NUTRIENT FORM AND FATE THROUGH MANURE PROCESSING

Rebecca A. Larson[1] and Horacio Aguirre-Villegas[2]

Manure processing is generally incorporated into livestock systems to change the characteristics of manure in order to gain a higher value end product, reduce operational burdens, or reduce risks associated with the land application of manure. Some common manure processing systems include composting, sand separation (SS), solid liquid separation (SLS), and anaerobic digestion (AD). For many processing systems, the processed manure or at least a fraction of the processed manure is still land applied, therefore understanding the impacts to the manure characteristics is critical for increasing nutrient use efficiency following land application. Processing technologies aside from composting are rarely found at facilities with less than 1,000 animal units, or the number of animals requiring a Wisconsin Pollutant Discharge Elimination System (WPDES) permit. For those permitted facilities SS is the most common processing technology reported from those that were surveyed with AD and SLS also being incorporated by many farms.

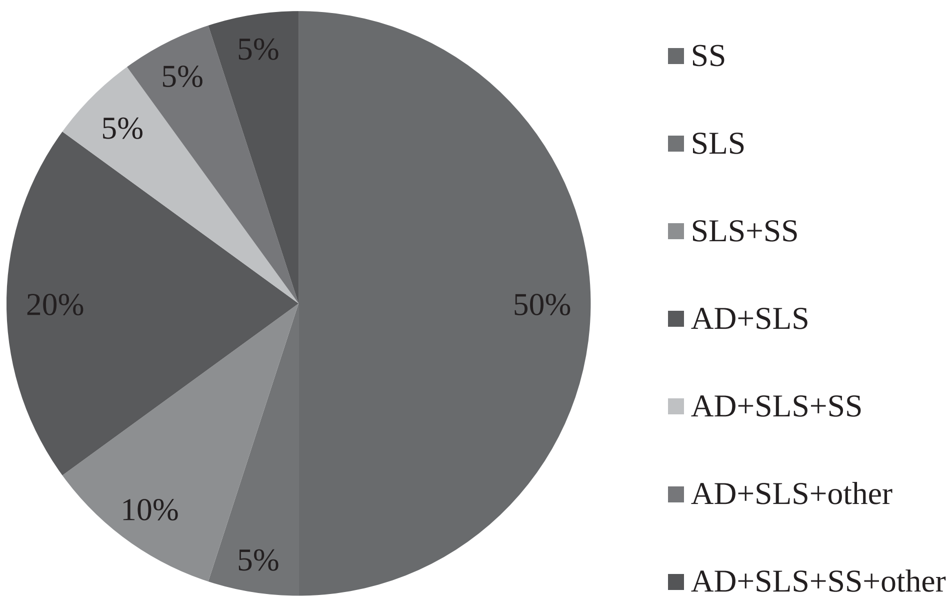

Figure 1. Processing technologies at permitted Wisconsin facilities surveyed (Aguirre-Villegas and Larson, 2017)

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A study was conducted on nine dairy facilities in Wisconsin to understand the form and fate of nutrient and pathogens through manure processing systems. This included manure sampling throughout the manure system for a year from farms with an AD and SLS systems. The nutrient forms and fate (as well as numerous pathogens/microbes (Burch et al., 2018)) were tracked through the system. The data shows that manure processing system selection and operation are important for estimating the impact to nutrients. Overall, centrifuge separation systems had greater separation efficiencies than those of screw press separation systems for all solids and nutrients, but these systems come at a much greater cost. Digesters can result in mineralization of a significant amount of nitrogen which must be managed to reduce losses in the form of ammonia after digestion. Understanding the forms or nutrients throughout the processing systems can aid in the land application of manure to improve yields and reduce losses.

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HOW TO BUILD SOIL ORGANIC MATTER

Matt Ruark [1/]

One of the simplest and most comprehensive measurements of soil health is soil organic matter (SOM). Soil organic matter is connected to the ability of the soil to provide nutrients, retain water, and improve yields. As farmers seek to increase the SOM in their fields, it is important to reflect on the management practices that will lead to increases in SOM, the long-term nature of the gain in SOM, and inherent soil factors that dictate the ability of farmers to increase (or decrease) their SOM rapidly. Soil OM is measured as loss on ignition, which requires burning the soil and measuring what remains. Soil OM is typically about 50% carbon. Most scientific studies measure and report SOM in terms of soil organic carbon (SOC). The SOC can be multiplied by two to estimate SOM percentage.

Soil Management – Adding Carbon

There are two ways to build SOM in soil: (1) increase the amount of carbon inputs into the soil and (2) reduce the amount of carbon loss from the soil. Increasing the amount of carbon inputs can come from crop residues, manure, or cover crops. Changing crop rotations to increase biomass return lead to SOM gains. For example, changing from a corn-soybean rotation to continuous corn rotation in Iowa increased SOC by 22% over 14 years (Poffenberger et al., 2017). However, there are certain economic and agronomic advantages to rotation corn with soybeans (i.e., increased corn yields and reduction in N fertilizer). Frequent manure additions to the soil can lead to increases in SOM over time. For example, 17 years of liquid dairy manure applications to a silt loam soil in British Columbia, Canada led to greater SOM in the upper 8 inches (Maillard et al., 2015). Long-term use of cover crops, however, typically show only modest increases in SOM (Poeplau and Don, 2015). However, for both manure and cover cropping, there is much variation in the results of different research studies. The ultimate effect of how an increase in carbon input will lead to increases in SOM will be dependent on tillage and soil properties.

Soil Management – Protecting Carbon

Reduction in tillage is the management practice that will increase carbon storage in soil. Tilling soil breaks apart soil aggregates, exposing “protected” SOM to the

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environment, allowing it to be mineralized (i.e., consumed and converted to CO_2) by soil bacteria. The fundamental concept here is that SOM is protected when an aggregate is formed. Soil aggregates (soil pieces between 0.05 and 2 mm) are "organo-mineral complexes" – meaning they are a creation of clay and silt tightly bound with decayed plant material or dead bacterial cells. This new structure (the aggregate) is the foundation of carbon storage in soil. Over time and with less soil disturbance, the soil forms a greater amount of aggregates and thus sequesters more carbon. It is this process that allows SOM to be built when carbon inputs are increased into soil. There is still a debate whether no-till alone increase SOM in soil, or if it is just changes where the SOM is stored (at the surface or at the depth of tillage).

Soil Properties

There are two key soil properties that will dictate your ability to build SOM: texture and drainage class. Texture is connected to the ability to form aggregates. Soils with greater clay content have a great ability to bind with organic material, form aggregates, and build SOM in the soil as compared with soils with greater sand content. Drainage class influences SOM in two ways. First, it indicates the historic, pre-agricultural SOM levels in the soil. Soils that are more poorly drained (and wetter) may have greater SOM than well drained soils (think about how much SOM are in wetlands and peatlands). If a poorly drained soil was recently tile drained, then this will cause a slow decline in SOM over a long period of time; implementing management practices to increase SOM may only serve to slow the decline in SOM. Second, if a soil is less well drained, crop yields may be lower compared to well drained soils, resulting in less carbon return (via crop residues) to the soil. In addition, these soils may require tillage to optimize yield and use of cover crops may be limited. The ability to build SOM on different fields will be dependent on these properties and expectations for SOM building should be different for different fields.

Time and Expectations

One of the biggest issues concerning soil organic matter building is the time required to see measurable increases. Building SOM takes time. Land managers should consider this a long-term investment in the soil. In addition, increasing carbon inputs and reducing tillage come with additional agronomic considerations. There will be challenges to overcome. It is also important that expectations be realistic. If farmers are managing on poorly drained soils or sandy soils, there may be less ability to increase the SOM compared to a well-drained silt loam. Another important consideration is historic soil management. For example, if a field had been historically managed in a corn-alfalfa rotation that received manure and then recently converted to a grain-based rotation not receiving manure, we would expect that SOM may decline over time. In this case, we would be starting from a condition of relatively high SOM. Even if farmers are using as much conservation management as possible for a grain-based cropping system, we would not be able to maintain as much SOM as compared to a perennial rotation that has three key aspects of SOM building (reduction in tillage, large inputs of crop residue, and frequent manure application).

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EFFECTS OF SEED TREATMENTS ON THE BIOLOGY OF SOYBEAN CYST NEMATODE

Gregory L. Tylka[1/]

Nematode-protectant seed treatments are available for managing the soybean cyst nematode (SCN). Information about how these products affect specific aspects of the biology of SCN is limited. Research methods were developed at Iowa State University to determine how seed treatments affect the biology of the nematode (Beeman et al., 2016; Jensen et al., 2018a), and then those methods were used in experiments with Avicta, Clariva, Ilevo, and Votivo seed treatments (Beeman and Tylka, 2018; Beeman et al., 2018; Jensen et al., 2018b). Results of experiments revealed that soybean roots grown from seeds treated with Avicta, Clariva, Ilevo, and Votivo did not attract or repel SCN juveniles. Leachates of soil in which Avicta-treated seeds were planted reduced the speed, movement, and curvature of SCN juveniles, and penetration by nematode juveniles of roots grown from Avicta-treated seeds was reduced. Movement of SCN juveniles incubated in leachates of soil planted with Clariva-treated seeds also was reduced, and development of the juveniles in roots grown from Clariva-treated seeds was slowed. Leachates of soil in which Ilevo-treated seeds were placed reduced hatching, speed, and movement of SCN juveniles, and penetration of roots from Ilevo-treated seeds by juveniles was reduced.

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CORN DISEASE CHALLENGES OF 2018 – WHAT WE LEARNED AND DIDN'T LEARN

Damon Smith[1/] and Brian Mueller[2/]

The 2018 Wisconsin corn growing season was a challenging one when it comes to diseases. There were substantial disease epidemics across the entire corn belt of Wisconsin in 2018, with some fields hit by multiple diseases. Gray leaf spot started earlier than normal in the southwest portion of the corn growing region of Wisconsin. The emerging disease, tar spot, then moved in. Tar spot started in the south and southwest but moved north and east leaving many corn fields to dry down abnormally quick. Northern corn leaf blight also caused some issues in the central and northern corn production areas of the state. Then ear rots started to show up near harvest, with mycotoxin levels, like vomitoxin, being a significant issue in corn silage and some grain fields. To add insult to injury a new bacterial disease of corn was also reported for the first time in Wisconsin. Bacterial leaf streak, caused by a *Xanthomonas* sp., showed up in one field in Pierce Co., Wisconsin. Admittedly, the tar spot epidemic was probably the most impactful, followed by issues with ear rot and vomitoxin contamination.

Why were all of these issues so significant this year? It comes down to the disease triangle. Remember that the only way a plant disease can occur is if there is a susceptible host planted close to a virulent pathogen while the weather is conducive (e.g. plant disease = pathogen + host + conducive weather). We have a lot of corn planted (maybe with some susceptibility to some of these pathogens) in Wisconsin, and clearly we had virulent pathogen propagules around, it just took the weather to complete the triangle and we had the numerous epidemics of 2018. This scenario was especially true for tar spot. Cool, consistently wet and humid conditions at points in the season where corn was especially vulnerable left a lot of fields struggling to finish out the season. Throw in gray leaf spot and northern corn leaf blight and plants didn't have the leaf area to keep up with filling the ears to full size. Starving ears forced plants to scavenge carbohydrates from stalks, leaving stalks weak and vulnerable to rotting fungi. Ears that didn't fill to the tip with kernels, acted like little funnels to encourage water inside the husk, ear rots set in hard and heavy with fungi that can produce mycotoxins. It was really the perfect storm for corn in 2018.

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This presentation will focus on analyzing the 2018 season. We will tease apart the various issues and look ahead to 2019. Do we think that 2019 will be as bad as 2018? Unfortunately, we don't have a crystal ball to answer that question. However, we will provide some insight as to how we might prepare for these events should they occur in 2019. This might include: (1) looking for resistant hybrids for the major diseases you struggled with in your own operation; (2) thinking about tillage and planting strategies that reduce plant stress; (3) making the decision to spray fungicide and to detail fungicide application timing to maximize efficacy and return on investment.

EFFECTS OF SEED TREATMENTS ON POPULATION DENSITIES OF SOYBEAN CYST NEMATODE AND SOYBEAN YIELDS IN IOWA

Gregory L. Tylka[1/]

Nematode-protectant seed treatments are a relatively new strategy to manage the soybean cyst nematode (SCN). And many such products now are available (see Table 1).

Table 1. Names, sources, and characteristics of currently available nematode-protectant seed treatments.

Product and provider	Crop(s)	Targeted nematodes	Active ingredient	Mode of action
Avicta Complete Syngenta	cotton, corn, soybean	all plant-parasitic nematodes	abamectin	inhibits nematode nerve transmission
N-Hibit Seed Treatment Plant Health Care, Inc.	all plants	all plant-parasitic nematodes	harpin protein	induced plant defenses
VOTiVO BASF	cotton, corn, soybean	all plant-parasitic nematodes	*Bacillus firmus*	living barrier of protection on roots
Clariva pn Syngenta	soybean	SCN	*Pasteuria nishizawae*	nematode parasite
ILeVO BASF	soybean	SCN, root-knot, reniform, lesion	fluopyram	SDHI enzyme inhibitor
NEMASTRIKE Technology Bayer Crop Science	cotton, corn, soybean	SCN, root-knot, reniform, lesion, others	tioxazafen	mitochondrial translation inhibitor
AVEO EZ Valent	corn, soybean	SCN, root-knot, reniform, lesion, others	*Bacillus amyloliquefaciens*	not stated or known
NEMASECT Beck's	corn, soybean	all plant-parasitic nematodes	heat-killed *Burkholderia rinojenses* + fermentation media	not stated or known
TRUNEMCO BASF	cotton, corn, soybean	???	*Bacillus amyloliquefaciens* + cis-Jasmone	induced plant defenses and ???

A total of 92 small-plot experiments were conducted between 2014 and 2018 throughout Iowa to assess the effects of several of nematode-protectant seed treatments on soybean yields and season-long changes in nematode population densities. The seed treatments were applied by the companies selling the products and were applied to seed of SCN-resistant soybean cultivars selected by the company. The experimental plots were four rows wide and 17 feet long, and each experiment had 12 replicate plots of two treatments: 1) the nematode-protectant seed treatment on a base of insecticide and fungicide and 2) the base insecticide and fungicide alone.

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In 32 experiments conducted from 2014 through 2017 with Clariva on a base of CruiserMaxx Advanced + Vibrance, significant ($P \leq 0.10$) yield increases occurred twice and significant ($P \leq 0.10$) reductions in season-long changes in SCN population densities occurred twice with Clariva (Bissonnette et al. 2018). The yield increases were 3.3 and 4.5 bushels per acre. Interestingly, the experiments where reduced SCN reproduction with Clariva occurred were not the experiments in which yields were significantly increased.

There were 27 experiments conducted with Ilevo on a base of Poncho/Votivo from 2015 through 2017. Significant ($P \leq 0.10$) increases in yield occurred with Ilevo in three experiments (3.7, 2.9, and 2.8 bushels per acre), and there were two experiments where season-long SCN reproduction was significantly ($P \leq 0.10$) less with the Ilevo treatment. As with the Clariva experiments, the experiments in which Ilevo significantly increased yield were not the same experiments in which Ilevo reduced season-long SCN reproduction.

A total of 17 experiments were conducted from 2017 to 2018 with Aveo on a base of Intego. There were single experiments in which Aveo significantly increased yield (3.3 bushels per acre, 2018) and significantly decreased yield (3.7 bushels per acre, 2017). No significant changes in SCN populations over the season were detected in any of the experiments in 2017. The SCN data for 2018 were not available before this paper was submitted. When yield data from all 8 experiments in 2018 were combined for analysis, mean yield with Aveo was significantly ($P \leq 0.05$) greater than the base by 2.0 bushels per acre. No significant yield difference was detected when data from all 9 experiments in 2017 were combined.

In eight experiments with Nemastrike on base of Acceleron F1 conducted in 2018, a significant ($P \leq 0.05$) yield increase of 4.5 bushels per acre occurred in one experiment. The yield differences in the other seven experiments were small and not significant. Also, there was no significant yield difference between treatments when yield data from all experiments were combined. The SCN data for 2018 were not available when this paper was prepared.

Trunemco is a nematode-protectant seed treatment currently under development by BASF with projected release in 2020. Eight experiments were conducted in 2018 with Trunemco, and it was on a base of Obvius Plus. There was no significant difference in yields between Trunemco plus base versus the base alone in any of the individual experiments. But when the data from all eight experiments were combined for analysis, mean yield with Trunemco was significantly ($P \leq 0.10$) greater than the base treatment by 1.0 bushel per acre. As with the other 2018 experiments mentioned above, SCN data for the experiments were not available when this summary was submitted.

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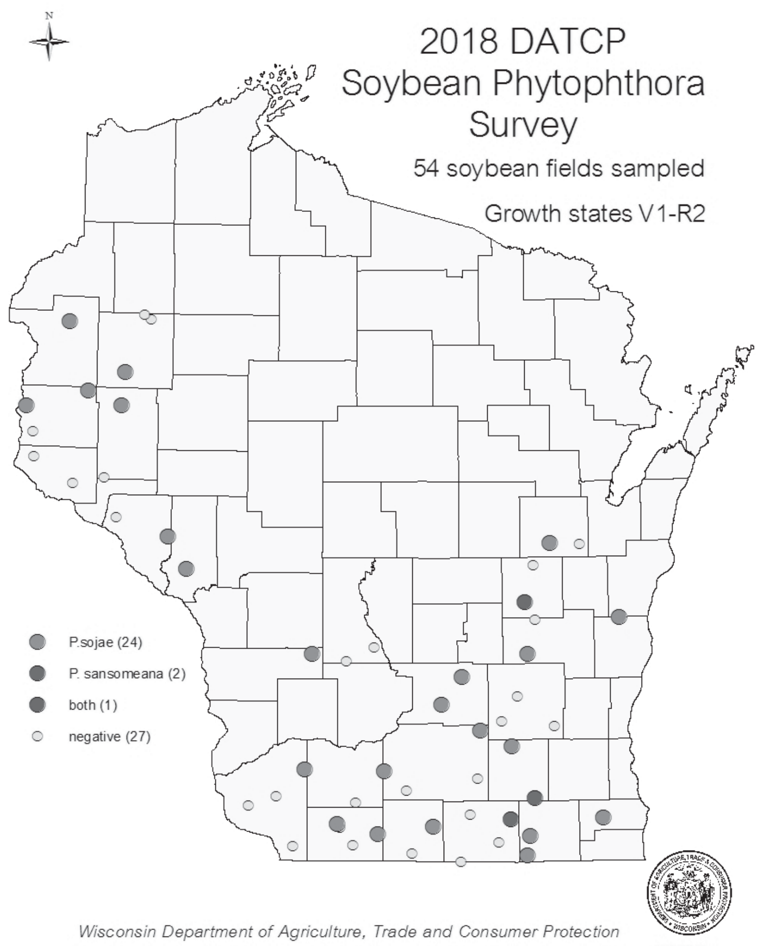
2018 WISCONSIN CROP DISEASE SURVEY

Anette Phibbs[1], Samantha Christianson[1] and Adrian Barta[2]

https://datcp.wi.gov/Pages/Programs_Services/PestSurvey.aspx

Plant Industry Bureau Laboratory (PIB lab) provides diagnostic services for DATCP pest and disease surveys and inspections. In 2018, the lab diagnosed 1,767 samples for plant diseases, nematodes and insect pests. These are the highlights from the 2018 season.

Soybean Seedling Rot Root -In 2018, DATCP surveyed 54 soybean fields from June 11 to July 6 for seedling root rot diseases. From each field, twenty seedlings were carefully dug up and submitted to the PIB Lab. Samples were tested for *Phytophthora sojae*, general Phytophthora species, and general Pythium species, using gene-based methods. Testing confirmed that 25 of 54 (46%) of fields were positive for *P. sojae*. This was an increase from the two previous years where in 2017, 24% of fields were found to have *P. sojae* and in 2016, 32% of fields were positive. The past decade of the survey has found *P. sojae* prevalence ranging from 13% in 2011 to 49% in 2014. Pythium was present in most fields (96%, 52 of 54) in 2018, the same as in 2017. In addition, another Phytophthora species, *Phytophthora sansomeana*, was found in three fields. These fields were located in Jefferson, Rock and Winnebago counties. Since first finding *P. sansomeana* in Wisconsin in 2012, it has been documented in twelve counties: Calumet, Dane, Dodge, Dunn, Eau Claire, Green, Jefferson, Outagamie, Marathon, Rock, Sheboygan and Winnebago. This year both Rock and Winnebago were new additions to this list.



The increase in Phytophthora root rot is most likely due to excessively wet spring conditions in 2018.

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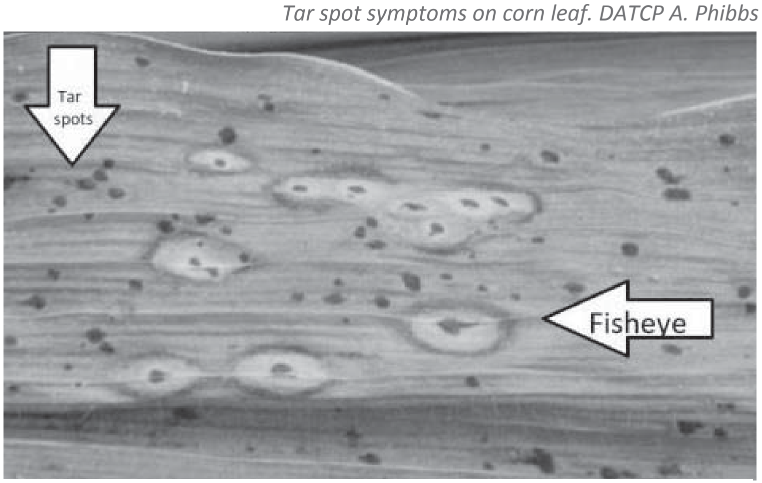
Tar spot of corn – Wisconsin and other Midwest states experienced a major outbreak of this disease in 2018. In Wisconsin, tar spot was first detected in Green and Iowa Counties in 2016. Appearing at low levels at the end of the season, tar spot was considered of no economic significance in 2016 and 2017. In Mexico, where tar spot has previously been reported to cause economic losses, the disease is described as a complex of the tar spot-causing-fungus *Phyllachora maydis* with two other fungi, *Coniothyrium phyllachorae* and *Monographella maydis.*

Tar spot symptoms on corn leaf. DATCP A. Phibbs



Two types of tar spot symptoms on a corn leaf. Simple black spots on the left and fisheye lesions on the right. DATCP A. Phibbs

In 2018, UW Field Crops Pathology reported widespread findings in southeastern Wisconsin, warning of severe damage and early dry-down. UW and DATCP Pest Survey documented tar spot of corn in 33 counties of the southern half of the state in 2018. DATCP surveyed corn fields from Sept 25 to Oct 16, 2018 and found tar spot in 77 of 79 fields (97%). A subset of fields was sampled and 36 symptomatic corn leaves were submitted to PIB lab for testing. Examination at PIB lab confirmed the tar spot causing fungus *Phyllachora maydis* and showed that most corn leaves were also infected with a variety of other common corn leaf diseases, notably grey leaf spot (100%) and anthracnose (98%). The next most-frequently found fungal leaf diseases were northern corn leaf blight (44%) and northern corn leaf spot (31%).

Tar spot is named for the black shiny fruiting structures of the Phyllachora fungus dotting infected corn leaves. Infected leaves often display fisheye-like spots formed by tan colored halos surrounding the black spots. We observed a second fungus sporulating out of these fisheye lesions. Gene-based testing identified the second fungus as a *Coniothyrium* species with a *Paraphaeosphaeria sp.* sexual reproductive state. The other fungi reported to be associated with the disease in Mexico, *Monographella maydis*, was not observed in Wisconsin. More research is needed to understand the tar spot disease complex in the Midwest and to explain this sudden outbreak.

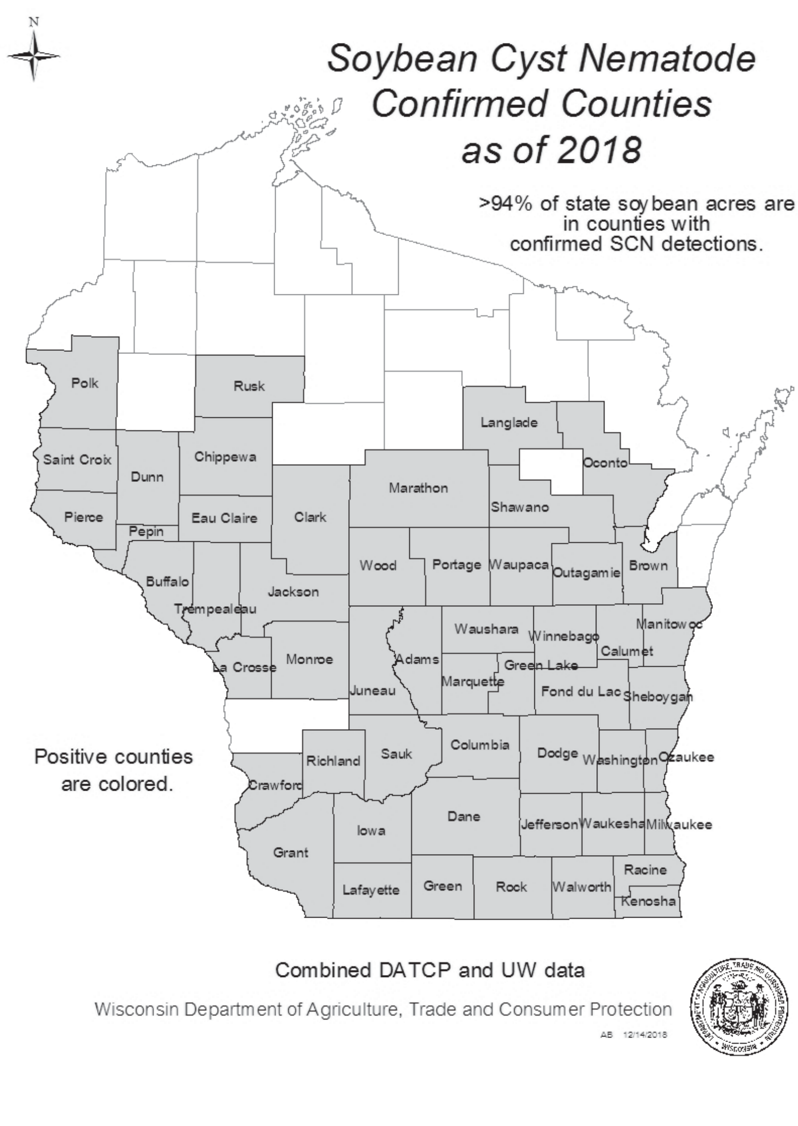
Traces of **Southern corn rust** (*Puccinia polysora*) were detected on three samples from fields in Walworth, Richland and Sauk counties in 2018. Southern rust is sometimes picked up at the end of the season after it moves up on strong winds from the southern part of the US.

Inspections and testing of **seed corn fields** showed neither **Goss's wilt** nor **Stewart's wilt** of corn in 2018. Goss's wilt was reported in 11.5% of inspected fields in 2017 and Stewart's wilt has not been found in Wisconsin since 2010.

Seed corn fields all tested negative for a new bacterial disease called **bacterial leaf streak** that is caused by the bacterium ***Xanthomonas vasicola pv. vasculorum.*** This disease was found for the first time in Wisconsin in Pierce Co. in September of 2018 by UW-Madison Plant Pathology. This find adds Wisconsin to the list of Midwest states where the disease has been confirmed. USDA confirmed first detections in the US in 2016 in CO, IL, IA, KS, MN, NE, OK, SD and TX.

Virus screening of corn continues to show no evidence of high plains virus (HPV), maize chlorotic mottle virus (MCMV) and sugarcane mosaic virus (SCMV)/maize dwarf virus (MDMV) and wheat streak mosaic virus (WSMV). HPV screening of small grains also came up negative.

Soybean cyst nematode *Heterodera glycines* has been found in more than 94% of Wisconsin's soybean acreage. The latest new county detections were Marathon Co. in 2013 and Langlade Co. in 2017. The map below shows all county detections since Racine Co. in 1981.



INTEGRATED APPROACHES TO WHITE MOLD MANAGEMENT

Damon Smith[1/], Brian Mueller[2/], Richard Webster[3/], Paul Mitchell[4/], and Shawn Conley[5/]

White mold is caused by the fungus, *Sclerotinia sclerotiorum* and frequently results in significant damage to soybeans in the upper Midwest. The white mold fungus has a notoriously wide host range, which can result in large reservoirs of inoculum in and near soybean fields. The primary inoculum (ascospores) are born on cup-shaped structures called apothecia. These apothecia form when the weather conditions are cool and wet, the soybean canopy is dense, and flowers are present. The presence of a susceptible host (e.g., flowering soybeans), active pathogen (e.g., sporulating), and conducive weather has to happen at the same time, in the field to result in infection. This can be difficult for farmers to anticipate for predicting if they might have white mold, or if they want to implement an in-season management strategy (Willbur et al., 2019a). To take some of the guess-work out of managing white mold, soybean farmers have been interested in learning more about resistant soybean cultivars, what fungicides might be available for controlling white mold, whether it is economical to spray fungicide under certain conditions, how to anticipate favorable weather to better time fungicide applications, and cultural practices such as row-spacing and planting population that lead to less white mold, but don't negatively affect yield. The Wisconsin Field Crops Pathology team in conjunction with the Wisconsin Soybean Team have been conducting research to address these questions.

One of the most elusive management strategies for white mold has been the deployment of highly resistant soybean cultivars. Resistance to the white mold fungus, in soybean, is highly quantitative. This means that many genes in soybean are responsible for resistance to the white mold fungus, with no one gene conferring a large amount of resistance. Thus, finding highly resistant cultivars for managing white mold has been challenging (McCaghey et al., 2019). However, a few do exist and will be highlighted in this presentation.

A white mold prediction tool has also been developed. This tool uses statistical models that were developed using data from Wisconsin and surrounding states (Willbur et al., 2018a). Weather information is inserted into the statistical models to form probabilistic predictions of risk of white mold development on any given day. The tool has been validated in multiple locations, including commercial fields (Willbur et al., 2018b). It is available as an electronic

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tool (Sporecaster) on the iPhone (https://itunes.apple.com/us/app/sporecaster/id1379793823?mt=8) and Android (https://play.google.com/store/apps/details?id=ipcm.soybeandiseasecalculator) platforms. The primary use of this tool is to anticipate favorable weather events that may result in the presence of apothecia that can lead to successful infection if flowers are present in soybean fields. Fungicide application decisions can then be made based on these predictions.

An additional electronic smartphone application for determining if certain fungicide programs result in positive return on investment (ROI) under different soybean production scenarios, has also been developed. This is a research-based tool (Willbur et al., 2019b) that is available for both the iPhone (https://itunes.apple.com/us/app/sporebuster/id1438463112) and Android (https://play.google.com/store/apps/details?id=edu.wisc.ipcm.sporebuster) platforms. This tool can be used in conjunction with Sporecaster. Once you know if you need to spray, Sporebuster can help farmers to decide which fungicide program fits their operation.

Finally, current, ongoing research is focused on understanding how a truly integrated approach to managing white mold might work. Effort has been placed on understanding how row-spacing (15 in. vs. 30 in.), planting populations (110,000 to 200,000 seed per acre), and the application of fungicide using Sporecaster can be used in an integrated fashion to maximize yield and reduce white mold damage. Research is being done in Wisconsin, Minnesota, Iowa, Michigan, and Illinois. So far, row-spacing and planting population are most influential on yield and white mold level. Wider row spacing typically results in less white mold. However, slightly higher yields are achieved in narrow row spacings. In heavy white mold environments, the added yield achieved in narrow row spacings (such as 15 in.) is offset by higher white mold that can compromise that yield. Thus, in heavy white mold environments, wider row spacing would be preferred with planting population around 140,000 seed per acre. Application of fungicide using the Sporecaster smartphone app can then provide an additional level of control.

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WATERHEMP MANAGEMENT IN ESTABLISHED ALFALFA

Mark Renz[1/]

Dairy production systems rely on alfalfa as a key component in their ration. Alfalfa provides a high yielding and quality forage as well as key ecosystems services as part of a rotation with annual crops. One of the under-valued services is weed control as it has been documented that alfalfa stands can reduce weed populations if managed correctly (e.g., Clay and Aguilar, 1998; Goplen et al., 2017). Few annual weeds can compete with alfalfa stands and do not germinate unless alfalfa stand density is below recommended levels or the alfalfa is stressed due to lack of precipitation or pest (insect disease) damage. What few annual weeds that emerge are not able to produce viable seeds due to the frequent harvest interval present in a dairy system (every 28 to 35 days). For example, giant ragweed, a highly competitive annual weed that is capable of germinating throughout the spring, had emergence reduced by 59% when grown under alfalfa compared to corn and didn't produce any viable seeds in a research project in Minnesota (Goplen et al., 2017). Unfortunately established alfalfa systems are currently being invaded by waterhemp (*Amaranthus tuberculatus* (Moq.) J.D. Sauer), a weed species that has the potential to germinate and produce viable seed within this competitive forage system.

Waterhemp, while present in the region for over a century, has been documented to be rapidly spreading throughout the United States. In Wisconsin, while this plant has been present for over 150 years, it has recently been observed to be expanding its range with populations now in over 80% of counties, with 40% of the observations being reported in the last 4 years (Renz, 2018). This plant is similar to other pigweed species (red-root, smooth) but can germinate later into the growing season (Werle et al., 2014) even if under established plant canopies (Steckel et al., 2003) and compete against established crops and produce viable seed (Wu and Owen, 2014). While the harvest frequency of alfalfa grown for use in dairy systems have historically prevented annual species from competing with alfalfa, recent observations suggest waterhemp has the potential to behave differently. This past year reports from multiple crop consultants documented productive alfalfa fields with significant waterhemp biomass in the second and third harvests in established alfalfa fields that resulted in viable seed production (personal communication, Wisconsin Extension Educators in Clark and Outagamie County). According to the consultants, these fields had adequate stand densities with no visible stresses that would have facilitated emergence. Similar reports of spread have been received in other Midwestern and Eastern United States (e.g., Hager 2016).

It is not known what the impact of waterhemp invasions have on forage quality and productiveity and resulting milk production from established alfalfa fields. Weeds harvested often increase yields and can be utilized as a forage, but reduce forage quality (Cosgrove and

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Barrett, 1987). While recent research suggests the level of reduction can be offset by the added biomass in milk production, weed biomass must be a minor component (<15%) of the total forage biomass (Renz et al., 2018). In addition, waterhemp may impact alfalfa stand density which could reduce long-term alfalfa stand life.

Several herbicides are registered for use in established alfalfa (acetochlor, flumioxazin, metribuzin, and pendimethalin) that have been documented to have success in controlling waterhemp in other crops. While effective, it is not clear when to apply each product to maximize season-long control of waterhemp in established alfalfa. In annual production systems (soybeans, corn), applications are typically applied at planting or just prior to waterhemp emergence, but labels restrict applications in established alfalfa to during green-up in the spring or after each harvest. The optimal timing for waterhemp control is not known in established alfalfa. While waterhemp emergence in annual crop systems is known (late May to early June), the dense canopy of established alfalfa may delay emergence. This has been observed with other annual weed species (Goplen et al., 2017). Applications during alfalfa green-up would provide early-season control, but may breakdown prior to the end of the season, thus not providing season-long control. While applications after the first harvest have the potential to provide season-long control with some products, it may not control early emerging waterhemp plants, which could produce significant biomass throughout the season.

Adding a post-emergent herbicide would be a common solution to this problem as it would provide control of emerged plants. Unfortunately many populations are resistant to commonly used products with post-emergent activity in alfalfa (imazamox, imazethapyr, and/or glyphosate) (Heap, 2018). Therefore these options cannot be relied on for manage-ment and greater emphasis on residual products for pre-emergent control. While these products may not provide complete control, several may provide sufficient control to eliminate impact on milk production.

Future research to be established in 2019 will evaluate the effectiveness of labeled residual herbicides at controlling waterhemp in established alfalfa for dairy systems and determine how treatments/timings impact forage quantity and quality and resulting milk production. Expected results will be discussed in this presentation. As many producers rely on alfalfa to reduce weed populations for subsequent crops, we will also assess the ability of treatments to prevent seed production. These efforts will provide valuable information that will allow producers to optimize waterhemp management in alfalfa production systems.

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KERNEL PROCESSING SCORE: DETERMINATION WITH SILAGESNAP[1]

Brian D. Luck[2], Jessica L. Drewry[2], and Rebecca L. Willett[3]

Adjustment of the kernel processor in a Self-Propelled Forage Harvester (SPFH) is critical to high quality feed production. Particle size reduction of the corn kernels contained within chopped and processed corn silage makes the starch more available in the rumen, increasing digestion and in-turn increasing milk production. Increased milk production is the most common train of thought when considering the economic benefit of properly setting a kernel processor, but machinery management and efficiency metrics should be considered as well. Kernel processors utilize a high percentage of the power produced by the engine during corn silage harvest. A substantial amount of material is being forced through a very small gap, causing the power requirements to process the crop to increase substantially. While maintaining the smallest gap possible will produce smaller geometric mean particle sizes of the corn kernels, opening the kernel processor gap just 0.5 mm would reduce the load on the engine. This reduced load would allow the machine to move more quickly through the field or increase the fuel efficiency of harvest. Optimization of the kernel processor gap setting could take move the industry closer to a more efficient harvest.

Harvest timing is also another critical aspect to consider when assessing the economic benefit of kernel processor settings and corn silage harvest. Harvesting the corn silage at the proper moisture content allows for proper ensiling and high quality feed production. Having the moisture of the corn too high or too low yields poor quality feed. Harvest efficiency must be maintained at a high level in order to harvest at the proper moisture over many acres. Staggered planting dates help the crop to hit the right moisture content at different dates, but weather and other factors sometimes negate these windows of opportunity. Moving the forage harvesters through the field as quickly as possible, while maintaining sufficient kernel processing, should be the goal of every silage harvest operation. This provides a high quality feed with sufficient kernel processing that was harvested at the proper moisture content.

Kernel processor setting is also a point of contention between the machine operator and the nutritionist. Machine operators prefer less kernel processing in order to harvest more quickly, while nutritionists prefer more kernel processing to achieve maximum milk yield. A common data collection method for both machine operators and nutritionists to accurately measure corn kernel particle size in the field would be beneficial and hopefully come to common ground about sufficient kernel processing for corn silage.

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Utilizing image processing methods we can accurately estimate kernel processing score quickly. A smart phone application, called SilageSnap, was developed and released in 2018 to help producers and custom operators to estimate kernel processing score during harvest. To use SilageSnap some sample processing is required. Hydrodynamic separation of the kernels from the plant material should be done to assess the kernels by themselves. A coin and a dark matte background is required to accurately assess the corn kernel particle size distribution. Directions for hydrodynamic separation and the use of SilageSnap can be found at:

https://fyi.uwex.edu/forage/making-sure-your-kernel-processor-is-doing-its-job/
https://wimachineryextension.bse.wisc.edu/precision-agriculture/silagesnap/

FORAGE HARVEST LOGISTICS MODELING UPDATE

Brian D. Luck[1]

Harvesting corn for silage utilizes multiple pieces of equipment to ensure rapid and economical production of silage. A model of corn harvest for silage production, capable of predicting machine working status and total harvest time for a field, using a single harvester, and any number of user defined transport vehicles, as a function of machine specifications and field properties was developed. Three forage harvesting systems were observed using Global Positioning System (GPS) equipment and the collected data used for the TruckSim model validation. The harvest model predicted harvest times within 10% of observed data and yielded similar results to a previously assessed harvest system. Model scenarios were used to explore the effect of differently sized transport vehicles on harvest time and it was found that placing transport vehicles with longer cycle times at the end of the rotation has the potential to reduce harvest time. The TruckSim model can be found at:

https://wimachineryextension.bse.wisc.edu/precision-agriculture/forage-harvest-simulation/#/home

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KEYS TO ALFALFA ESTABLISHMENT IN HIGH YIELDING SILAGE CORN

John H. Grabber[1/]*, Mark J. Renz[2/], Heathcliffe Riday[1/], William R. Osterholz[2/], Damon L. Smith[3/], and Joseph G. Lauer[2/]

Alfalfa has often been replaced in rotations by corn silage, in part because corn produces greater forage dry matter yield than alfalfa. First year yields of spring-seeded alfalfa are particularly low, often being one-half that of subsequent full production years. Planting small grain, grass, or legume companion crops with alfalfa can modestly improve forage yields in the establishment year, but seeding companion crops with alfalfa often reduces forage quality. Thus, new approaches are needed to increase the yield of alfalfa, especially during its first year of production.

One way to bypass the low yielding establishment year would be to interseed alfalfa into corn to jumpstart full production of alfalfa the following year. When successfully established, first year dry matter yields of interseeded alfalfa are two-fold greater than conventionally spring-seeded alfalfa. During and after establishment, interseeded alfalfa also serves as a cover crop to reduce soil and nutrient loss from cropland. Unfortunately, this system has been unworkable because traditional intercropping methods require producers to plant corn at low density (sacrificing high silage yields) to allow reliable establishment of alfalfa. Therefore the USDA-Agricultural Research Service, the University of Wisconsin, and institutions in other states are working to develop reliable methods for establishing alfalfa in high yielding silage corn. During the course of this work in Wisconsin, it has become apparent that successful establishment of alfalfa in corn can be greatly improved by using growth altering and protective agrichemicals. Using appropriate alfalfa varieties, adequate alfalfa seeding rates, and proper planting dates also help to ensure successful establishment of alfalfa in silage corn.

Initial studies from 2008 to 2014 demonstrated that foliar applications of a growth retardant known as prohexadione (PHD) on interseeded alfalfa increased seedling survival by 40 to 300% under high yielding corn seeded at up to 35,000 plants per acre. Because of its effectiveness and low toxicity, efforts are now moving forward to register PHD this use in time for the 2020 growing season. Work conducted in 2017 and 2018 found that fungicide and insecticide applied after PHD further doubled survival of interseeded alfalfa to give good stand establishment, even when corn was planted at populations of up to 44,000 plants per acre. Follow up work in 2018 and 2019 will identify suitable rates and the best timing to apply PHD, fungicide, and insecticide to ensure good establishment of interseeded alfalfa at reasonable cost. Other work from 2015 to 2017 found that alfalfa interseeding suppressed weeds in corn. Weed control was further improved by applications of Roundup, Warrant and Buctril herbicides.

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Other Wisconsin interseeding studies in 2015 and 2016 found substantial and consistent differences in plant survival among 38 conventional, glyphosate-resistant, and leafhopper-resistant alfalfa varieties. Without PHD treatment, plant density of alfalfa varieties following corn ranged from 2 to 8 plants per square foot in 2015 and from 0 to 1 plants per square foot in 2016. Applying PHD to alfalfa varieties increased plant density by up to 5-fold. Several studies in 2012 and 2013 indicated shifting the seeding rate of alfalfa from 8 to 16 lb per acre increased alfalfa plant density by up to 50% following corn harvest. Other studies carried out from 2016 to 2018 suggested survival of PHD treated alfalfa under corn was up to 50% greater when interseeding was carried out immediately after corn planting rather than waiting until corn had emerged or reached the two-leaf stage.

Based on the abovementioned work, experiments on producer fields were recently initiated in Wisconsin and in three other states to identify factors that influence the success or failure of alfalfa establishment under corn in a wide variety of growing conditions. In 2018, these experiments confirmed the benefits of PHD and fungicide applications and highlighted the need for adequate weed control and good seedbed preparation for good alfalfa establishment. Additional farm cooperators will be needed for studies in 2019. Other ongoing or planned experiment station trials will investigate breeding of alfalfa for improved survival under corn, evaluate the compatibility of various corn hybrids with interseeded alfalfa, and refine nitrogen fertilizer and other management practices to ensure corn-interseeded alfalfa production systems will be reliable, high yielding, and profitable for farmers.

THE ANATOMY OF GRAIN DUST EXPLOSION AND HOW TO AVOID IT

Bruce McLelland [1/]

Grain dust explosions can and must be prevented by engaging in safe handling and processing practices as identified in NFPA 61 and NFPA 652. Prevention and mitigation of fire, flash fire, and deflagration are essential to life safety and property protection and at the same time can create production efficiencies. This session will cover examples of loss, recommendations for prevention, as well as responsive protective measures that can be implemented in simple handling as well as complex processing.

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UNDERSTANDING THE GROWTH STAGES FOR CORN, SOYBEAN, AND WHEAT

Lindsay Chamberlain [1/]

In-season management decisions for weed control, disease, and insect pests are often based on the stage of crop growth. Understanding growth stages of different crops is crucial to make effective management decisions. In addition to ensuring efficacy of control, accurate growth staging is important to ensure any chemical application aligns with the label's restrictions. Several common herbicides and pesticides are labelled for use at or up to certain growth stages. The legal application window for these products refers to the growth stage present in the field, so it is important for the applicator to be able to identify crop growth stages accurately.

For information on soybean and wheat growth stages, please visit www.coolbean.info.

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