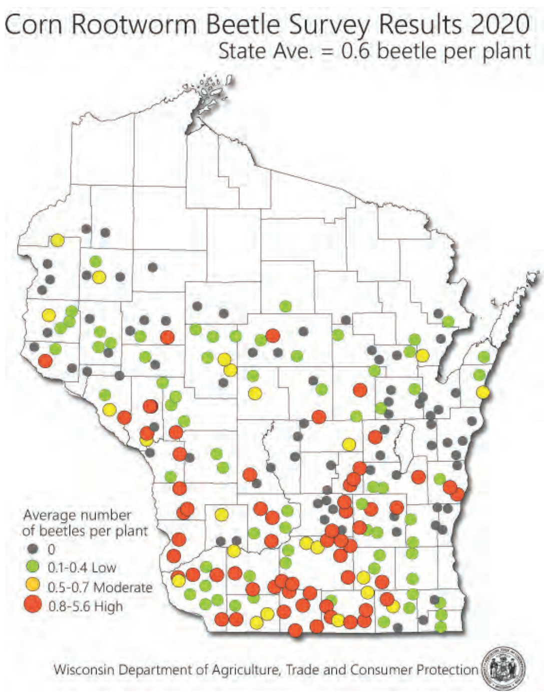
District	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	10-Yr
NW	0.15	0.04	0.07	0.06	0.03	0.13	0.09	0.02	0.00	0.06	0.07
NC	0.07	0.01	0.02	0.04	0.00	0.08	0.04	0.01	0.01	0.05	0.03
NE	0.13	0.05	0.02	0.01	0.04	0.00	0.00	0.02	0.01	0.00	0.03
WC	0.12	0.09	0.06	0.12	0.03	0.15	0.01	0.05	0.02	0.06	0.07
C	0.05	0.01	0.01	0.00	0.01	0.24	0.02	0.02	0.01	0.03	0.04
EC	0.03	0.01	0.01	0.01	0.04	0.00	0.01	0.01	0.01	0.05	0.02
SW	0.03	0.03	0.06	0.00	0.03	0.14	0.04	0.00	0.01	0.00	0.03
SC	0.20	0.01	0.08	0.01	0.02	0.14	0.06	0.00	0.02	0.00	0.05
SE	0.01	0.00	0.01	0.00	0.00	0.04	0.04	0.01	0.00	0.00	0.01
WI Ave.	**0.09**	**0.03**	**0.04**	**0.03**	**0.02**	**0.11**	**0.03**	**0.01**	**0.01**	**0.03**	**0.04**

[1/] Entomologist, Dept. of Agriculture, Trade and Consumer Protection, 1812 Park Ave., LaCrosse, WI 54601.

Beetle populations increased in 2020 to the highest levels recorded in 5 years. The annual survey in August documented a state average count of 0.6 beetle per plant in 229 fields, or twice the average found in 2019. The greatest increase was documented in the south-central district (0.5 beetle to 1.3 beetles per plant), while counts were also relatively high in the southwest and central regions, at 0.6 and 0.7 beetle per plant, respectively. Cornfields with populations above the 0.75 beetle-per-plant economic threshold comprised 27% of this year's sites, compared to last year's 12%.

In addition, the 2020 total count of 1,332 beetles was 47% higher than the 711 beetles counted in 2019. Seventy percent of this season's beetles were northern corn rootworm, which has been the predominant species in the state for 7 consecutive years.

Based on the higher populations observed this season, southern Wisconsin corn producers are advised to closely review their rootworm management plans for 2021 and consider crop rotation if practical. Growers opting for a rootworm trait package are reminded that planting continuous corn with the same trait should be avoided.



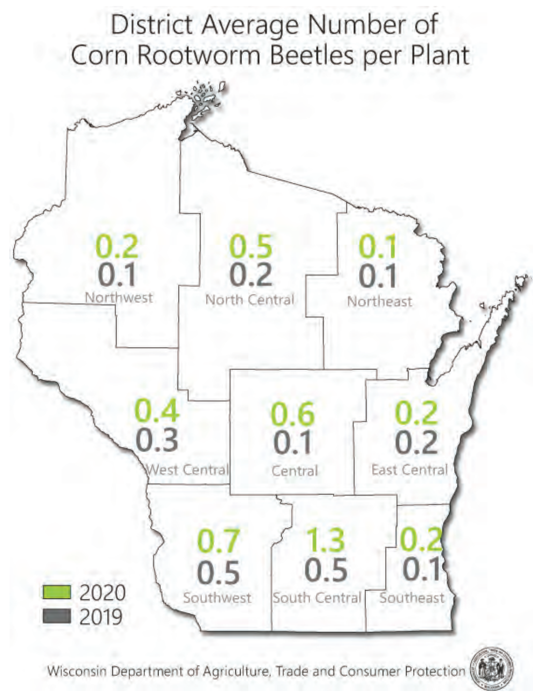


Table 2. Corn rootworm beetle survey results 2011-2020 (Average no. beetles per plant).

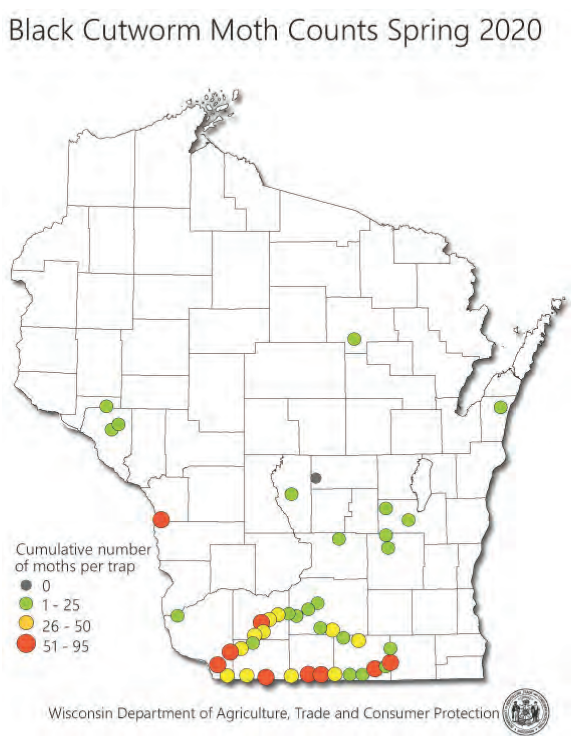
District	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	10-Yr
NW	0.1	0.5	0.7	0.5	0.2	0.5	0.2	0.2	0.1	0.2	0.3
NC	0.1	0.3	0.2	0.2	0.5	0.7	0.2	0.2	0.2	0.5	0.3
NE	0.3	0.6	0.2	0.1	0.2	0.7	0.2	0.4	0.1	0.1	0.3
WC	0.6	0.4	0.4	0.6	0.3	0.6	0.2	0.3	0.3	0.4	0.4
C	0.8	0.5	0.2	0.2	0.5	0.3	0.3	0.2	0.1	0.6	0.4
EC	0.5	0.4	0.3	0.3	0.8	0.4	0.2	0.2	0.2	0.2	0.4
SW	1.1	0.8	0.6	0.9	0.8	0.7	0.3	0.3	0.5	0.7	0.7
SC	1.4	0.9	0.5	0.3	0.8	0.4	0.3	0.3	0.5	1.3	0.7
SE	0.7	0.9	0.8	0.4	0.7	0.2	0.1	0.1	0.1	0.2	0.4
WI Ave.	**0.7**	**0.6**	**0.5**	**0.4**	**0.6**	**0.5**	**0.2**	**0.2**	**0.3**	**0.6**	**0.4**

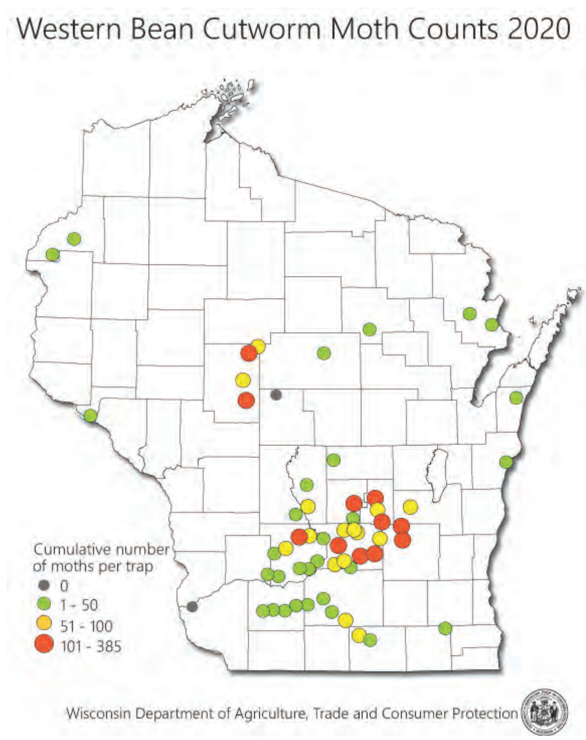
Corn Earworm

Pheromone traps captured a cumulative total of 4,747 moths in 18 traps during the late-season monitoring program, with the largest flights recorded during the first week of September. The highest individual pheromone count was 433 moths at Beaver Dam in Dodge County from August 27 to September 2. Compared to 2019 when 3,495 moths were collected in 15 pheromone traps, this year's total count was 26% higher. The risk to late sweet corn from migrating corn earworm adults was also elevated in 2020, and the September moth flights produced localized larval damage to apples, corn, and tomatoes. Earworm caterpillars were found in 10% of sites surveyed for ECB this fall.

Black Cutworm

Early corn planting and a delayed moth migration resulted in a low risk of spring cutworm damage to emerging corn. Although migrants began appearing in survey traps by April 8, the first intense flights of nine or more moths in two nights did not occur for another month, until May 4. The April 8 to June 5 trapping survey captured 1,355 moths in 44 traps, with a peak recorded May 13 to 19. Significant black cutworm injury was not observed or reported this season.





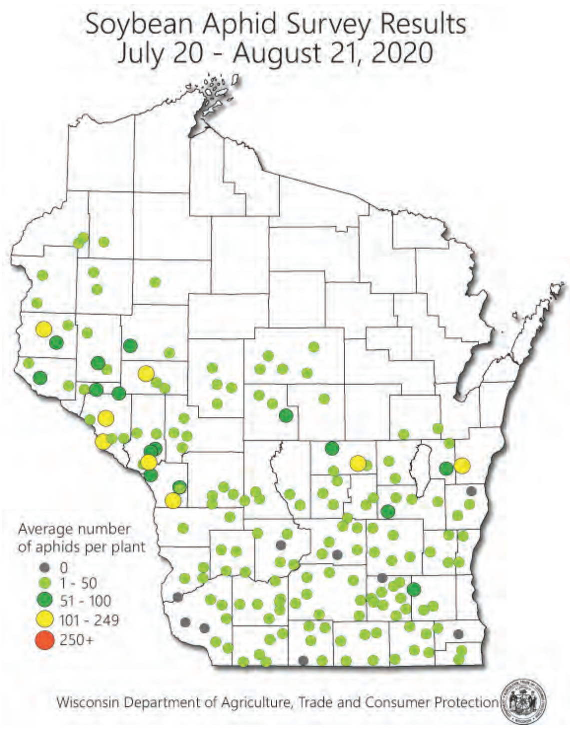
Western Bean Cutworm

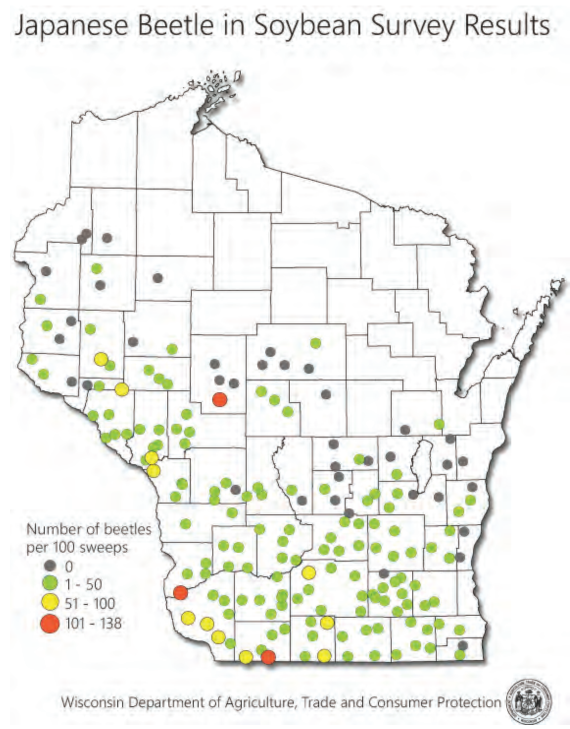
Moth counts in 2020 were remarkably similar to those recorded in 2019. The annual trapping program from June to August registered an average of 65 moths per trap (3,789 moths in 58 traps), tying 2019 for the second highest average in 16 years. The survey record of 79 moths per trap (10,807 moths total) was set in 2010. The highest individual count for the 10-week monitoring period was 385 moths at Princeton in Green Lake County, the same location that collected the high count of 405 moths in 2019. This season's relatively large flight generated larval injury to scattered cornfields in the west-central and central counties in August and September.

Soybean Aphid

Populations recorded during the annual survey were mostly low. Ninety-one percent of the 180 fields sampled from July 20 to August 21 had average counts below 50 aphids per plant, 5% had 51 to 100 per plant, and only 4% had moderate populations of 101 to 175 aphids per plant. The 2020 state average count was just 15 aphids per plant, with no surveyed fields showing above-threshold populations of 250 aphids per plant. For comparison, the 2019 survey found a record-low average of five aphids per plant, the 2018 average was 14 aphids per plant, and surveys from 2010 to 2017 documented average counts of 6 to 55 aphids per plant.

Results of this season's effort suggest that while aphid pressure was slightly higher than in 2019, the soybean fields sampled did not meet treatment guidelines during the survey timeframe.





Soybean Gall Midge

An emerging pest of Midwestern soybeans, the soybean gall midge (SGM) was not found in Wisconsin in 2020. Populations were confirmed this season in Iowa, Minnesota, Nebraska, and South Dakota. Larvae of the SGM, a member of the Hessian fly family (Cecidomyiidae), feed internally at the base of soybean stems and cause stem discoloration. Infested plants snap off near the ground and the orange or white maggots can be found feeding inside. Much remains unknown about this insect, including the exact species and whether it is a direct or a secondary soybean pest. Consultants and soybean growers are encouraged to remain alert for symptoms associated with SGM for 2021 and collect a sample for definitive identification if SGM is suspected.

Japanese Beetle

Defoliation was observed in 70% of the 180 soybean fields examined in August. Counts recorded during the annual aphid survey ranged from 1 to 138 beetles per 100 sweeps, with a state average of 17 per 100 sweeps (the 2019 average was 14 per 100 sweeps). The highest counts of 50 or more beetles per 100 sweeps were noted in the southwestern and west-central districts for the third year in a row. Individual fields in Clark, Crawford, and Lafayette counties had counts exceeding 100 beetles per 100 sweeps and defoliation levels well above the 20% economic threshold for this pest.

Table 3. Soybean pest survey results 2020 (Average no. insects per 100 sweeps).

District	Bean leaf beetle	Japanese beetle	Northern CRW	Southern CRW	Western CRW	Green Cloverworm	Grass-hopper	Stink Bug
NW	3.1	5.6	0.6	0.2	0.0	3.2	2.5	0.5
NC	0.6	14.8	0.4	0.2	0.0	3.8	2.3	1.2
NE	NA	NA	NA	NA	NA	NA	NA	NA
WC	1.0	25.3	1.6	0.1	0.1	4.1	1.8	0.4
C	0.1	6.2	0.0	0.1	0.0	2.6	3.1	0.8
EC	0.1	1.4	0.7	0.0	0.0	3.4	0.6	0.1
SW	0.7	31.0	0.7	0.3	0.6	3.2	11.9	0.5
SC	0.6	17.2	0.8	0.2	0.5	2.8	3.1	0.4
SE	0.7	3.7	9.1	0.1	0.2	2.2	7.5	0.0
WI Ave.	**0.8**	**16.8**	**1.6**	**0.2**	**0.3**	**3.2**	**4.6**	**0.4**

SOYBEAN APHID MANAGEMENT AND INSECTICIDE RESISTANCE

Robert Koch [1/]

Soybean aphid remains a significant pest of soybean, especially in Minnesota and parts of neighboring states. For about two decades, this pest has been managed primarily with insecticides. Multistate research was used to develop guidance for scouting and decision making for insecticide applications against soybean aphid. However, the continued reliance on insecticides for management of this pest has resulted in the development of insecticide resistance in soybean aphid and concerns about environmental contamination from these insecticides.

Because other management tactics (e.g., aphid-resistant varieties) for soybean aphid are limited in availability, the agricultural community must work together to preserve the effectiveness of and continued access to effective insecticides for protection of soybean from this pest. Judicious, IPM-based (i.e., scouting and thresholds) use of insecticides can provide multiple benefits including continued protection of yield, reduced selection for insecticide resistance, and reduced environmental contamination.

Recent survey results from Minnesota farmers and agricultural professionals indicate that most individuals use and trust the research-based threshold of 250 aphids per plant to determine when to apply insecticides. Among factors contributing to distrust of the threshold by some individuals is a perception that the threshold is too high or that yield loss can occur before 250 aphids per plant. Therefore, continued review and better explanation of concepts such as the economic threshold, damage boundary, and economic injury level are required. Along with continued validation of the threshold with field research.

The development of insecticide resistance in soybean aphid has complicated management of this pest. Caution must be taken in insecticide selection, because resistant populations are widespread, but do not necessarily occur in all fields. Several new insecticides provide effective control of soybean aphid and are less impactful to natural enemies, but are less familiar to growers and consultants. In addition, scouting is required after insecticide applications to ensure the desired efficacy of the application was achieved. Finally, if another insecticide application is required, it is important to alternate to a product from a different insecticide group, but insecticide resistance has limited the number of products available for such alternations.

[1/] Associate Professor and Extension Entomologist at the Univ. of Minnesota.

MANAGING CORN ROOTWORMS IN 2021

Bryan Jensen [1/]

Introduction

Use of Bt toxins to manage corn rootworms has been a primary, if not singular, control tactic. However, field resistance has been a concern for several years, which has resulted in fields with unacceptable losses.

Scope of Bt CRW Resistance in Wisconsin

Nationally, focus has been on resistance of the western corn rootworm which is the predominant species in many midwestern states. However, Wisconsin also has the northern corn rootworm species and resistance has been documented in North Dakota in 2018. Recently, the northern corn rootworm has been the most abundant, although personal observations suggest that western corn rootworm numbers are increasing. For this article, and for considerations of future management plans, we should collectively look at both species and assume either can be resistant to the plant incorporated Bt toxins.

Rootworm damage is cryptic. Feeding injury is below ground and not easily detected until lodging is severe. Furthermore, other causes of lodging (compaction, wind, etc.) may be misdiagnosed as rootworm injury. As a result, it is difficult to determine the scope of Bt resistance in Wisconsin. However, both documented and anecdotal reports of injury have occurred in many areas of the state. Resistance may be more commonplace in areas of high concentration of continuous corn and/or repeated reliance on the same Bt toxin.

Detecting Resistance

To detect corn rootworm resistance, evaluate roots for feeding after mid- to late-July when larvae are nearing the end of their feeding period. For best results, finish root evaluations before corn roots have a chance to regenerate (mid- to late-August). Dig a representative sample of roots from each field and wash all soil off the roots. Look for signs of feeding damage that include scarring and root pruning. This step is important because it can verify early stages of Bt resistance, which allows for selection of management practices that can slow the spread of resistance.

Corn Rootworm Management Practices

Diversifying corn rootworm management practices should be considered the corner-stone of future corn rootworm management plans. Crop rotation is at the top of the list. Rootworms overwinter as eggs that are deposited in corn during August or early September. Hatch will start the following spring and larvae will die if a crop other than corn is present.

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There have been some exceptions. In southeast Wisconsin, female western corn rootworm had been known to lay eggs in soybeans. However, this phenomenon has not been reported in the past decade. If concerned about damage to first-year corn, consider evaluating roots of first-year corn fields for feeding. This practice will give some insight into the damage potential in future years. Northern corn rootworms have acquired, through the natural selection process, a method to circumvent annual corn/soybean rotations. Although not documented in Wisconsin, a proportion of their population can survive two winter chill periods before hatching.

To ensure the long-term durability of Bt CRW hybrids, incorporate other management practices in your rootworm management plans. Prior to EPA approval of the Bt CRW hybrids, soil applied, at plant insecticides (SAP) were the primary management tactic if crop rotation was not used. Use of a SAP on non-Bt hybrids can be a good alternative to Bt hybrids even at high beetle populations. However, soil insecticides will vary in their effectiveness and reading labels can provide good insight regarding their control niche. If the label language indicates if high beetle populations are expected to use a second management practice (high seed treatment rate, Bt hybrid) then consider using a different insecticide for those fields with high pressure. Rotating SAP and/or modes of action, is important. Although resistance has not been documented with the current EPA-approved insecticides, it must be considered a potential concern. Resistance has been documented to antiquated classes of insecticides that are no longer labeled and to foliar applied insecticides used to control adults. The point is to be aware of this potential for resistance.

The high rate of either thiamethoxam or clothianidin seed treatments on non-Bt hybrids partnered with field scouting can be an effective management practice only if beetle populations are low but still over threshold. Scouting data are important if seed treatments are to be used otherwise there may be significant risk of injury.

Beetle Scouting

Although rootworm beetle populations were higher in 2020 compared to 2017 to 2019, it must be remembered that beetle populations were at historic lows during that 3-year period. Using field-specific beetle scouting data will allow crop consultants to choose those fields that are best suited for the above-mentioned alternative practices. Furthermore, it may indicate if field populations are below-threshold levels in which no control practices will be needed. To take advantage of below-threshold fields, adult beetle counts need to be conducted during the egg laying period (mid-August to early September) and at least two counts spaced 7 to 10 days apart are needed for accuracy. Beetles are somewhat migratory and may move from field-to-field depending crop phenology. A third scouting period would be nice but a minimum of two scouting dates would be required.

Rotating Bt Toxins

Prior to a discussion of how to diversify management practices we should consider how to manage Bt CRW toxins if they are to be considered. Using the same, or similar, toxin for more than two years should be avoided. Annual rotation is better. Using the same, or similar, toxin on a routine basis will select for resistance to that toxin(s). Currently there are only four Bt toxins available. Three toxins have similar protein structure (Cry3Bb1, mCry3, eCry3.1Ab) and cross resistance has been documented between them. The fourth is Cry34/35Ab1 and has not been documented to be cross resistant with the previously mentioned proteins.

Single vs. Pyramid Proteins

Using a pyramid hybrid, which can be loosely defined as a hybrid which has two Bt toxins to control the same insect, is a good management practice compared to a single toxin. Although there are some single toxin trait families available, most seed companies are moving to pyramids. However, if one of the two Bt toxins has been previously compromised you are essentially using a single toxin hybrid. Control maybe acceptable for a period of time because the effective toxin masks the ineffectiveness of the compromised protein. However, selection pressure will be increased for the effective protein until it fails.

Diversifying CRW Management Practices

Being aware of the management practices listed above, their management niche, the need to rotate Bt toxins and especially the need for these practices to be linked with a scouting program will provide the background necessary to diversify management practices. Using a one size fits all management program is at direct odds with the IPM concept.

General IPM principles should be used to develop a rootworm management program that avoids resistance while providing economical control. For example, fields with high (or higher) potential for rootworm damage consider using Bt hybrids or SAP on non-Bt hybrids. Perhaps a mix of both depending on acreage. Your goal is to reduce dependance on Bt hybrids and to provide an opportunity to rotate Bt toxins.

Corn fields with moderate beetle populations would still be good candidates for SAP insecticides on non-Bt hybrids. This will likely reduce input costs yet keeps your options open for using and rotating Bt toxins on those fields with high populations.

Based on current rootworm populations trends and/or your location in the state, you will undoubtedly have fields with low populations. Using the high rate (CRW rate) of a thiamethoxam or clothianidin seed treatment will provide economic and efficacious control while most importantly keeping options open for the high-pressure fields. This management option needs scouting data to verify low beetle populations.

Using SAP with Bt CRW Hybrids

Questions are often asked regarding the need for overlaying SAP with Bt hybrids to control rootworms. This practice should be considered only if scouting information verifies beetle populations are extremely high and there is concern that either practice by themselves may fail. It should not be considered for average populations if trying to protect a Bt toxin that is already compromised. Using a compromised Bt toxin in this situation will only continue to select for resistance.

SOYBEAN GALL MIDGE: UNDERSTANDING A NEW PEST IN THE MIDWEST

Justin McMechan [1/]

Soybean gall midge (SGM) was identified as a new species in 2018 in the Midwestern United States causing extensive injury to soybean in eastern Nebraska, western Iowa, southwestern Minnesota, and eastern South Dakota (Fig. 1).

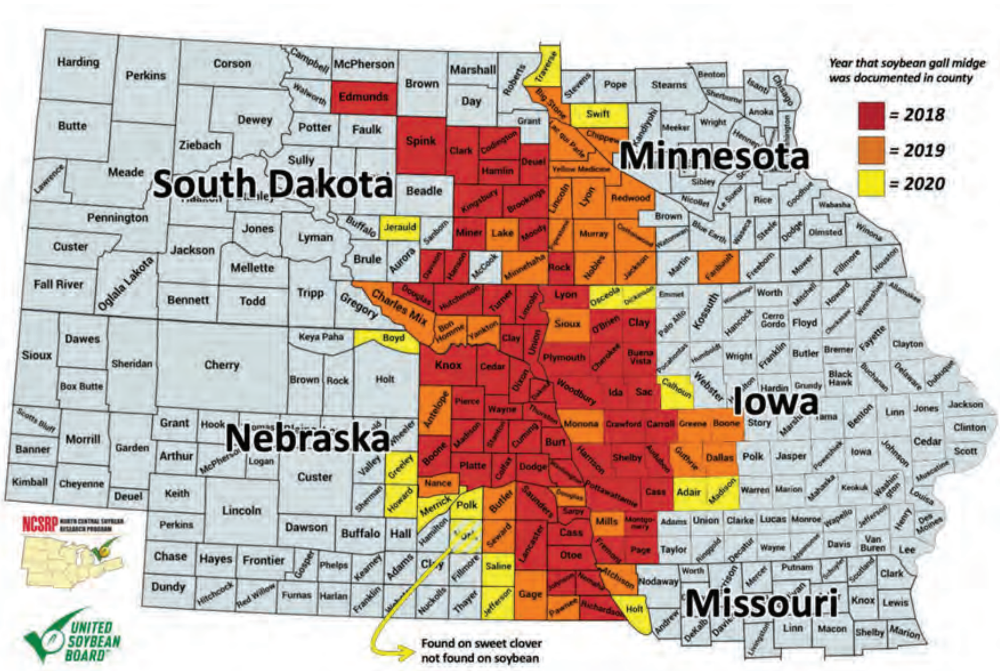

Figure 1. Counties documented as infested with soybean gall midge larvae in 2018 (red), 2019 (orange), and 2020 (yellow)

Since it's discovery, soybean gall midge adult emergence has been tracked each year from soybean fields that were infested the previous year. In east central Nebraska, the duration of adult emergence from these overwintering sites averaged 15 days in 2019 to 25 in 2020 with emergence beginning in mid-June each year. This long duration of emergence from overwintering sites poses a significant challenge for management tactics to mitigate soybean injury in adjacent soybean fields.

Several studies were conducted over the last two seasons to evaluate the efficacy of seed treatments, in-furrow, and foliar insecticides on soybean gall midge. None of the treatments tested provided complete control of soybean gall midge, however, some chemistries, especially in combination with cultural control strategies (planting date) showed early season potential to mitigate soybean gall midge injury to soybean plants.

As of 2020, soybean gall midge has not been found in Wisconsin. Regardless, soybean farmers should be on the lookout for this new pest. To scout for soybean gall midge, focus on the edge of the field especially in soybean field that are adjacent to a field that was soybean the previous year. To learn more about what to look for visit the https://soybeangallmidge.org/scouting-for-soybean-gall-midge to watch videos on what to look for in your field.

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IMPROVED MANAGEMENT OF SOYBEAN WHITE MOLD: REVISITING GENETIC RESISTANCE, INTEGRATED MANAGEMENT, AND DISEASE PREDICTION

R.W. Webster[1], M. McCaghey[2], B. Mueller[3], D.S. Mueller[4], M.I. Chilvers[5], S. Conley[6], and D.L. Smith[7]

Introduction

The fungal pathogen *Sclerotinia sclerotiorum*, causes the disease Sclerotinia stem rot (SSR; a.k.a. white mold) of soybean. This disease can cause severe losses under highly conducive conditions throughout the Upper Midwest (Roth et al., 2020). As a result, there is large interest in understanding the most effective methods of controlling SSR. This includes the use of cultural and chemical control methods in an integrated approach. In previous research, the use of wider row spacing (30 inches) resulted in decreased levels of disease while narrow row spacing (10 and 15 inches) increased disease (Grau and Radke, 1984). Additionally, research showed the use of planting populations above 175,000 seeds/acre resulted in increased disease incidence compared to lower populations (Lee et al., 2005).

Another method of reducing the impacts of SSR is through the use of genetic resistance. Due to many minor effect quantitative trait loci (QTL) of soybean associated with resistance to SSR, breeding for high levels of resistance has thus far been challenging (Arahana et al., 2001; Vuong et al., 2008). The recent advancements in identifying and understanding such resistance QTLs may lead to more accurate breeding and development of soybean lines with high resistance while also maintaining high yields (Moellers et al., 2017).

Chemical control has also proven to be an effective method for managing SSR, more recently (Willbur et al., 2019). Coupled with this practice, is the use of predictive modeling. Predictive disease models may lead to the better understanding of a fields risk for disease development, thus helping to make better decisions on whether a fungicide application is needed. Models for predicting diseases caused by *Sclerotinia* spp. in other cropping systems have been previously developed (Smith et al., 2007; Clarkson et al., 2007), and more recently, work had been performed to create predictive models for SSR in soybean across the Upper Midwest (Willbur et al., 2018a, 2018b). This work led to the creation of probability-based models for both irrigated and non-irrigated environments. These models are publicly available in the form of a smartphone application tool called Sporecaster. The Sporecaster tool is currently being refined and improved for accuracy in a range of environments where SSR is a problem in soybean production systems.

Materials and Methods

The work presented here examined the use of two row spacings (15 and 30 inches), four planting populations (110,000, 140,000, 170,000, and 200,000 seeds/acre), and two foliar fungicide programs. The first fungicide program used was a soybean growth stage dependent protocol where applications were

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made at both the R1 and R3 growth stages and will be referred to as the “standard application”. The second fungicide program was a model-based risk prediction program following the models developed by Willbur et al. (2018a, 2018b) and implemented using the Sporecaster tool. This second fungicide program will be referred to as the “Sporecaster application”. All fungicide applications were made using picoxystrobin (Aproach®; Corteva Agriscience) at 9 fl oz/acre. By integrating these practices between 2017 and 2019 at 10 locations across the Upper Midwest, we examined the effect of these combined management practices on controlling SSR (disease severity index; DIX) while also maintaining high yields.

Breeding for resistance is another method of improving control of SSR, and currently we have two groups of breeding lines in the pipeline. The first group of breeding lines were crossed in 2016 with the assistance of Dr. Asheesh Singh at Iowa State Univ. These included crosses between “SSR51-70” and “51-23” and between “51-23” and “52-82B”. These three parental lines were previously developed by Dr. Craig Grau and were identified as being either moderately resistant or highly resistant to SSR. By the use of a winter nursery in Chile, and our nurseries in Wisconsin, the progeny lines were progressed through generations quickly. In 2019, 25 F_7 lines were selected for favorable agronomics and were progressed to greenhouse disease screenings. These lines were tested using a cut-petiole technique developed by Peltier and Grau (2008) and were compared against a standardized panel of soybean genotypes with known resistance levels to SSR (Webster et al., 2021). In the summer of 2020, these 25 lines were grown in two locations in Wisconsin in preliminary yield trials and resistance screenings for SSR. The second group of breeding lines consists of four populations which were initially produced in the summer of 2018 by crossing a combination of four lines with favorable agronomics and resistance to SSR (“Savoy”, “42-136”, “SSR51-70”, and “91-38”). The progeny of these crosses were advanced through generations using bulk planting plots. During the 2020 growing season, the F_4 progeny were again planted as bulk plots, and approximately 100 plants were selected from each population. Focus of selection was on favorable agronomics (lateral branches, low lodging, high pod count, etc.).

Improvements of the prediction models for Sporecaster have also been a focus of attention over the past few years. The integration of soybean resistance levels is currently being looked at to improve the prediction accuracy of disease risk. Prior to this study, four soybean genotypes were identified, referred to as the check lines, exhibiting a range of resistance to SSR (Webster et al., 2021). These four check lines include Dwight (public cultivar) which was identified as susceptible, 51-23 and SSR51-70 (breeding lines) were identified as moderately resistant, and 52-82B (breeding line) was identified as highly resistant. These four lines had also previously been tested for their field resistance in 2016 (data not shown). Recently, these lines were identified and validated in controlled greenhouse studies to standardize screening assays for examining soybean genotypes physiological resistance levels to SSR. From these greenhouse studies, the soybean genotypes were given their respective resistance rankings. By incorporating these resistance levels into the already developed Sporecaster risk prediction model, error associated with difference between genetic resistance levels could be more accurately accounted for. This could be accomplished by moving the spray threshold on the models depending on the soybean resistance level.

In 2020, two separate field trials were performed in Hancock, Wis. and Rib Falls, Wis. The Hancock location was at the Hancock Agricultural Research Station, and the field has an artificially high level of *Sclerotinia sclerotiorum* inoculum which helps to ensure disease development. This location is under irrigated conditions. The Rib Falls location is located on land belonging to a producer collaborator with a history of high disease pressure, and this field is under non-irrigated conditions. At each trial site, the four check lines were planted in combinations with multiple fungicide programs. These programs include a phenology-based application between the R2 and R3 growth stages, and three separate programs based on Sporecaster risk action threshold levels with either a low action threshold (5% for irrigated conditions and 10% for non-irrigated conditions), medium action threshold (10% for irrigated and 40% for non-irrigated), or a high action threshold (20% for irrigated and 75% for non-irrigated). All fungicide applications were made with boscalid (Endura®; BASF) at 8 oz/a. A non-treated control was also included.

Results

In the integrated management study, SSR developed in 13 site-years between 2017 and 2019. There was also a total of five site-years that did not have any SSR. Due to this, the analysis was split between environments where disease was present or absent. In the locations where disease was present, row spacing had a minor effect on DIX (*P* = 0.06; Fig. 1) where wider row-spacings resulted in lower disease levels compared to narrower row-spacings. Yield in environments where disease was present resulted in an interaction between row spacing and planting population effects (*P* = 0.02; Fig. 2). Yield was highest in the narrow row-spacing with high planting populations but was lowest in the wide row-spacing with low planting populations. In environments where disease was absent, the main effects of row spacing (*P* = 0.02) and planting population (*P* < 0.01) resulted in a significant effects on yield, where narrow row spacing and planting populations above 170,000 seeds/ac had the highest yields. The use of fungicides was found to be significant in explaining DIX (*P* < 0.01; Fig. 3) and yield in both environments where SSR was present (*P* < 0.01; Fig. 3) or absent (*P* = 0.02). Across both analyses the use of the standard fungicide program led to decreased DIX and higher yields compared to the non-treated controls.

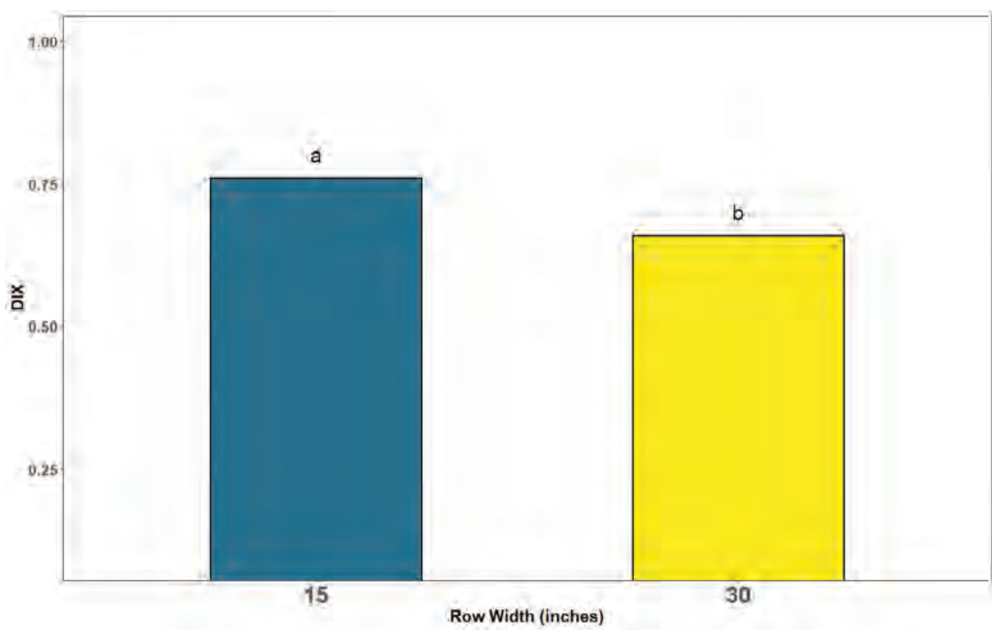

Figure 1. Effect of row spacing on Sclerotinia stem rot disease severity index (DIX; *P* = 0.06) across seven environments where disease developed. These trials examined the combinations of two row-spacings, four planting populations, and two fungicide programs across the Upper Midwest soybean growing region between 2017 and 2019. Plots were planted with a susceptible cultivar to enhance disease development. Bars with the same letters are statistically similar according to Fisher's least significant difference test (α = 0.10)

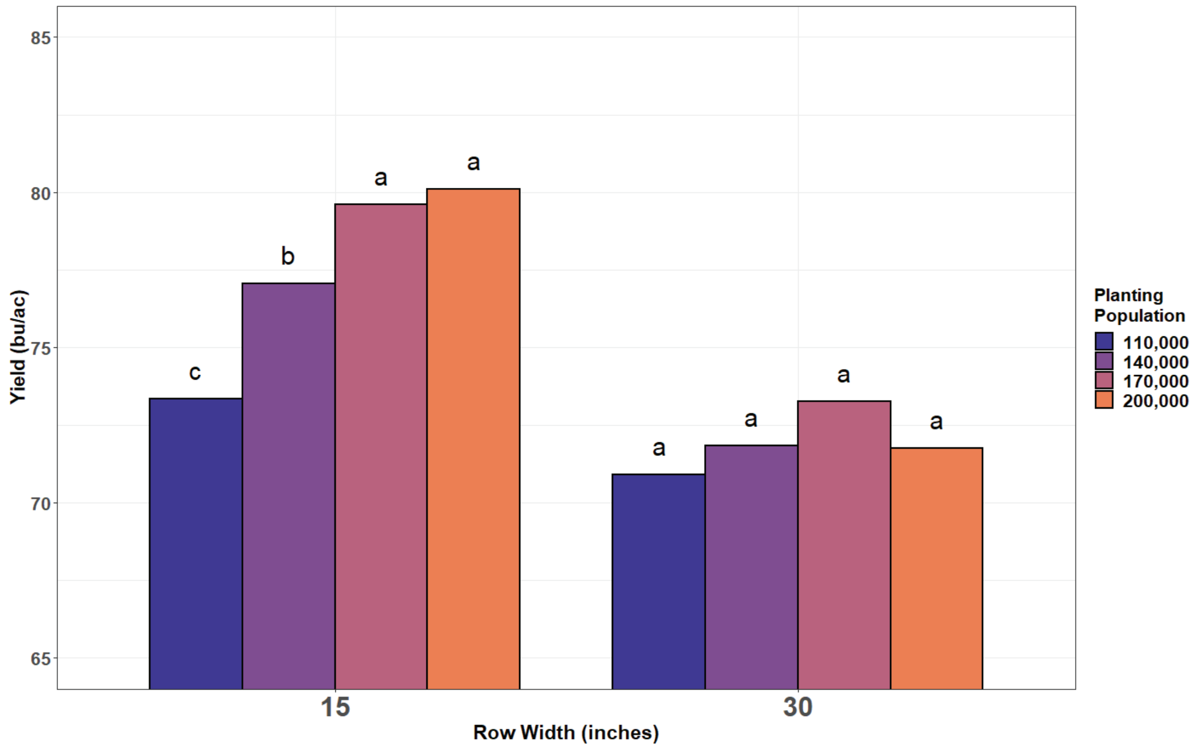

Figure 2. Effect of row spacing and planting population (*P* = 0.02) on soybean yield across seven environments where Sclerotinia stem rot developed. These trials examined the combinations of two row-spacings, four planting populations, and two fungicide programs across the Upper Midwest soybean growing region between 2017 and 2019. Plots were planted with a susceptible cultivar to enhance disease development. Bars within each row spacing with the same letters are statistically similar according to Fisher's least significant difference test (α = 0.05).

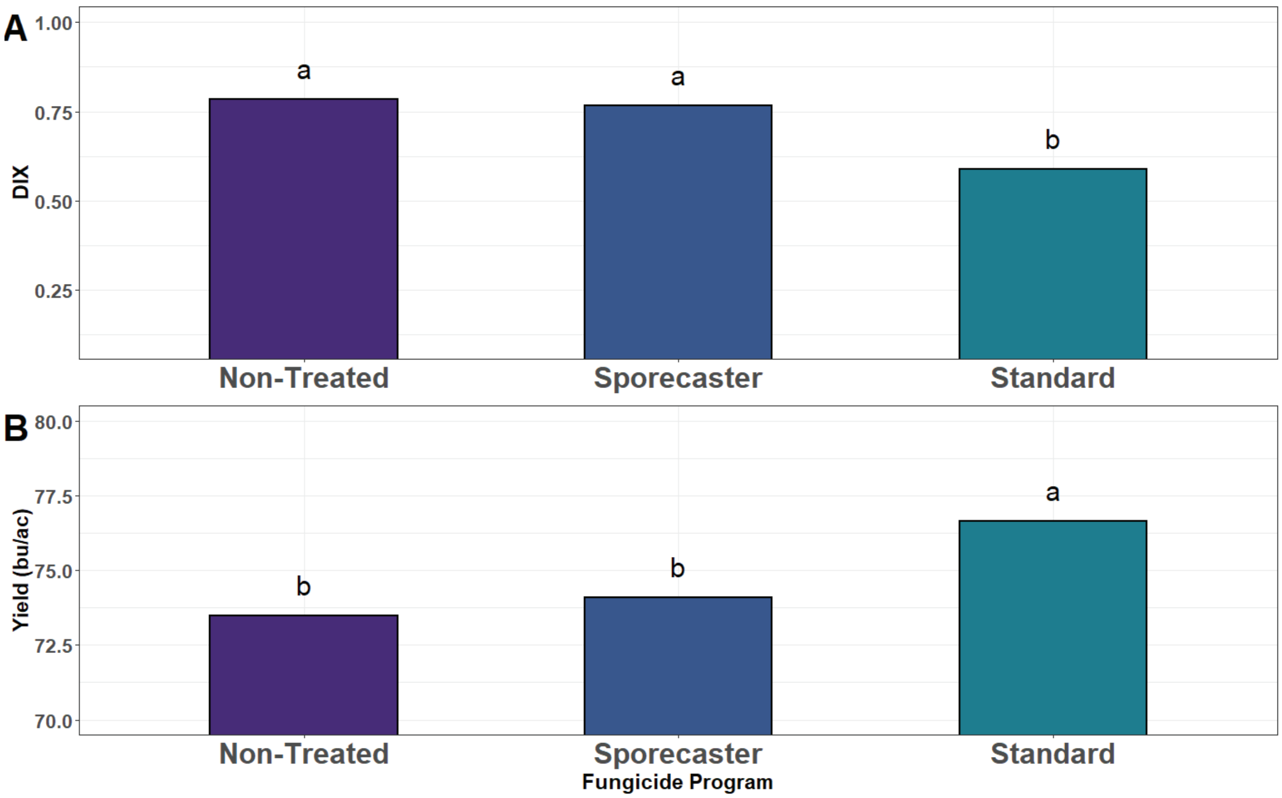

Figure 3. Effect of fungicide application programs on Sclerotinia stem rot disease severity index (DIX; A; $P < 0.01$) and yield (B; $P < 0.01$) in seven environments where disease developed. These trials examined the combinations of two row spacings, four planting populations, and two fungicide programs between across the Upper Midwest soybean growing region between 2017 and 2019. The two fungicide programs, the "Standard program" which includes applications at both the R1 and R3 soybean growth stages, and the "Sporecaster program" following the model-based risk prediction tool, Sporecaster. When Sporecaster risk level reached the 40% threshold or above, an application was made, and if an application was made, two weeks later the risk level was reassessed for a potential second application. Both fungicide programs were compared against a non-treated control. Plots were planted with a susceptible cultivar to enhance disease development. Bars with the same letters are statistically similar according to Fisher's least significant difference test ($\alpha = 0.05$).

During the spring of 2020, the 25 breeding lines from the first group of materials were examined for resistance to SSR in greenhouse screenings. From this preliminary work, differences in resistance levels were found between these lines, and a few lines were promisingly similar to our resistant check line, "52-82B". During the 2020 growing season, the same 25 breeding lines were examined in two separate environments. SSR developed in one of these locations and disease ratings were taken. Additionally, data from other diseases such as frogeye leaf spot and Cercospora leaf blight were recorded. From this data, selections of 10 lines exhibiting high levels of resistance to SSR as well as favorable agronomics and resistance to the other noted diseases were made. These 10 lines will be further tested in greenhouse screening assays to better understand their physiological resistance levels to SSR and other yield limiting diseases of the Upper Midwest growing region. Additionally, the 10 lines will be taken to yield trials in multiple environments across Wisconsin in the 2021 growing season.

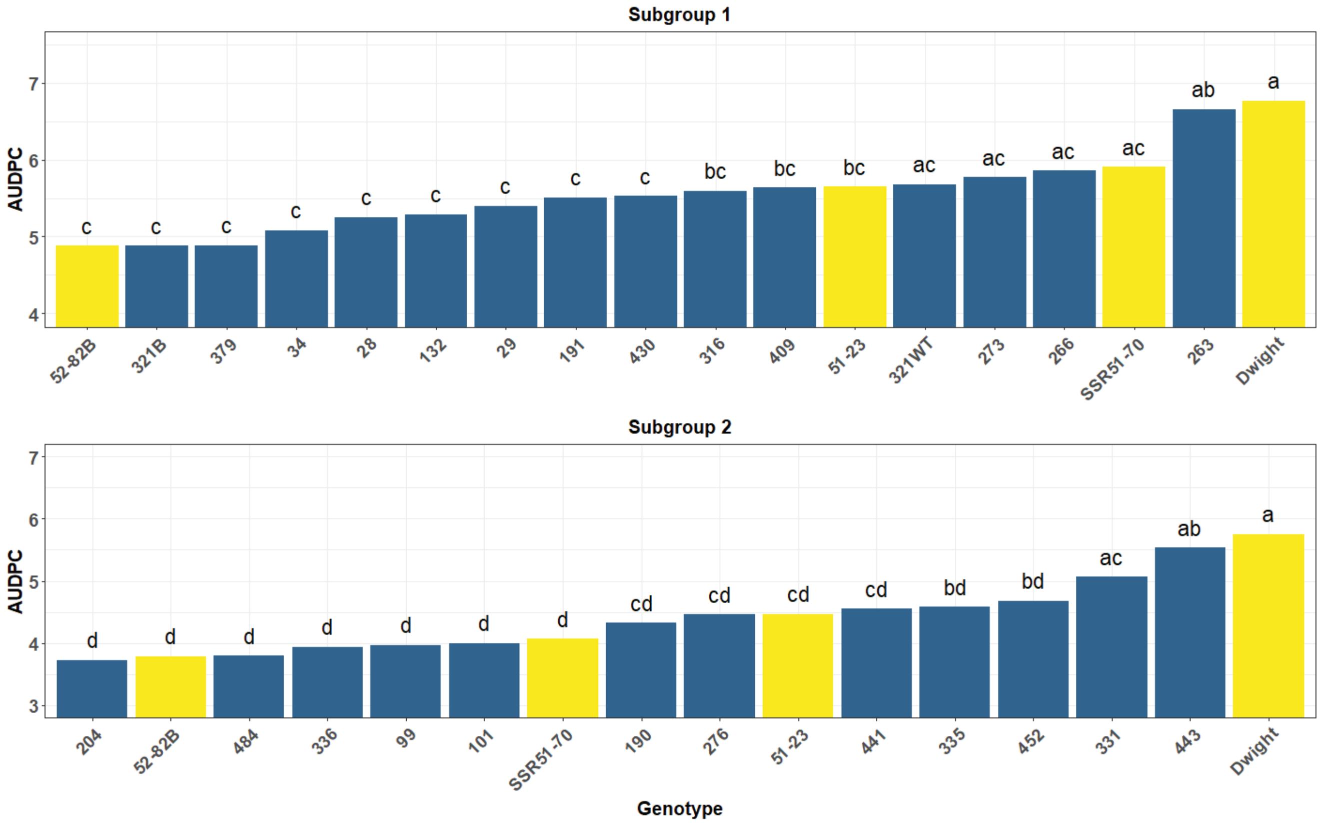

Figure 4. Area under the disease progress curves (AUDPC) of 25 soybean breeding lines (blue bars) and the four soybean check lines (yellow bars) when challenged with *Sclerotinia sclerotiorum*. These experiments were performed under greenhouse conditions during the spring of 2020. AUDPC values were subjected to a logarithmic transformation to achieve normality. Bars with the same letters are statistically similar according to Fishers least significant difference test (α = 0.05).

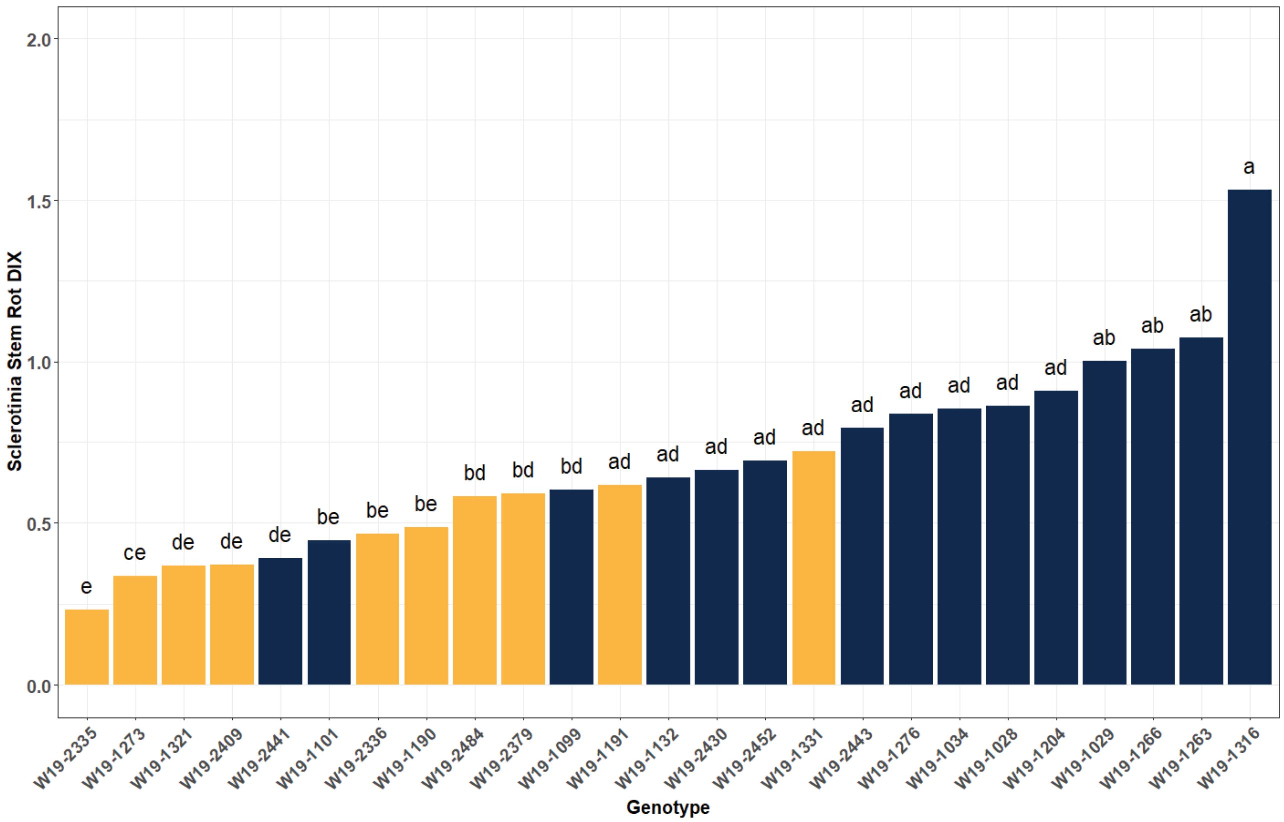

Figure 5. Sclerotinia stem rot disease severity index (DIX) of 25 breeding lines planted at the Hancock Agricultural Experiment Station located in Hancock, Wis during the 2020 growing season. Disease levels were assessed on September 10th at the R6/R7 growth stages. Lines shaded orange were selected in 2020 and will be advanced to further greenhouse screenings and yield trials. Bars with the same letters are statistically similar according to Fishers least significant difference test (α = 0.05).

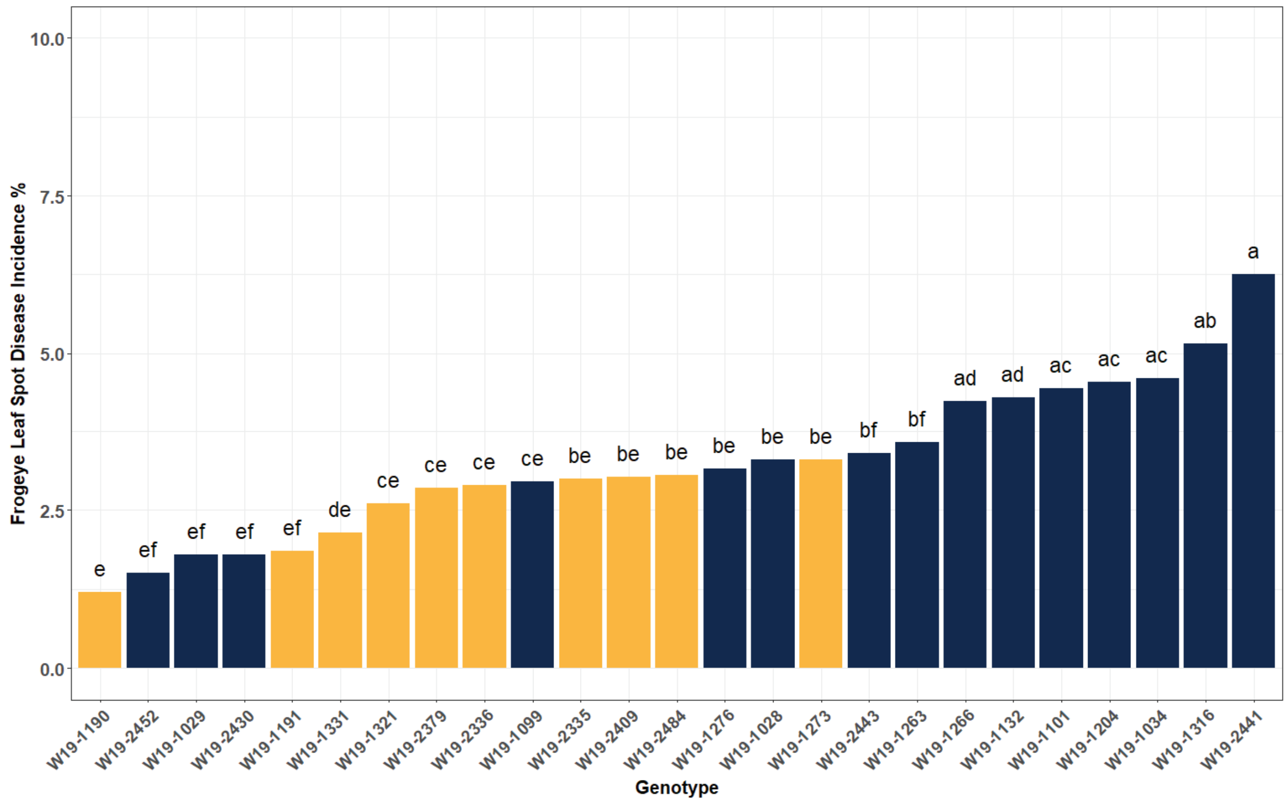

Figure 6. Frogeye leaf spot incidence of 25 breeding lines planted at the Arlington Agricultural Research Station in Arlington, Wis. during the 2020 growing season. Disease levels were assessed on September 4th at the R6/R7 growth stages. Lines shaded orange were selected in 2020 and will be advanced to further greenhouse screenings and yield trials. Bars with the same letters are statistically similar according to Fishers least significant difference test ($\alpha = 0.05$).

The integration of soybean genetic resistance levels to SSR could aid in the improvement of Sporecaster accuracy in predicting risk levels. Across two locations in 2020, an effect due to soybean genotype was found to affect both DIX ($P < 0.01$) and yield ($P < 0.01$). Dwight, the susceptible check line, resulted in the highest disease levels, but also yield the highest as well (Figs. 7 and 8). On the other hand, SSR51-70 had the lowest DIX but also yielded the as one of the lowest (Figs. 7 and 8). 52-82B had more intermediate disease levels while also maintaining more moderate yields (Figs. 7 and 8). In this dataset from two locations, no significant differences were found by the use of the different fungicide programs.

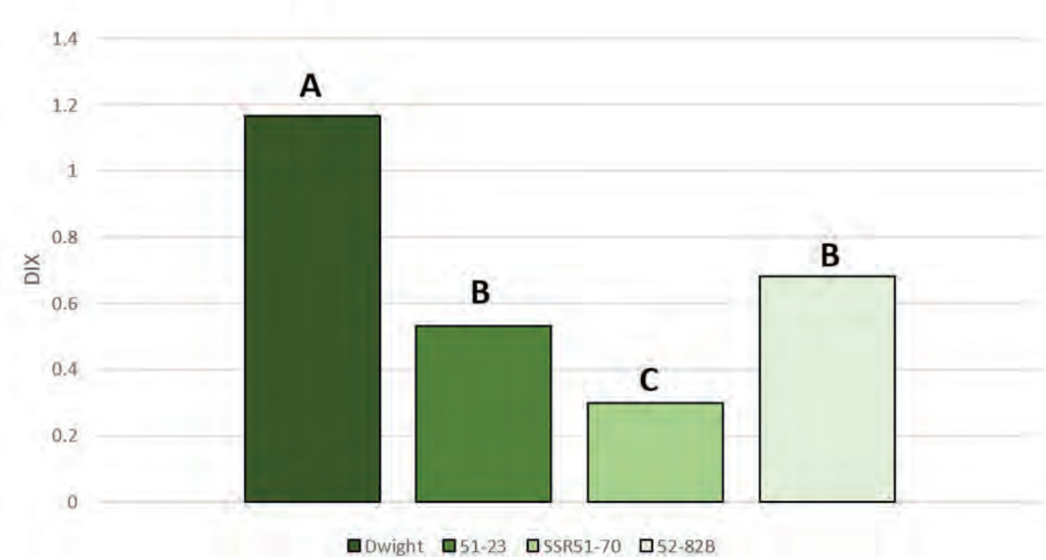

Figure 7. Effect of four soybean genotypes on Sclerotinia stem rot disease severity index (DIX; $P < 0.01$) across two locations (Hancock, Wis. and Rib Falls, Wis.) in 2020. Bars sharing a letter do not statistically differ as calculated by Fisher's test for least significant difference ($\alpha = 0.05$).

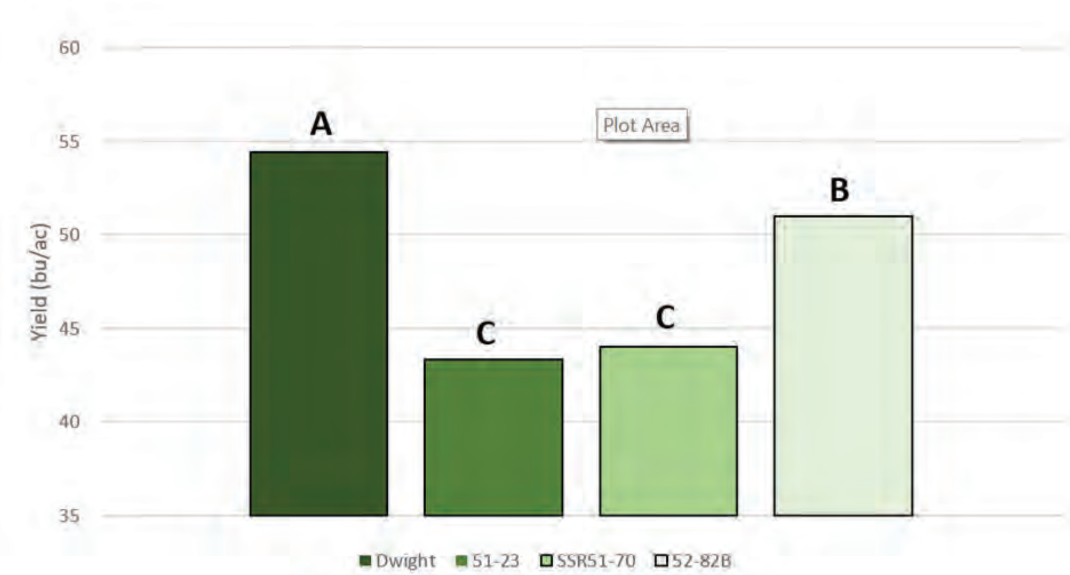

Figure 8. Effect of soybean genotype on yield ($P < 0.01$) across two locations (Hancock, Wis. and Rib Falls, Wis.) in 2020. Bars sharing a letter do not statistically differ as calculated by Fisher's test for least significant difference ($\alpha = 0.05$).

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LET'S TALK: USING FUNGICIDES ON CORN AND SOYBEANS AND HOW TO MAXIMIZE ROI

Damon Smith[1/]

Fungicide use on corn and soybeans has increased dramatically since the turn of the 21st century. This is partially due to the increased labeling of fungicides for use on those crops, along with significant epidemics of yield-reducing diseases in recent years, combined with physiological influences that some of these products have on agronomic crops in the absence of disease. The decision to apply a fungicide to corn and soybeans can be a complicated one. Farmers and practitioners must balance the impending risk a disease might pose to a crop, the possibility of fungicide resistance development in a particular pathogen if using a fungicide, the efficacy of a particular product on a particular pathogen, and the return on investment (ROI) potential for a particular program.

In field corn, the best time to apply a fungicide is between the VT (tasseling) and R1 (white silks outside the husk) corn growth stages. One should use the past history for disease in a field, along with scouting, and weather information to make the decision to apply a fungicide or not. For diseases such as gray leaf spot, northern corn leaf blight, and tar spot, scout the lower canopy prior to the VT growth stage. If symptoms of these diseases are present on the lower leaves on 50% or more plants, there is a history of these diseases in the field, and weather is warm, wet/humid, then a fungicide might be warranted to protect the upper leaves. Other factors to consider are the susceptibility of the hybrid being grown, the presence of previous-crop corn residue, and supplemental irrigation.

In soybean, fungicides should be applied between R1 (one open flower on the mainstem) and R4 (3/4 inch long pod at one of the four uppermost nodes on the mainstem with a fully developed leaf) growth stages based primarily on the risk for white mold and foliar disease such as frogeye leaf spot. Use past history to gauge the risk of white mold and foliar disease. You can also use the Sporecaster smartphone app to make the decision to apply fungicides for targeting white mold. Scout during bloom (R1-R3 growth stages) to make a decision to apply fungicide for foliar disease control. Make the decision to spray for foliar diseases if symptoms are present and weather is warm, wet/humid.

This presentation will cover research-based information supporting the recommendations detailed above. In addition, we will take a look at return on investment probability for several examples. Finally, we will talk about the latest field data from fungicide testing during the 2020 season for corn and soybeans.

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DON MYCOTOXIC AND THE ONTARIO EXPERIENCE!

Albert Tenuta [1/]

Gibberella ear rot is the most common ear rot in Ontario and unfortunately has resulted in not only significant yield losses to farmers but reduction in corn grain and feed quality due to mycotoxin accumulation. Although the pathogen Gibberella zeae (Fusarium graminearum) produces several mycotoxins including Zearalenone (ZEN) and T-2 toxin, the most economically important in Ontario is Deoxynivalenol (vomitoxin or DON).

Gibberella ear rot and DON is a concern every year and in epidemic years such as 2006, 2011 and most recently 2018 has resulted in significant disruptions to the corn supply chain. In 2018, over $200 million (CDN) was lost by Ontario farmers due to elevated levels of DON (10 ppm+) which led to high discounts and load rejections.

The Ontario experience with DON in corn and mitigation initiatives undertaken since 2018 will be discussed during this session.

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WILL NOVEL SOYBEAN HERBICIDE TOLERANCE TRAITS SOLVE MY PIGWEED PROBLEM?

Rodrigo Werle[1], Nick Arneson[2], and Ryan DeWerff[3]

Recently developed herbicide trait platforms have provided soybean growers with additional tools for POST-emergent pigweed management including 2,4-D choline (Enlist E3™ soybean), dicamba (Xtend, Xtendflex), and glufosinate (Liberty Link, LLGT27, and Xtendflex). Pigweed (waterhemp and Palmer amaranth) management in soybeans can prove rather difficult as previously there were limited POST herbicide options available. Recent research from the UW-Madison Cropping Systems Weed Science program has shown that resistance to glyphosate (Group 9), imazethapyr (Group 2), and PPO-inhibitor (Group 14) is widespread in waterhemp populations across Wisconsin. With limited POST options and widespread herbicide-resistance, we anticipate a heavy reliance on 2,4-D choline, dicamba, and glufosinate in the coming growing seasons. Alone, these POST herbicides will not be enough to provide season long waterhemp control in soybeans and growers will need to adopt more effective integrated weed management strategies. It is imperative that herbicide stewardship is used when relying on these herbicides so that their effectiveness is preserved, and the onset of herbicide resistance is delayed. Moreover, previous research from our lab indicates that season long waterhemp control is more likely when effective PRE-emergence residual herbicides are adopted.

Several years of research trials were conducted in Wisconsin soybean fields supporting the value of effective soil residual herbicides in providing season long waterhemp control. Additionally, research evaluating drift and volatility of 2,4-D choline and dicamba were conducted. Summaries and insights from these research trials will be shared. To complement these research summaries, other non-chemical weed control strategies will be highlighted to continue to promote integrated waterhemp management strategies.

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GIANT RAGWEED IN WISCONSIN: MANAGEMENT AND HERBICIDE RESISTANCE STATUS

Felipe Faleco[1], Nick Arneson[2], David Stoltenberg[3]and Rodrigo Werle[4]

Giant ragweed *(Ambrosia trifida)* has become one the most difficult weeds to manage in row crops in the U.S. Corn Belt. Due to giant ragweed's early emergence, rapid growth and biomass accumulation, high photosynthetic rate, and ability to adapt to diverse environments, when no properly managed it can quickly outgrow and outcompete the crop and other weeds for resources such as water, nutrients and light. The extended emergence window of some giant ragweed biotypes makes it difficult to control this weed with POST-emergence herbicides alone. Moreover, ALS- and EPSPS-inhibitor resistant giant ragweed have been confirmed in 7 and 12 U.S. states, respectively, including Wisconsin. These characteristics and current state of herbicide resistance indicates a need for effective integrated management strategies to control giant ragweed season long.

A comprehensive investigation of herbicide resistance status in giant ragweed across Wisconsin cropping systems is lacking. Greenhouse experiments were conducted with the objective to evaluate putative resistance of giant ragweed populations from Wisconsin to cloransulam (ALS-inhibitor; Group 2), glyphosate (EPSPS-inhibitor; Group 9), and fomesafen (PPO-inhibitor; Group 14) herbicides applied POST emergence, hypothesizing that cloransulam and glyphosate resistance are present in the populations evaluated while fomesafen resistance is not. Seed samples from 9 giant ragweed populations were collected and submitted by Wisconsin stakeholders in the fall of 2018 (five of them collected from non-GMO soybean fields). One additional glyphosate-susceptible population was included for comparisons. Two experimental runs were conducted. Treatments were sprayed in a single-nozzle spray chamber, 15 gal acre^{-1} spray volume for all applications. Treatments included cloransulam (FirstRate®, 1x = 0.3 oz a^{-1} + 0.6 v/v % HSOC + 8.5 lb gal^{-1} AMS), glyphosate (Roundup PowerMax®, 1x = 22 fl oz a^{-1} + 8.5 lb gal^{-1} AMS), and fomesafen (Flexstar®, 1x = 1 pt a^{-1} + 0.5 v/v % HSOC + 8.5 lb gal^{-1} AMS) at 1x and 3x the label rate, plus a non-treated control for each population. Treatments were sprayed when plants reached 2-4 inches in height. At 21 days after application, visual evaluation (VE) was taken on a scale from 1 (dead plant) to 10 (healthy plant) and biomass collected. Populations with 50% ≥ of treated plants with VE ≥ 7 were classified putative-resistant to the herbicide treatment of interest. According to our results, 33% and 22% of giant ragweed populations were classified putative-resistant to 1x cloransulam and glyphosate, respectively. Additionally, glyphosate non-rapid response (NRR) phenotype was observed. A putative fomesafen-resistant giant ragweed population was detected (Rock County, WI) and will be further investigated.

Additional research was conducted in 2019 and 2020 at the Rock County Farm near Janesville, WI to compare PRE-emergence herbicides with single and multiple sites of action on residual control of giant ragweed in soybean. Preliminary results indicate the value of applying PRE-emergence herbicides that contain ALS- and PPO-inhibitor chemistries. Additionally, products containing multiple sites of action more consistently reached effective levels of giant ragweed control. Additional research conducted at the Rock County farm continues to showcase the value of "starting clean", where fields infested with giant ragweed should receive either an effective pre-plant tillage or chemical burndown to control the giant ragweed that has emerged before crop planting. Effectively controlling the emerged giant ragweed before or at the time of planting is needed to minimize early season competition between the crop and weeds.

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Upcoming research from the UW-Madison Cropping Systems Weed Science Lab will include evaluating the impact of fall-seeded cereal rye before soybean on giant ragweed emergence and its interaction with PRE-emergence residual herbicides.

COVER CROPS AS AN INTEGRATED MANAGEMENT STRATEGY AGAINST TROUBLESOME WEEDS IN KANSAS

Sarah Lancaster [1/]

Cover crops are a promising integrated management strategy for Palmer amaranth and other troublesome weed species. Multiple factors contribute to weed control associated with cover crops. This presentation will review data describing the impact of cover crops on weed suppression in field crop production systems with an emphasis on Palmer amaranth and other troublesome species that occur in Kansas. Studies conducted between 2017 and 2020 in corn, soybean, and grain sorghum at various locations in Kansas will be discussed, as well as supporting data from other locations. When considered collectively, the data suggest that the primary factors influencing weed control by cover crops in Kansas are timing of weed emergence and cover crop biomass production.

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IMPACT OF CEREAL RYE COVER CROP ON WEED DYNAMICS, HERBICIDE FATE AND CROP PRODUCTIVITY IN WISCONSIN

Kolby Grint[1], Daniel Smith[2], Ryan DeWerff[3], Nicholas Arneson[4], Maxwel Oliveira[5], and Rodrigo Werle[6]

Integrated weed management involves combining multiple weed management tactics into a program that allows a farmer to achieve sustainable weed control. Simplification of production systems with reliance on herbicides for post-emergence weed control has led to the development of herbicide resistant weed populations and potential for the loss of herbicides as effective weed management tools (Young, 2006). Systems which integrate CCs and herbicides for weed control reduce the selection pressure for the development of herbicide resistance and can improve cropping system resiliency by reducing soil erosion (Blanco Canqui et al., 2015), improving nutrient retention (Brandi Dohrn et al., 1997), and improving soil physical quality (Steele et al., 2012). Field research was conducted in the 2019-2020 growing seasons to study the use of integrated weed management with a fall established cereal rye (*Secale cereale*) CC and Pre-emergence herbicides (PRE) in Wisconsin corn-soybean systems. Data collected included early season weed biomass/density, visual weed control prior to post-emergence herbicide application, crop yield, and soil persistence of PRE herbicides. Treatment combinations of PRE herbicide (yes or no) and six soil management strategies including tillage, no-till, and four CC termination timings/strategies (early, at plant, forage harvest at plant, and late) were included to collect 4 site-years of data for each crop.

Use of a PRE herbicide in corn improved weed control prior to POST application in 3 out of 4 site-years when soil was managed with conventional tillage, no-till, and early CC termination. Use of a PRE herbicide improved corn yield at Arlington 2020 (p-value <0.0001) and late CC termination reduced the corn yield at Arlington over both years. At Lancaster, corn yield was highest when soil was managed with conventional tillage for both years. Use of PRE herbicides in soybean improved weed control in all soil management treatment during Arlington 2019 (p-value= 0.017) prior to POST application, and when soil was managed with conventional tillage, no-till, early CC termination, at plant CC termination, and forage harvest CC termination at Arlington and Lancaster 2020. Soybean yield was similar between all treatments in Arlington 2019 and 2020. In Lancaster 2020 soybean yield was reduced in the conventional tillage soil management treatment.

Soil was sampled approximately 30 days after PRE application in all studies to determine the concentration of herbicide persisting in soil. There were differences in the soil concentration of S-metolachlor in corn and sulfentrazone in soybean between site-years. Arlington 2020 had the highest S-metolachlor and sulfentrazone concentration. There were differences in soil concentration of S-metolachlor and sulfentrazone between soil management strategies where conventional tillage had a higher concentration of S-metolachlor and sulfentrazone compared to no-till and CC soil management practices. Delaying cereal rye CC termination until two weeks after planting for late may planting dates greatly improved visual weed control. There is potential for reduced corn yield when delaying cereal rye CC termination until two weeks after planting. Observations of soil management effects on weed control and yield indicate a cereal rye CC with delayed termination can be beneficial prior to late May soybean establishment to help control weeds and provide other CC associated benefits without sacrificing yield.

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STREAMLINING SNAPPLUS

Part I. Your input will help build SnapPlus 3

SnapPlus is nutrient management (NM) planning software designed for Wisconsin farming systems and landscapes. This software usually has annual updates to add features and accommodate changes to nutrient management guidelines. Every year following the first release in 2005, the SnapPlus development team from the Univ. of Wisconsin Department of Soil Science has teamed with Wis. Department of Agriculture, Trade and Consumer Protection (DATCP) Nutrient Management staff to do training and discuss new features in the software at this conference. This year will be different. We will be virtual, and we will be discussing options for a major redesign of SnapPlus. The SnapPlus code is due for an update, and while we are at it, we are updating the way information is displayed in the program to better suit the needs of the type of planner. We know that agronomists who write many plans do not have the same needs as farmers writing their own plans. In this session, we will review ideas on how SnapPlus can better assist professional NM planners. These include:

- Planning for field areas with seasonal manure prohibitions
- Selecting fields for manure application
- Post-harvest updates of crops, tillage, and applications
- Providing farmers with information help them understand the benefits of their management.

Part II. Simplifying NR243 plans in SnapPlus 3

Nutrient management planning for livestock operations that are large enough to be required to obtain a water quality discharge permit (aka CAFOs) is more complicated than for other farms. This is both because of additional NM requirements and restrictions and the large number of fields that are part of these operations. We will propose options for simplifying CAFO NM planning, with a focus on the following areas:

- Planning for SWQMA buffers and other no-manure areas,
- Record-keeping for manure applications, manure analysis, and yields,
- Providing farms with clear management direction through custom reports.

AN INTRODUCTION TO THE APLE-LOTS BARNYARD RUNOFF MODEL

John Panuska [1/]

Abstract

Comprehensive nutrient management planning has become an increasingly important aspect for agricultural land management throughout Wisconsin. Phosphorus (P) loss from agricultural lands can adversely impact the quality of receiving water bodies. For dairy and beef farms, P loss originates from cropland, grazed pastures, and open-air cattle lots, such as feedlots, barnyards, exercise lots, or over-wintering lots. From a whole-farm perspective, P loss from all sources should be evaluated to effectively identify the major P sources to target remediation practices. Research shows cattle lots can be significant sources of P loss for two reasons. First, the high concentration of cattle leads to high rates of manure deposition and P accumulation relative to pastures and cropland. Second, cattle holding areas can be partially or completely devoid of vegetation and have a compacted or impermeable (e.g., concrete) surface, which can lead to high rates of runoff and erosion. This combination of a concentrated P source and active transport pathways creates the potential for high rates of P loss. In areas with both non-point source P pollution issues and a high prevalence of cattle farms with outdoor lots, there is a need to assess the P loss impact of lots relative to other agricultural land uses to see if alternative lot management is needed. Computer models can be cost- and time-effective tools to help quantify P loss from farms and identify alternative management practices that reduce the impact of agriculture on water quality.

Historically, the Natural Resources Conservation Service (NRCS) and local county Land Conservation Departments (LCDs) in Wisconsin have used the BARNY model. BARNY was developed by the U.S. Dept. of Agriculture/Agricultural Research Service and dates from the late 1970s and early 1980s. In 1991, the Wisconsin NRCS developed a spreadsheet version of BARNY. Though a definite improvement over the original model, several of the model algorithms were lacking calibration and validation to reliability predict P losses for management decision support.

In 2014, Dr. Peter Vadas from the U.S. Dairy Forage Research Center conducted a comprehensive review and evaluation of barnyard runoff data and algorithms that included the Annual Phosphorus Load Estimator (APLE) model previously developed by Vadas. This framework formed the basis for a new model that predicts annual runoff, total solids loss, and total and dissolved P loss from cattle lots. Model inputs include annual precipitation, lot surface type (paved or earthen), soil test P for earthen lots, cattle number and type, frequency of cleaning and percent vegetative cover. Annual runoff is estimated using a precipitation data set and curve numbers, annual solids loss is based on annual runoff, annual particulate P loss is based on solids loss and manure and soil P content, and annual dissolved P loss for each runoff event. Testing showed that the model reliably estimated runoff, solids, and P loss from a wide variety of lots more accurately than other currently used models.

In 2015, the U.S. Dairy Forage Research Center provided funding to the UW Madison SNAP-Plus development team, who developed an interactive, air photo-based animal lot model. The new version of APLE-Lots already includes Wisconsin precipitation data, allows you to make maps of the barnyard area and identify areas with high groundwater or surface water contamination risks. The new APLE-Lots considers the P loss impacts from the number and types of animals coming on and off the lot, the frequency of lot scraping, the diversion of flow onto or away from the lot and presents or absence of a settling basin. APLE-Lots can be used in developing whole-farm estimates of P loss and allows more effective targeting of P loss mitigation practices.

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LONG-TERM IMPACT OF MANAGEMENT ON DYNAMIC SOIL HEALTH PROPERTIES

Francisco J. Arriaga[1], Laura Paletta[2], and Jason Nemecek[3]

Introduction

Soil health is important for productivity and ecosystem services of agricultural systems. However, research continues to try to identify which soil properties are the appropriate ones to measure. Soil properties that relate to soil health and function likely vary between regions. The objective of this work is to investigate which soil methods are relevant for soil health assessment in Wisconsin.

Materials and Methods

Two sites were identified with known long-term management systems. Each site included the following managements that had to be in place for at least 6 years each: natural system, an enhanced management agroecosystem, and a traditional management agroecosystem. The natural system was either a grassed or wooded undisturbed area, while the enhanced management agroecosystem included practices such as reduced tillage, cover crops and crop rotations. The traditional management targeted full-width tillage practices with low residue left on the soil surface and no use of cover crops. Detailed ecosystem information is included in Table 1. These sites were located in Arlington and Lancaster, Wisconsin. The soil at the Arlington site was a Plano with a slope of 2 to 3% that formed under prairie, while at Lancaster the Fayette soil was formed under woods with a 3 to 6% slope.

Table 1. Description of the management systems at the two locations in Wisconsin.

	Arlington	Lancaster
Site description	Corn-silage alfalfa rotational study	Crop sequence study
Establishment time in years	6	51
Type of management:		
Natural system	Orchard grass	Wooded, mixed deciduous
Enhanced agroecosystem	No-tillage with cereal rye cover crop; 3rd year corn silage after 3 years of alfalfa	C-S-C-O-H rotation with rotational reduced tillage; sampled in the corn grain phase
Conventional agroecosystem	Fall chisel with spring cultivator; 3rd year corn silage after 3 years of alfalfa	Continuous corn with annual fall chisel and spring cultivator

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We would like to express our gratitude to the USDA-Natural Resources Conservation Service in Wisconsin for funding this work.

Soils were sampled to a depth of 100 cm (39 inches) where possible with a truck mounted hydraulically driven sampler with a 7.5 cm (3 inches) diameter. Three sampling locations within each system were identified, with five cores taken within each location. Soil cores were partitioned in the laboratory by depth near the surface (0 to 5 cm and 5 to 10 cm; 0 to 2 inch and 2 to 4 inch) and horizon (Ap, Bt1, Bt2, etc.). Two sub-samples were collected and composited from each depth within a sampling location. One of the sub-samples was stored in zip-lock plastic bags and frozen, and the other set of sub-samples was dried pending analysis. Soil samples were analyzed for total carbon (C) and (N) nitrogen content by dry combustion, active C by the potassium oxidizable C procedure (POxC), autoclavable citrate extractable protein (ACE), water stable aggregates by Cornell sprinkle approach and the overnight wet sieve method, and for various enzymes expressed as ρ-nitrophenol released in mg/kg soil per hour (β-glucosidase, β-glucosaminidase, phosphodiesterase, and acid and alkaline phosphatase). Other measured properties are not included in this document or the accompanying presentation.

Results

Total C in the soil was assumed to be similar to organic C after testing for carbonates. In general, the C content was greater in the upper soil depths (0 to 5 cm and Ap horizon) for the natural system compared to the agroecosystems at the two locations (Table 2). Soil organic C were similar between the enhanced and conventional agroecosystem managements in all depths.

Table 2. Soil organic C content at the Arlington and Lancaster sites for different depths and three management systems. The same letter next to a value within a depth and location denotes no statistically significant difference between values.

	Arlington			Lancaster		
Depth	Conventional	Enhanced	Natural	Conventional	Enhanced	Natural
-- cm --	-------------------- Soil organic C, g/kg of soil --------------------					
0 – 5	20.3 bc	24.1 b	30.2 a	17.5 bc	20.6 bc	34.3 a
5 – 10	18.7 bc	18.7 bc	23.0 b	12.3 c	15.3 bc	22.9 b
Ap	17.4 b	18.9 b	23.7 a	13.0 b	14.4 b	19.6 a
Bt1	6.2 cd	7.3 cd	9.2 c	3.0 d	8.1 cd	3.4 d
Bt2	3.5 d	4.1 d	3.5 d	2.3 d	2.7 d	2.5 d

Active C was more sensitive in detecting differences between systems at the 5- to 10-cm depth at Arlington; however, there was no difference in active C between systems at 0 to 5 cm (Table 3). There were no differences in active C at the Lancaster site. Similarly, there were significant differences in ACE protein in Arlington but not Lancaster (Fig. 1). The near surface depth had greater ACE protein than the agroecosystems. Depth decreased ACE protein content.

Soil aggregates were more stable in the natural systems than agroecosystems with the two methods studied (Table 4). Both methods used, the Cornell based aggregate stability and the overnight aggregate stability, detected differences between systems and depths. However, the ranking between them varied between methods.

Table 3. Active soil organic C for three different management systems and depths at Arlington and Lancaster measured as potassium permanganate oxidizable organic C. The same letter next to a value within a depth and location denotes no statistically significant difference between values. Ns- no statistically significant differences.

	Arlington			Lancaster		
Depth	Conventional	Enhanced	Natural	Conventional	Enhanced	Natural
-- cm --	-------------------- soil active C, mg/kg of soil --------------------					
0 to 5	1032.8 ab	1169.7 a	1228.4 a	447.7 ns	475.1	508.2
5 to 10	1000.6 b	1007.5 b	923.4 c	329.3	213.6	481.9
Ap	743.0 a	807.2 a	826.8 a	300.7 ns	320.6	369.1
Bt1	246.8 cb	255.6 c	325.7 c	50.3	132.4	72.2
Bt2	130.8 e	165.3 de	164.0 de	48.5	68.3	32.6

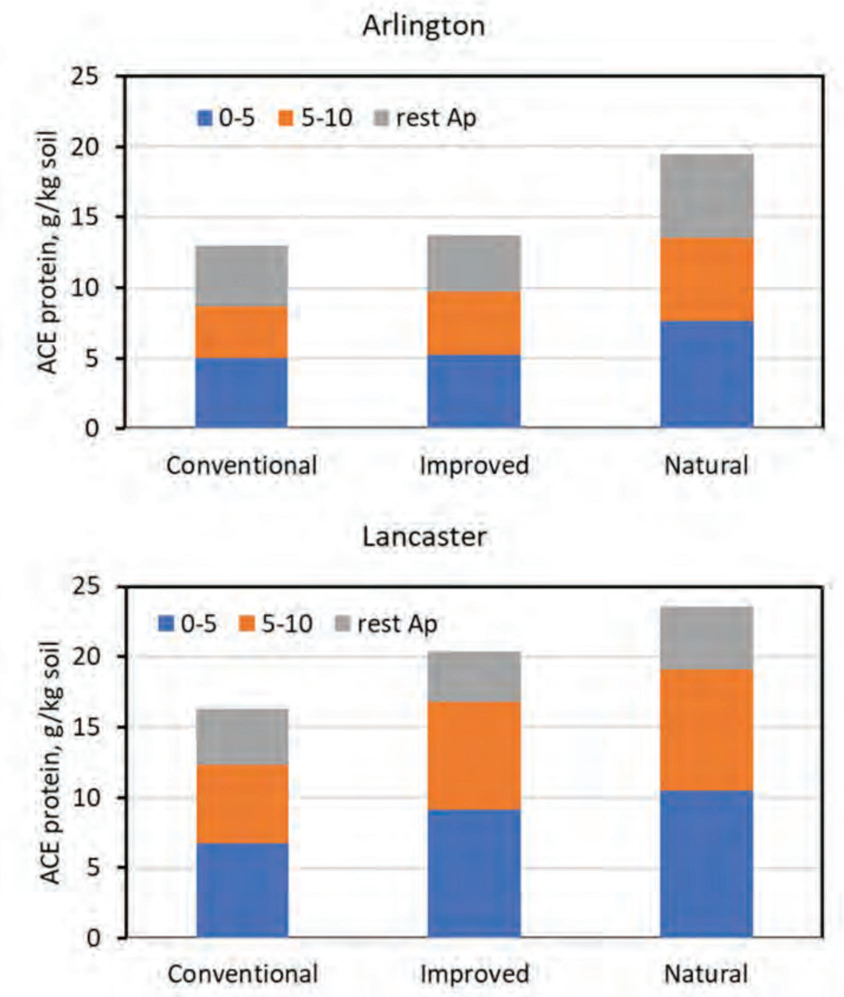

Figure 1. Autoclavable citrate extractable (ACE) protein in soil samples collected from three different management systems and depths at Arlington and Lancaster.

Table 4. Water stable aggregates by two methods for soil collected from three different management systems and two depths in Arlington and Lancaster. The same letter next to a value within a depth and location denotes no statistically significant difference between values.

	Arlington			**Lancaster**		
Depth	Conventional	Enhanced	Natural	Conventional	Enhanced	Natural
-- cm --	-------------------- stable aggregates, % --------------------					
	Cornell Aggregate Stability					
0 – 5	64.9 b	73.2 ab	81.5 a	46.6 b	45.0 b	64.7 a
5 – 10	72.3 ab	75.2 ab	77.2 a	39.0 b	53.5 ab	67.8 a
	Overnight Aggregate Stability					
0 – 5	33.5 c	48.9 b	84.5 a	50.7 b	66.2 b	94.2 a
5 – 10	34.6 c	47.7 b	72.6 a	30.5 c	57.6 b	88.5 a

Discussion and Conclusions

Some of the discussed soil properties were sensitive and detected differences between systems. Not all the properties studied are included in this document and in the presentation. Organic C by dry combustion is a helpful measure, but active C appears to be less useful. β-glucosidase and/or β-glucosaminidase might be better measures for labile C. Total N by dry combustion was more sensitive than ACE protein. Other properties need to be investigated to relate N cycling. Aggregate stability by either Cornell sprinkle or overnight wet sieve appear to be useful. We are also investigating wet fractionation approaches. Enzyme activities showed promising results as a soil health factor. Work continues on the methods discussed here and additional ones. A long-term objective is to relate the economic value of soil health on agricultural productivity.

Acknowledgements: we would like to express our appreciation to USDA-Natural Resources Conservation Services in Wisconsin, Bayer-Monsanto Corporation, UW-Madison College of Agricultural and Life Sciences Hatch Formula Grant Program, and the Arlington and Lancaster Research Stations for their support.

TILE FLOW – WHEN DOES IT HAPPEN, WHAT'S IN IT, AND AGRONOMIC FACTORS THAT IMPACT IT

Tim Radatz[1/] and Eric Cooley[2/]

Subsurface tile drainage from agricultural fields removes gravitational water from the soil profile which creates benefits for agricultural production including better plant establishment, growth, and yield and can reduce the risk of surface runoff and associated soil and nutrient losses. However, tile drainage also presents additional pathways for potential nutrient movement and it is important to understand the agricultural management practices that can limit this risk. Discovery Farms programs in Wisconsin and Minnesota have conducted edge-of-field tile water quality monitoring since 2004. This includes work on 49 farms and 187 site years of data. This comprehensive dataset has assessed differences in surface runoff and tile drainage and identified management practices to enhance agricultural production and reduce water quality risks.

Soil and phosphorus are generally lost from the soil surface, not tile flow. Soil and phosphorus losses are typically five times higher from the surface compared to tile. Most often, soil and phosphorus losses are controlled by adopting management strategies that reduce erosion. However, there are certain cases when soil and phosphorus losses are higher from tile sites than from surface sites. These scenarios suggest that updating and maintaining tile systems and managing soil test phosphorus levels can help prevent such high losses.

Nitrogen is primarily transported with tile flow. Nitrogen losses are typically five times higher from tile flow compared to the surface runoff. Nitrogen loss is controlled by adopting management strategies that reduce leaching into tile systems. On average, for every inch of tile flow, 5 lb/ac of nitrogen is lost. Nitrogen losses can be reduced by decreasing the concentration of nitrogen in soil water. Nitrogen management programs that carefully assess the products, rates, timings, and methods of nitrogen management can decrease nitrogen losses to tile water.

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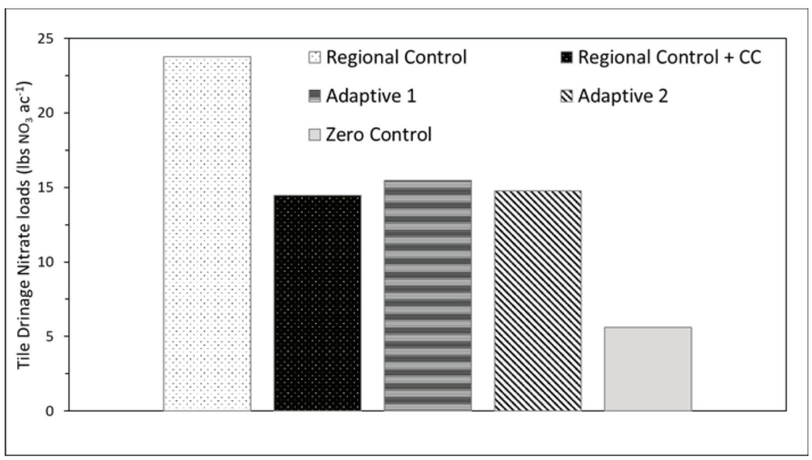
SOIL NITRATE FATE AND WATER QUALITY IN TILE-DRAINED SUSTAINABLE CROPPING SYSTEMS

Shalamar Armstrong [1/]

Introduction: The goals of a **Sustainably Intensified Agriculture (SIA)** system are to maximize agronomic production, while minimizing environmental degradation. Thus, fulfilling and aligning with all four pillars of sustainability, human, social, economic, and environmental. The demand for increased agriculture production due a growing human population is a reality within the state and globally. On the same scale, there is a need to develop row crop sustainable agricultural systems that can meet the production demand, while not violating the social, economic, and environmental pillars of sustainability is also pressing and critical. Tile-drained row crop agriculture has been identified as a major contributor of nitrogen (N) from the Upper Mississippi River Basin (UMRB) to the hypoxic zone of the Gulf of Mexico. Cover cropping has been identified as the most effective in-field conservation strategy that can be adopted on a large scale to achieve the non-point nutrient loss reduction goals.

Objectives: The goal of this presentation is to share published and preliminary results from studies.



Only 7 drainage events were recorded in the 2020 cover and cash crop growing seasons and two of the events accounted for an averaged 64% of N lost through the tile-drainage. However, adopting CR continue to result in significant nutrient loss reductions, despite N fertilizer management. The data suggested reductions of 35-39% in nitrate loss via tile drainage relative the not cover crop control. One significant finding is that 30% more fertilizer N was applied to the Adaptive 2 treatment relative to the non-CR Regional Control, yet the Adaptive 2 treatment resulted in 38% less N lost via tile drainage, which was similar to the other CR treatments. This finding suggests that growing CR in the fallow period generates a larger capacity for fertilizer to be applied without the result of greater nitrate loss via tile drainage. This greater capacity could be contributed to the slow release of residue N from both above and below ground CR biomass, greater microbial adsorption of fertilizer N due to the carbon generated from CR biomass, and in terms of the soil physical environment CR could have significantly increased the

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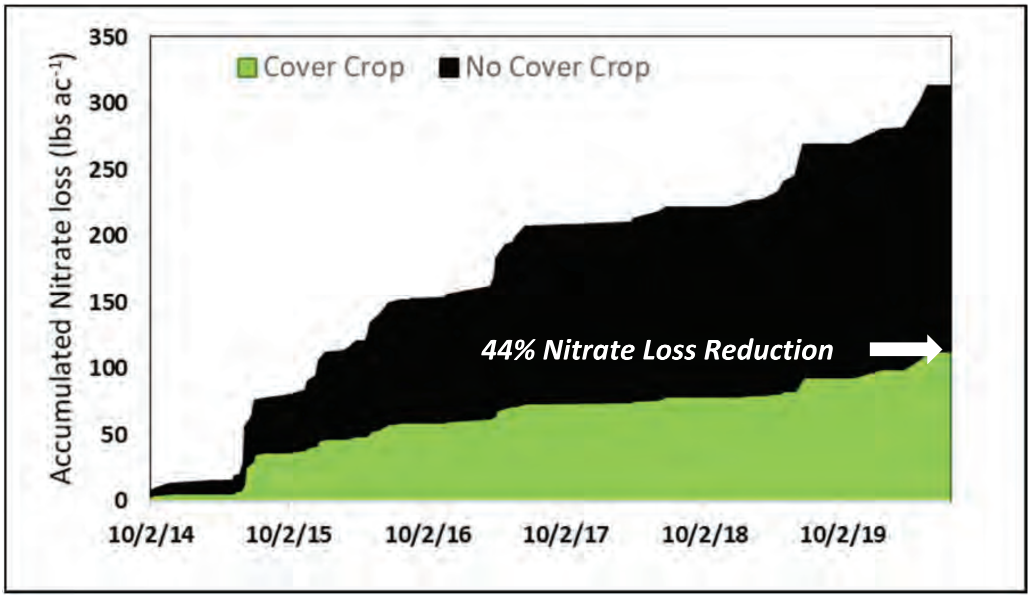
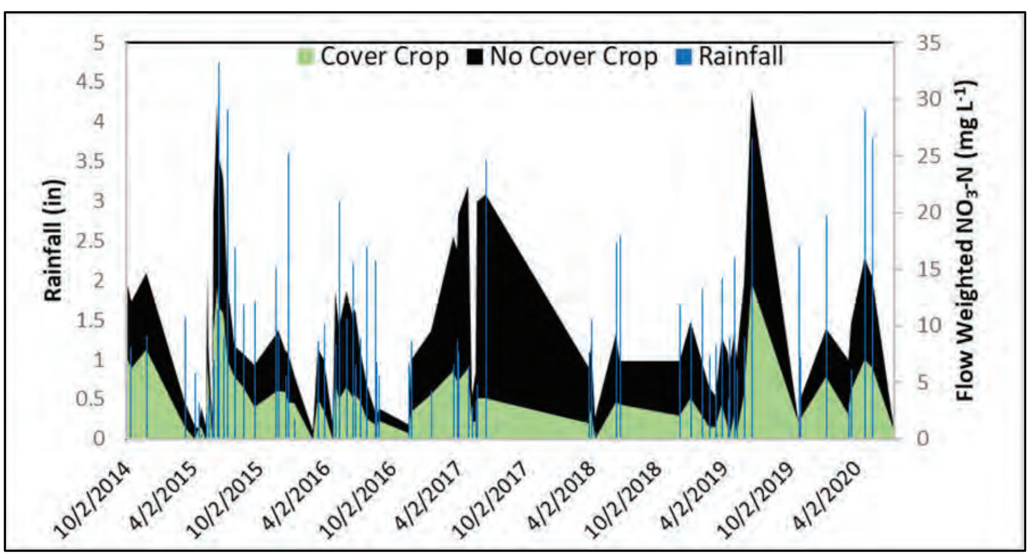
water holding capacity of the soil resulting in a lessor potential to leach. However, it is important to note that applying 60 additional lbs of N fertilizer in a wetter year could have possibly resulted in greater N loss in CR plots.



Since October 2014 to October 2019, the adoption of a CR dominated cover crop mixture has resulted into a 44% (88 lbs ac^{-1}) nitrate loss reduction relative to the non-Cover Crop Control. The figure below illustrates the impact of cover crop adoption on nitrate concentration in the tile water without the effect of tile-water flow volume. Despite the clear positive relationship between precipitation and tile water nitrate-nitrogen concentration, cover crops (green area) consistently resulted in reduced concentrations within cover crop and cash crop growing seasons.

Cereal rye dominated cover crop mixes have demonstrated the ability to significantly reduce nitrate loss by an average of 48%. Thus, it is imperative that we develop Next Generation Management Strategies to generate SIA cropping systems that maximize profit and minimize environmental degradation.



WINTER WHEAT: 100 BUSHELS OR BUST!

Kurt Steinke [1/]

Continued improvements in wheat (*Triticum aestivum* L.) grain yield have generated interest towards more focused input applications within enhanced managed systems. However, maintaining or improving profitability has become increasingly important as broad implementation of enhanced management has not produced consistent yield gains. Several field studies conducted over the last several years evaluated multiple inputs including autumn starter fertilizer, plant growth regulator, greater rates of N, sulfur, fungicide, and seeding rates. Autumn applied starter fertilizer was the only individual input to consistently produce a grain yield response and accounted for 71% of the grain yield difference between enhanced (i.e., multiple input) and traditional (i.e., base N only) management systems. In each scenario where autumn starter positively affected grain yield, pre-plant soil nitrate concentrations have been < 10 ppm and wheat planted prior to October 1. Autumn starter fertilizer increased straw yield 30-50% on average compared to no starter fertilizer with responses varying by cultivar mean height. Plant growth regulator used solely in combination with greater rates of N has not significantly increased grain yield. Despite some grain yield increases to specific inputs, producers need to consider site-, soil-, and plant-specific characteristics in combination with realistic yield potentials and economics prior to implementing enhanced wheat management.

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IMPACT OF BIOCHAR ON AGRICUTURAL NITROGEN MANAGEMENT [1/]

Rebecca A. Larson and Joseph Sanford [2/]

Biochar is a carbon rich product resulting from the pyrolysis of organic materials. Biochar produced through this process is generally used as a soil amendment or incorporated into other agricultural nitrogen management systems and is thought to reduce nitrogen leaching and improve available nitrogen for crop production. However, biochar characteristics vary significantly based on the feedstock and production characteristics. The varying production characteristics and feedstocks can significantly alter the surface chemistry which leads to varying impacts when integrated into the soil or other agricultural nitrogen management systems. When biochar was applied to soil systems in agricultural filter strips, it was able to significantly reduce cumulative nitrate leaching by 40% in a field trial (Sanford and Larson, 2020a). Most of this nitrate leaching reduction was attributed to the retention of nitrogen within the soil matrix. When biochar soil amendments were further investigated in laboratory soil column studies, nitrate reductions were attributed primarily to retention of organic nitrogen and nitrate within the soil (Sanford and Larson, 2020b). In addition, the integration of biochar within these soils resulted in reductions of nitrous oxide emissions, a potent greenhouse gas. Biochar has potential to reduce losses of nitrogen to the environment and retain this nitrogen within the soil matrix for crop needs.

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2. Sanford, J., and R.A. Larson. 2020b. Assessing nitrogen cycling in corncob biochar amended soil columns for application in agricultural treatment systems. *Agronomy*, 10:979. https://doi.org/10.3390/agronomy10070979

[1/] This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture under project numbers 2015-67019-23573 and 2017-67003-26055. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

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SOYBEAN NUTRIENT FRUSTRATIONS: DOING MORE WITH LESS OR LESS WITH MORE?

Kurt Steinke [1/]

Increases in soybean (*Glycine max* L. Merr.) biomass production have some practitioners questioning whether reduced interplant competition from below recommended seeding rates may provide opportunities for greater response to early and mid-season nutrient applications. Additionally when soil test nutrient concentrations are above critical, soybean producers often question whether alternative in-season nutrient management strategies may improve yield and profitability. Below recommended seeding rates can reduce input costs without decreasing soybean grain yield while simultaneously increasing biomass production, nutrient uptake, and yield per plant. However, non-irrigated nutrient management strategies may not directly transfer to irrigated production and vice versa. Multiple field studies conducted over the last several years evaluated soybean grain yield, dry matter accumulation, nutrient uptake and partitioning, and net economic return as affected by seeding rate and in-season nutrient applications under both irrigated and non-irrigated environments. Seeding rates included 60,000, 120,000, and 180,000 seeds A^{-1}. Fertilizer strategies consisted of: no fertilizer, 150 lb. MESZ (12-40-0-10S-1Zn) A^{-1} applied two inches to the side and two inches below the seed (2x2) at planting, 15 gal. liquid K_2O (0-0-28) A^{-1} applied using a Y-drop applicator at growth stage V6, 16 gal. 10-34-0 A^{-1} applied using a Y-drop applicator at growth stage R1, and a combination of the MESZ, liquid K_2O, and 10-34-0 fertilizer applications. Results from the 2020 growing season indicate fertilizer applications should not accommodate for alterations in seeding rate, and that nutrient application beyond what is recommended in accordance with soil test concentrations may not increase grain yield or profitability regardless of environment (i.e. irrigated or non-irrigated). Although fertilizer application (especially starter fertilizer in a 2x2) may increase early season biomass production and likely nutrient uptake, accelerated crop growth rate and the ability of soybean to compensate for inter-plant competition could diminish early season differences. Among the tested seeding rates, ≥120,000 seeds A^{-1} increased grain yield at the non-irrigated site. However under irrigated conditions, seeding rate did not impact grain yield. Economic return was not impacted at the irrigated or non-irrigated site due to high seed cost offsetting greater grain yield.

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SOYBEAN FOLIAR FEEDING TRIAL 2019 SUMMARY

Emma G. Matcham, Shawn P. Conley, Laura E. Lindsey,
and Rachel A. Vann

Participants

University of Arkansas System, Division of Agriculture	Jeremy Ross
University of Florida	David L. Wright
University of Kentucky	Carrie Knott
University of Kentucky	Chad D. Lee
Michigan State University	Maninder Singh
University of Minnesota	Seth Naeve
Mississippi State University	Trent Irby
University of Missouri	William Wiebold
North Carolina State University	Rachel Vann
North Dakota State University	Hans Kandel
The Ohio State University	Laura E. Lindsey
South Dakota State University	Johnathan Kleinjan
Virginia Polytechnic Institute and State University	David Lee Holshouser
University of Wisconsin—Madison	Shawn P. Conley

Partial funding provided by the soybean checkoff (QSSB) in some participating states.

Introduction

Farmers across a wide range of US soybean growing environments are interested in using foliar nutrient products to increase yield and profitability. But, applying foliar fertilizers increases on-farm expenses and could decrease profitability where these fertilizers are not associated with a yield increase. In 2019, we established field trials to better understand which growing environments may see a yield increase when foliar nutrient products are applied. Trials were placed in 20 locations across 13 states in fields with different environmental conditions and yield potentials. Yield averages for each location can be found across the 20 environments in Figure 1.

Methods

Six foliar nutrient products, selected with the input of industry professionals, and one untreated control were applied to small plots in a randomized complete block design at all sites (Table 1). Products were applied at soybean growth stage R3 to align with commonly used fungicide and insecticide application timing. Nutrients applied in each product are listed in Table 2.

For the 2019 yield data, all sites were analyzed separately using Analysis of variance (ANOVA) in R 3.6.2. Means separation was performed using least significant differences as calculated using the package *agricolate* (α=0.05 for all analyses). A summary of yield by treatment for each site is in Table 3. For sites with statistically significant differences in yield between treatments, the highest average yield at each site is in bold and the yield for treatment(s) that are statistically similar to the highest-yielding treatment are denoted with asterisks (*).

Results

Of the 20 sites in 2019, significant differences in yield between treatments were only observed at the Fond du Lac, WI site. At Fond du Lac, WI, Maximum NPact K yielded 61.4 bu/ac, which was significantly higher than the untreated control. Average yield for HarvestMoreUreaMate and Smart B-Mo was not statistically different from Maximum NPact K. At all other sites (19 sites out of 20 sites total in 2019), yields for all treatments were not statistically different. Trials are being conducted again in 2020. Upon completion of harvest in 2020, we will analyze and post additional data from both years of the trial including yield, tissue nutrient concentration, soil samples, and protein and oil concentration.

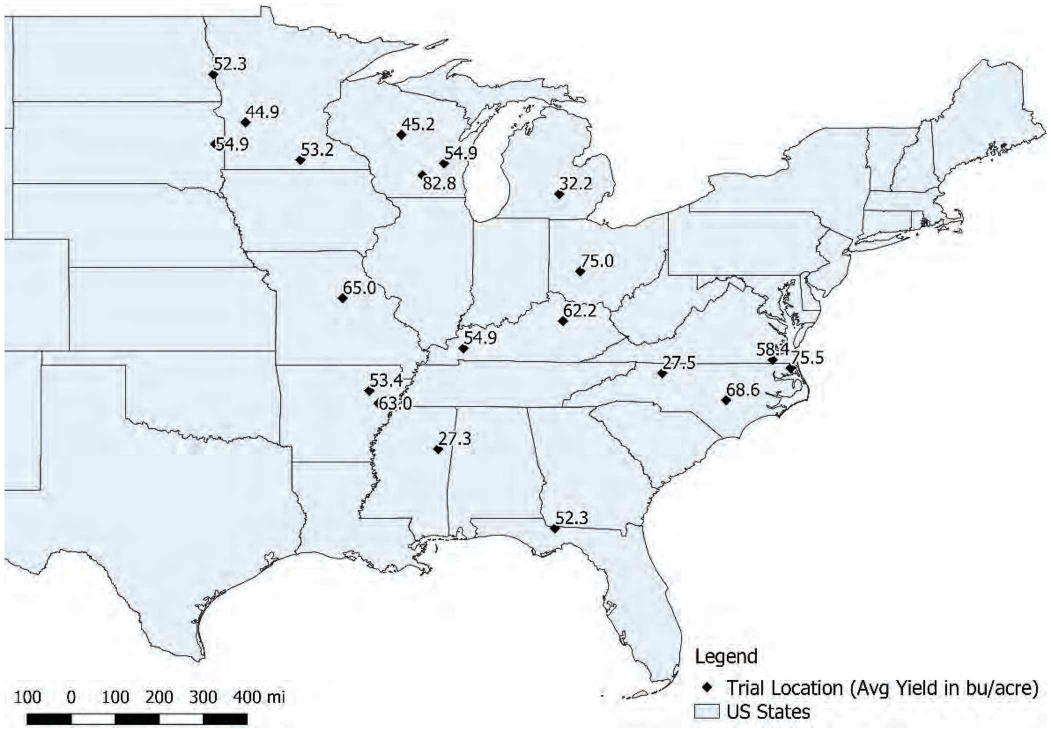

Figure 1. Map of 2019 sites with their average yield (bu/acre).

Table 1. List of foliar products names, brands, and application rate.

Treatment Name	Company	Application Rate
FertiRain	AgroLiquid	3 gal/A
SureK	AgroLiquid	3 gal/A
HarvestMoreUreamate	Stoller	2.5 lb/A
Smart B-Mo	Brandt	1 pt/A
Smart Quarto Plus	Brandt	1 qt/A
Maximum NPact K	Nutrien	1.5 gal/A
Untreated Control	-	-

Table 2. Nutrients applied for each treatment in lb/A.

Treatment Name	N	P	K	S	Mn	Fe	Mo	Zn	B	Other
FertiRain	3.5	0.9	0.9	0.5	0.02	0.03	-	0.03	-	-
SureK	0.6	0.3	1.7	-	-	-	-	-	-	-
HarvestMoreUreamate	0.1	0.25	0.56	-	0.01	-	0.002	0.01	-	Ca, Mg, B, Co, Cu
Smart B-Mo	-	-	-	-	-	-	0.006	-	0.07	-
Smart Quarto Plus	0.13	-	-	0.05	0.05	-	0.001	0.05	0.01	-
Maximum NPact K	1.9	-	1.9	-	-	-	-	-	-	-
Untreated Control	-	-	-	-	-	-	-	-	-	-

Table 3. Treatment means (standard deviation) for each site in 2019. HarvestMoreUreaMate was not applied at the Lexington, Kentucky site. For sites with statistically significant differences in yield between treatments, the highest yield at each site is in bold and the yield for treatment(s) that are statistically similar to the highest-yielding treatment are denoted with asterisks (*).

Site	Control	FertiRain	SureK	HarvestMoreUreaMate	Smart B-Mo	Smart Quarto Plus	Maximum NPact K
Newport, Arkansas	53.7 (4.7)	54.4 (4.5)	56.7 (6.3)	53.2 (7.1)	53.4 (7.9)	53.6 (8.4)	54.2 (8.2)
Pinetree, Arkansas	62.7 (7.0)	63.5 (6.8)	64.7 (5.5)	60.3 (6.3)	62.7 (2.3)	62.6 (6.4)	65.2 (4.1)
Florida	53.7 (5.4)	54.4 (11.3)	50.5 (14.6)	50.1 (10.2)	56.8 (5.2)	50.4 (8.1)	50.5 (8.6)
Lexington, Kentucky	67.6 (4.8)	60.1 (8.9)	65.6 (6.8)	---	58.3 (9.6)	61.9 (16.2)	60.5 (7.6)
Princeton, Kentucky	56.5 (4.1)	57.7 (14.0)	55.4 (6.7)	53.7 (12.2)	53.4 (7.5)	56.0 (8.5)	52.1 (7.8)
Michigan	34.1 (4.4)	31.4 (4.6)	35.9 (12.8)	33.0 (9.9)	32.2 (7.3)	35.0 (4.8)	33.6 (5.4)
Danvers, Minnesota	44.5 (5.6)	44.8 (4.6)	44.3 (10.3)	50.0 (6.7)	43.9 (6.7)	43.5 (12.6)	43.0 (9.1)
Minnesota Lake, Minnesota	53.4 (1.2)	52.5 (0.4)	54.2 (3.7)	52.7 (3.0)	51.0 (4.4)	55.1 (2.7)	53.3 (3.1)
Mississippi	27.2 (3.1)	26.4 (3.5)	27.2 (3.0)	27.5 (3.1)	27.2 (2.4)	29.5 (1.3)	26.8 (2.6)
Missouri	64.4 (2.4)	64.2 (3.9)	66.2 (2.4)	64.7 (1.8)	63.8 (3.4)	65.5 (1.8)	67.3 (2.9)
Currituck, North Carolina	77.0 (2.1)	76.4 (2.1)	72.5 (3.3)	73.6 (3.0)	75.9 (2.4)	77.0 (3.9)	76.7 (4.5)
Sampson, North Carolina	73.4 (3.9)	66.6 (3.3)	67.8 (4.9)	70.2 (3.5)	70.2 (4.9)	70.0 (5.4)	65.9 (7.8)
Yadkin, North Carolina	29.0 (7.1)	26.9 (2.8)	26.8 (5.0)	26.6 (4.5)	28.9 (7.5)	27.2 (1.9)	27.2 (4.2)
North Dakota	51.4 (9.0)	52.0 (5.9)	55.4 (4.5)	53.1 (5.3)	50.7 (7.5)	52.5 (7.7)	52.3 (4.8)
Ohio	75.2 (3.5)	73.9 (3.2)	74.9 (3.0)	76.1 (3.4)	75.1 (4.4)	75.2 (4.6)	75.7 (3.3)
South Dakota	55.5 (2.9)	54.4 (6.7)	56.4 (3.3)	53.5 (5.1)	53.5 (3.8)	55.6 (2.8)	56.1 (5.2)
Virginia	54.9 (9.2)	60.0 (7.0)	56.8 (10.2)	56.9 (7.0)	56.8 (7.1)	61.8 (3.8)	62.6 (4.8)
Arlington, Wisconsin	82.0 (4.7)	82.5 (6.6)	81.6 (6.9)	79.5 (7.3)	83.1 (4.1)	82.2 (5.9)	83.3 (4.7)
Fond du Lac, Wisconsin	54.9 (4.7)	53.2 (6.7)	50.5 (6.9)	56.5* (7.3)	58.4* (5.4)	53.8 (5.1)	**61.4** (6.8)
Marshfield, Wisconsin	47.5 (7.1)	42.0 (6.3)	43.8 (6.8)	50.5 (8.9)	46.9 (8.2)	41.0 (7.4)	45.6 (10.2)
Average (all sites)	55.9	54.9	55.4	54.8	55.1	55.5	55.7

UPDATE ON THE NITRATE TARGETED PERFORMANCE STANDARD

Chris Clayton [1/]

Abstract

Nitrate is the most widespread groundwater contaminant in Wisconsin, and it is especially prevalent in areas with highly permeable soils. The majority of the state relies on groundwater as their source of drinking water, and numerical groundwater standards for nitrate are in place to protect public health. While Wisconsin adopted statewide performance standards and prohibitions for agricultural and nonagricultural facilities in 2002 to achieve surface water and groundwater quality standards, evidence suggests that the statewide standards and prohibitions are insufficient to achieve groundwater standards for nitrate. The Department of Natural Resources is developing targeted performance standards and prohibitions to achieve the groundwater standard for nitrate in areas of the state that are susceptible to groundwater contamination. The DNR convened a Technical Advisory Committee during 2020 to provide input on rule development, and in 2021, the department will seek public comment on a draft rule.

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ARC and PLC Recommendations for 2021 for Wisconsin Farmers

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Summary of recommendations for Wisconsin farmers for the 2021 crop year:

1. **Corn**: Signup for **PLC**
2. **Soybeans**: Signup for **County ARC** (ARC-CO)*****
3. **Wheat**: Signup for **PLC**
4. **Oats**: Signup for **County ARC** (ARC-CO)
5. **Sorghum, Barley, Sunflower Seeds**: Signup for **PLC**

*Note, if you want to buy SCO (Supplemental Coverage Option) with your crop insurance, you will need to choose PLC for all of your soybean acres.

Additional Resources (https://aae.wisc.edu/pdmitchell/extension/arc-plc-signup/)

- Video: Signup Recommendations for 2021 (https://youtu.be/z8OBrPXzdlk)
- FarmDOC ARC/PLC Payment Simulator (https://fd-tools.ncsa.illinois.edu/)
- Video: How ARC and PLC work (https://youtu.be/piyOLFnPMnI)
- Video: How ARC-IC (Individual Coverage) works (https://youtu.be/fQeDQSC-d0s)
- Video: Who Should Consider ARC-IC in 2021 (https://youtu.be/Kfz0A2beQGk)

2021 CORN AND SOYBEAN SITUATION AND OUTLOOK

Brenda Boetel [1/]

This past year has been a rollercoaster ride. The corn market has seen a roughly 30% increase in price since last January. Depending on your cash market the low price of the year was either the end of May or the end of August. Since the low of the year, and depending on your cash market, prices have increased between 61% and 66%. Soybean price has seen a similar pattern. Since January 2020, soybean price has increased 44%. The low soybean price occurred the end of May and since that time price has increased 66%.

Corn

Corn prices continue to rise based on demand. Chinese corn purchases for the 2021 marketing year are estimated at between 630 and 670 million bushels compared to 300 million bushels last year. As of December 31, 2020, total commitments to China were 460 million bushels, compared to 2.4 million bushels at the end of 2019. Chinese purchases are increasing due to the expansion of their poultry and hog industries. Through December 31, 2020 corn export sales to all countries were significantly ahead of the previous year's pace. As of the end of December, accumulated exports for the 2021 marketing year were at 600 million bushels, which is 22% above the previous year's accumulated exports of 359 million bushels. Total commitments were at 1730 million bushels, which is 65% higher than December 2019 total commitments of 729 million bushels. Although corn exports are extremely strong, they have begun to taper and have not met the pace needed to meet the current USDA export expectation of 2.65 billion bushel. The USDA will likely keep export expectations the same in the January supply and demand schedule.

Ethanol production is down 8% relative to the same time period last year; yet USDA has a 4% increase in their projection for corn used for ethanol production. Either ethanol production will have to increase in the next months, or USDA will begin to lower the expectations. Oil prices will likely increase in 2021 compared to 2020, which will give incentive for ethanol production provided lockdowns continue to ease.

January is typically the last month the USDA makes changes to the supply estimates. No changes were made in December, but there is potential for a small increase in production in the January report. Depending on changes to production, ending stocks will likely tighten more. Global corn stocks are the lowest since 2013-2014.

Corn acreage in 2021 will be stable to slightly higher than 2020. Since the middle of December, the soybean to corn price ratio has increased from 2.46 to 2.62. Numbers over 2.5 favor soybean production. Some acreage will be added to corn though as acres are pulled from CRP, as well as small grain acres. I would not expect much more than 1 million acres added to corn production in 2021.

Most market news has already been priced into the market. Dependent on the January reports, corn has the potential to continue to increase through January and into the beginning of February.

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Nonetheless prices are currently high, downside risks are increasing, and basis provides little incentive to store. The market is expecting the January report to decrease carryover to 1.5 billion bushels, if this does not happen prices will fall. Downside risk for 2021 marketing year prices is around $0.60. Hopefully the majority of old crop is sold. New crop has had several opportunities for forward contracts and 15-20% of new crop should be contracted.

Most market news has already been priced into the market. Dependent on the January reports, corn has the potential to continue to increase through January and into the beginning of February. Nonetheless prices are currently high, downside risks are increasing, and basis provides little incentive to store. The market is expecting the January report to decrease carryover to 1.5 billion bushels, if this doesn't happen prices will fall. Downside risk for 2021 marketing year prices is around $0.60. Hopefully the majority of old crop is sold. New crop has had several opportunities for forward contracts and 15-20% of new crop should be contracted.

Soybean

Soybean price has surged due to increased exports and strong crush. As of the end of December 2020, the US has accumulated exports for the 2021 marketing year of 1.4 billion bushels, where 1 billion bushels have gone to China. Compared to the same time period for the 2020 marketing year, the US had accumulated exports totaling 807 million bushels, of which only 346 million had gone to China. Another way to see the fast pace of exports this year is to consider that the US has already achieved 65% of the USDA projected soybean exports for the 2021 marketing year, compared to having achieved 49% of the USDA projected soybean exports during the same time in the 2020 marketing year.

Although November 2020 crush was down 6 million bushels (3.2%) compared to October 2020, it is up 16 million bushels (9.4%) compared to November 2019. The first quarter of 2021 marketing year has seen a 7.1% increase in crush, compared to last year. Although USDA increased their projected crush estimates to 2.195 billion bushels, there is still potential for further increases to 2.213 billion bushels.

The January reports will likely see an increase in soybean production of between 15-25 million bushels. Even with this increase, carryover will likely be around 200 million bushels, giving a stock-to-use ratio of approximately 4.2%. Compare this to a stocks-to-use ratio last year of 13.2%. The lower the stocks-to-use ratio the higher the price. These tight stocks have allowed the price increases this fall. Planted acreage for soybeans in 2021 will be higher and could increase between 3 to 4.5 million acres.

Old crop is likely sold. If not, prices are good, but there is some opportunity for further increases due the extremely tight supply, New crop has also seen some great opportunities. Hopefully, you have between 10% and 20% of your new crop forward contracted.