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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.

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# 2016 Wisconsin Agribusiness Association Distinguished Service Awards

**Distinguished Organization Award**
Badger State Ethanol
*{For Exemplary Industry Professionalism}*

**Education Award**
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*{For Leadership & Commitment to Educational Excellence}*

**Outstanding Service to Industry**
John Shutske, UW-Madison CALS and UW-Extension
*{For Dedication & Support to WABA and Its Members}*

**Friend of WABA Award**
Representative James Edming
*{Wisconsin State Assembly}*

**Board Member Service Award**
Kathy Dummer, Buck Country Grain
*{For Full-Term Board of Director Service}*

**President's Service Award**
Scott Firlus, United Cooperative
*{For Dedication, Service, & Leadership}*

# 2016 – 2017
# Scholarship Recipients

## Wisconsin Agribusiness Association Scholarships

Casey Hahn
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Derek Potratz
*UW-Stevens Point*

Katelyn Greenwood
*Southwest Wisconsin Tech*

Justin Laporte
*Chippewa Valley Tech*

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Justine Engman
Cheyenne Zipp
*North Central Tech*

Matthew Kronschnabel
Maria Weber
*UW-Madison*

## Wisconsin FFA Foundation

Jared Retzlaff
Erica Helmer
Beth Zimmer
Ashley Zimmerman

## Mike Turner Memorial Scholarship

Adam Meinert
Amber Francois
*Fox Valley Technical College*

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## FORAGE CROPS

**WEED MANAGENET**



**AGRIBUSINESS MARKETING**

## GRAIN MANAGEMENT



## SPRAY RIG OPERATOR REFRESHER



## ECONOMICS AND TECHNOLOGY

# SOIL EROSION: HOW MUCH IS OCCURRING, WHEN, AND WHERE?

Rick Cruse[1/], Brian Gelder[1/], David James[2/], and Daryl Herzmann[1/]

## Introduction

Soil erosion and water runoff drive water quality degradation and are liabilities to crop production, yet their magnitude is neither quantified nor inventoried for US agricultural areas. This project's goals are to: (1) estimate soil erosion and surface runoff across the Upper Midwest as contributors to soil and water degradation and (2) inventory these quantities for the next several years.

The newly released Daily Erosion Project (DEP) gives daily estimates of water runoff and sheet and rill erosion for each of Iowa's 1,647 HUC 12 agricultural watersheds (HUC 12 average area is approximately 35 square miles). For each watershed, water runoff and soil erosion is recorded over time, allowing for a spatial and temporal inventory of runoff and soil erosion for identification of soil degraded areas as well as water quality impairment source areas. These estimates are made publicly available on a daily basis from an open access interactive website. This data, as well as all input data, is publically available through this website. We are currently in the process of expanding the use of this tool from Iowa only to other states in the Midwest. This includes all or parts of Minnesota, Missouri, Kansas, Nebraska, and Wisconsin. Results for Iowa will be exemplified as work in Wisconsin is not yet complete.

## Approach

The Daily Erosion Project is a next generation upgrade of the original Iowa Daily Erosion Project (Cruse et al., 2006). DEP provides statistically robust, daily estimates of hillslope water runoff, sheet and rill soil erosion and profiles soil water storage on agricultural fields in the covered area. DEP takes advantage of recent technological advancements that enable a field level modelling approach to produce estimates important for crop production, environmental evaluations and policy analysis. High temporal and spatial resolution precipitation data required to drive soil erosion and water runoff estimates came from a 2-minute, 1-kilometer square (about 0.4 square miles) NEXRAD rainfall product. Soil and crop management inputs were field-based and determined from Landsat satellite imagery of land cover, LiDAR surface elevations, the USDA NASS Cropland Data Layer, and the USDA Soil Survey Geographic database. These

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[1/] Brian Gelder, Associate Scientist, Agricultural and Biosystems Engineering, Iowa State University, Ames, IA
[2/] David James, Geographic Information Specialist, National Laboratory for Agriculture and the Environment, USDA/ARS
[1/] Daryl Herzmann, Systems Analyst III, Department of Agronomy, Iowa State University, Ames, IA

data, excluding tillage management practices, are available as the USDA ARS' Agricultural Conservation Planning Framework (ACPF; http://northcentralwater.org/acpf/) and are a critical component of DEP. Soil erosion, water runoff and soil water content are estimated using the process based WEPP model and publicly reported at the HUC 12 level, which coincides with existing watershed monitoring data and multiple federal and state projects addressing soil and water quality improvements. While daily public reporting is at the HUC 12 level, erosion, water runoff, and soil water storage estimates are made for each agricultural subcatchment within each HUC 12; these sub catchments average 200 acres in size. Depending on user needs and computer power available, these estimates could be made at a much finer scale. Within the current project structure, a statewide rainfall event resulted in over 200,000 hillslope water runoff and soil erosion estimates.

## Results

To illustrate the utility of DEP, hill slope soil erosion and water runoff losses for Iowa were estimated for an eight year period beginning in 2007 based on archived input data (precipitation, crops and tillage in each field, hill slope steepness and slope length, soil types…). The statewide hill slope soil erosion estimates with DEP matched the USDA estimate published in the National Resources Inventory (NRI) (5.7 tons/acre/year for DEP and 5.8 tons/acre/year for NRI). NRI uses RUSLE, an empirically based model, as the basis for soil erosion estimates. However, DEP estimates illustrate the wide range of soil erosion that occurred spatially and temporally during this period, a critically important capability not offered by any other technology. DEP results indicate that average annual statewide soil erosion ranged from 10.6 tons/acre in 2010 to 1.6 ton/acre in 2012. Key findings show the greatest soil erosion rate estimates exceeded 50 tons/acre in multiple HUC 12 watersheds in 2010. A majority of Iowa experienced less than 1 ton/acre hill slope loss of soil in 2012, which was a drought year in the Midwest.

Soil erosion averages over large areas (a state) and over long time periods (such as occurs when long term average precipitation is used over a broad area) have value for land use planning and for trend analysis on a broad scale. The NRI (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri/ ) is a current tool, and a well-respected tool. DEP adds to this value by not only identifying critical areas in need of elevated attention, but it also inventories soil loss through time for all HUC 12 watersheds in the state.

DEP results can be accessed at: https://dailyerosion.org/

## References

Cruse, Richard, Dennis Flanagan, Jim Frankenberger, Brian Gelder, Daryl Herzmann, David James, Witold Krajewski, Michal Kraszewski, John Laflen, Jean Opsomer, and Dennis Todey. 2006. Daily estimates of rainfall, water runoff, and soil erosion in Iowa. J. Soil Water Conserv. 61:191-198.

# CONNECTING SOIL AND NUTRIENT LOSS TO CROP PRODUCTION

Francisco J. Arriaga [1/]

The 4R concept (right source, right rate, right time and right place) provides a useful structure to achieve increased crop production, improved farm profitability, greater environmental protection and better sustainability. However, crop nutrient management should go beyond the 4Rs of fertilizer and manure stewardship. Other soil management factors that affect crop productivity, farm profitability, the environment, and sustainability should be considered when thinking about crop nutrient management. While fertilizer and manure applications affect nutrient availability to crops short-term (e.g., current growing season or following year), other soil management factors affect nutrient availability long-term. More specifically, factors that affect crop residues after harvest and soil structure/ aggregation affect the availability of nutrients in future years. One such soil property is soil organic matter content.

Organic matter in the soil has several important roles. One such role of organic matter is helping the formation of soil aggregates which are indispensable for well-functioning soil hydraulic properties. Greater levels of soil aggregation are associated with greater infiltration rates, plant water availability and drainage capacity (Hillel, 1998). However, organic matter also helps increase the cation exchange capacity of a soil. The cation exchange capacity of soil is often referred to as the store house of fertility. Soil particles have a small negative charge, which helps retain positively charged plant nutrient ions. Note that an ion is a chemical element or molecule with either a positive or negative charge; a positively charged ion is also called a cation. Most plant nutrients exist as ions in the water within the soil (Foth and Ellis, 1988). Plant roots uptake these ions that are dissolved in the soil water, or soil solution. As crop roots take up these nutrient ions from the soil solution, they are replaced by other ions that were stored near a soil particle thanks to the cation exchange capacity of soil. The cation exchange capacity also prevents plant nutrients in a cationic form from been lost out of the root zone by leaching.

As mentioned earlier, soil particles inherently have a negative charge. However, organic matter can contribute significantly to the cation exchange capacity of soil and boost the nutrient retention capacity of soil (Parfitt et al., 1995). In some soils it has been reported that organic matter contributes between 30 to 60% of the cation exchange capacity of the plough layer (Schnitzer, 1967). Therefore, avoiding reductions and increasing organic matter content in soil helps increase the nutrient retention capacity of a soil. Further, plant nutrients are released and made available for root uptake as organic matter decomposes in soil.

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There are several ways that organic matter content in soil can decrease, such as erosion, fast oxidation from excessive tillage, and reductions in additions of organic materials to soil (e.g., long-term reductions in crop residue inputs because of crop biomass harvest). The impacts and implications of crop/soil management practices such as tillage and crop residue handling from a crop nutrient perspective and fertilizer replacement value will be discussed during this presentation.

## References

Foth, H.D., and B.G. Ellis. 1988. Soil fertility. John Wiley & Sons, New York.

Hillel, D. 1998. Environmental soil physics. Academic Press, San Diego, CA.

Parfitt, R.L., D.J. Giltrap, and J.S. Whitton. 1995. Contribution of organic matter and clay minerals to the cation exchange capacity of soils. Communications in Soil Science and Plant Analysis 26:1343-1355.

Schnitzer, M. 1965. Contribution of organic matter to the cation exchange capacity of soils. Nature 207:667-668.

# MANAGING SILAGE LEACHATE AND RUNOFF FOR WATER QUALITY

Becky Larson [1/] and Eric Cooley [2/]

SPACE PROVIDED FOR QUESTIONS OR NOTES

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[2/] Co-Director, Discovery Farms, Univ. of Wisconsin-Extension.

# THE BENEFIT OF GYPSUM FOR CROP PRODUCTION IN WISCONSIN

Francisco J. Arriaga[1/] and Richard P. Wolkowski[2/]

Abstract

Gypsum is a mineral whose chemical structure consists of calcium sulfate with two water molecules in its structure ($CaSO_4 \cdot 2H_2O$). This mineral has been used in agriculture as a fertilizer for centuries, mainly as a source of calcium and sulfur. There are three main sources of gypsum available today for agricultural use: mined, recycled wallboard, and flue-gas desulfurization (FGD) gypsum. Chemically these sources are identical, with the exception of recycled wallboard gypsum, which might contain pieces of paper within the material. Currently there is considerable interest in FGD gypsum for agricultural use as it is readily available. Flue-gas desulfurization gypsum is generated in air scrubbers engineered to remove sulfur from exhaust gases in coal-burning electric power plants. This type of gypsum typically has a smaller particle size than mined sources; thus it dissolves and reacts more readily.

Several benefits are attributed to gypsum application to soil, other than supplying calcium and sulfur to crops. It is said that gypsum applied to soil works as a soil conditioner that improves soil structure, infiltration capacity, drainage properties, can improve nitrogen utilization of some crops, and reduce aluminum toxicity of the profile of acid soils. Further, FGD gypsum application to soil in specific has been proposed as a potential practice to reduce nutrients losses such as phosphorus. Research conducted in Wisconsin has mainly concentrated on the impact of FGD application to soil as an amendment and its impact on crop productivity, soil properties and phosphorus losses. The most recent data from research studies conducted in the State focusing on gypsum application to soil will be presented.

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# WHY CONSERVING WISCONSIN SOIL AND WATER RESOURCES IS A GLOBAL NECESSITY

Rick Cruse[1/]

As the world population continues to grow, and the environmental uncertainty of a less stable climate becomes more manifest, the importance of our soil resources will only increase. The goal of this presentation is to synthesize the catalysts of soil degradation, to highlight the interconnected nature of the social and economic causes of soil degradation, and articulate why maintaining or improving Wisconsin's soil and water resources is imperative. An expected three billion people will enter the middle class in the next 20 years; this will lead to an increased demand for meat, dairy products, and consequently grain. As populations rise so do the economic incentives to convert farmland to other purposes. With the intensity and frequency of droughts and flooding increasing, consumer confidence and the ability of crops to reach yield goals are also threatened. In a time of uncertainty, conservation measures are often the first to be sacrificed. In short, we are too often compromising our soil resources when we need them the most.

[1/] Professor, Dept. of Agronomy, Iowa State University, Ames, IA.

# INDUSTRY ROUNDTABLE ON HERBICIDE RESISTANT TRAIT PIPELINE IN SOYBEAN – PANEL

Steven Snyder [1/], Tim Trower [2/], Nick Weidenbenner [3/], and Steve Langton [4/]

SPACE PROVIDED FOR QUESTIONS OR NOTES

[1/] Dow AgroSciences.

[2/] Syngenta.

[3/] Bayer Crop Science.

[4/] Monsanto.

# REVAMPING SOYBEAN NUTRIENT UPTAKE, PARTITIONING, AND REMOVAL DATA OF MODERN HIGH YIELDING GENETICS AND PRODUCTION PRACTICES

Adam P. Gaspar[1], Carrie A.M. Laboski[2], Seth L. Naeve[3], and Shawn P. Conley[1]


## Abstract

Soybean [*Glycine max* (L.) Merr.] nutrient uptake and partitioning models are primarily built from work conducted in the early 1960s. Since the 1960s, yields have nearly doubled to 47.5 bu acre$^{-1}$ in 2014 and soybean physiology has been altered with approximately one more week of reproductive growth and greater harvest index's for currently cultivated varieties. These changes in soybean development along with new production practices warrant re-evaluating soybean nutrient uptake, partitioning. This study's objective was to re-evaluate these factors across a wide yield range of 40 to 90 bu acre$^{-1}$. Trials were conducted at three locations (Arlington and Hancock, WI and St. Paul, MN) during 2014 and 2015. Plant samples were taken at the V4, R1, R4, R5.5, R6.5, and R8 growth stage and partitioned into stems, petioles, leaves, pods, seeds, fallen leaves, and fallen petioles, totaling about 7,000 samples annually. Results indicate that dry matter accumulation at R6.5 was only 84% of the total and that as yield increased the harvest index by 0.2% per bushel. Nutrient uptake for N, $P_2O_5$, and $K_2O$ was 227, 55, and 153 lb a$^{-1}$, respectively and crop removal was 188, 44, and 74 lbs. a$^{-1}$, respectively at a yield level of 60 bu acre$^{-1}$. Data showed that the extended reproductive growth phase (~7 days), greater nutrient remobilization efficiencies (>70%) and higher nutrient harvest index with increasing yields helped contribute to higher yields without greatly increasing total nutrient uptake.


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ARE THESE CORN YIELD TRENDS REAL? CAN WE COUNT ON THEM?

Joe Lauer [1]

The 2016 corn production year was the best on record in Wisconsin. On November 10, 2016, the Wisconsin Agricultural Statistics Service projected corn to be harvested from 3.1 million acres with an average yield of 180 bushels per acre and total production of 558 million bushels. Final estimates will be released in January of 2017.

Since 1996, Wisconsin corn yields have increased an average of 1.7 bu/A per year (Figure 1). The previous yield record was set in 2015 when corn yielded 164 bushels per acre. The increase of 16 bushels per acre over the previous record year represents a 10% jump. Only five other times in Wisconsin's history has corn yields increased at comparable or better rates (Figure 2).

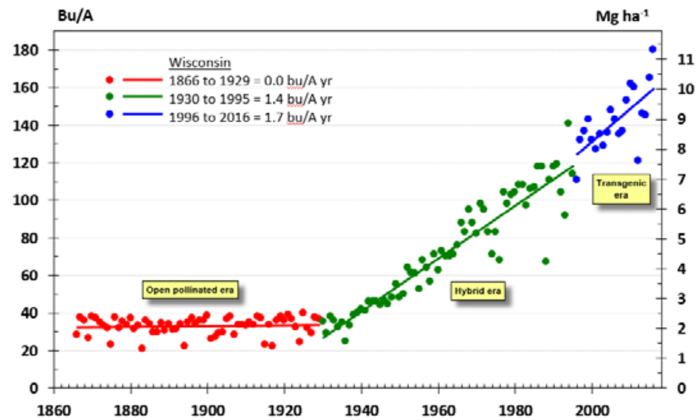


**Figure 1. Corn grain yield for Wisconsin since 1866. Source USDA-NASS.**

Many people are asking what

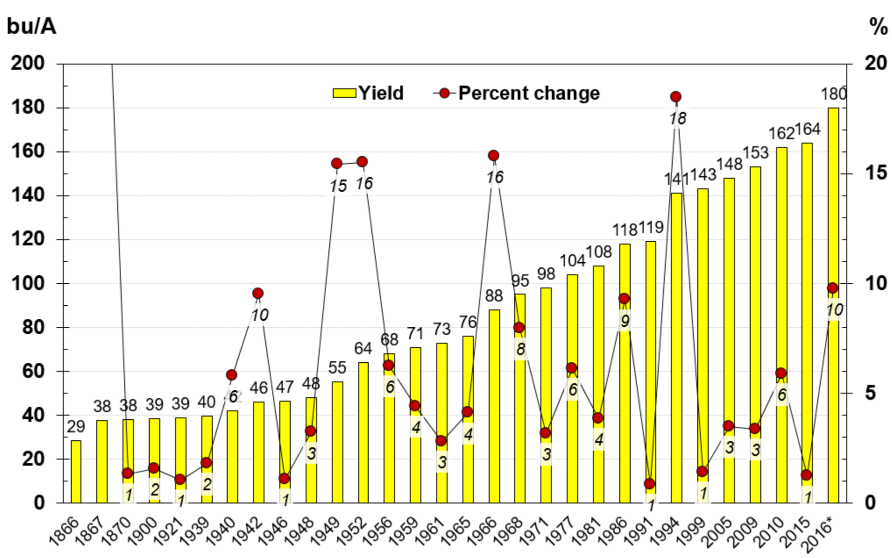


**Figure 2. Years of record corn yield (N= 29 of 151) and the percent increase over the previous record year. Source USDA-NASS.**

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happened during 2016 to produce record yields? More importantly, why did corn yields jump 10% over the previous record? Are corn hybrids that much better? What management practices were different during 2016? Was it the weather? If one were to list the top reasons for the bumper crop, 8 of the top 10 reasons would have to be weather related. Improved hybrid genetics and management might also make the top 10.

Common characteristics between these record years include: (1) earlier than normal planting, (2) adequate spring soil moisture, (3) mild moisture stress during early corn development with soil moisture eventually replenished to normal levels, (4) corn development was typically ahead of normal at some point during the growing season, (5) fall killing frosts were at the end of September or during October, and (6) fall harvest conditions were typically dry.

In most years, the majority of Wisconsin's corn acreage is planted past the optimum date. On average, approximately 27% of the corn acreage is planted by May 10, 45% by May 15, 62% by May 20, and 77% by May 25. In numerous studies, the optimum planting date for corn production in Wisconsin was found to be between May 1 for southern Wisconsin and May 10 for northern Wisconsin. Shortly after the optimum date, corn yields decrease 0.3 to 0.5% per day which accelerates to 1.5 to 2.3% per day when corn is planted during late May. In the record years, planting was reported to be earlier than normal with more of the acreage planted around the optimum planting date.

In record years, inadequate soil moisture supplies were often reported during late May and early June. Mild moisture stress, during early corn development, increases the allocation of photosynthate to roots at the expense of shoots and leaves, thus, promoting deeper root growth and increased soil exploration for water, minerals and other nutrients. As moisture stress becomes more severe, total root weight can decrease. In all of these years, rainfall replenished soil moisture supplies to normal or above normal levels by late June to early July.

Will 2017 be another record year? A record year follows another record year or tie about 31% of the time. There is no reason why another record year could not take place in 2017.

# COMPARISON OF SOYBEAN YIELDS IN ON-FARM TRIALS VS. SMALL PLOT EXPERIMENTS

Tristan Mueller [1/]

## Abstract

Performance of foliar fungicides can be evaluated in field-scale on-farm replicated strip trials and in small-plot experiments. This presentation will present analyses of two datasets from Iowa to compare yield and yield response variability to fungicide applications in on-farm trials versus small-plot experiments. An estimate number of locations, replications and years required to detect yield differences of interest will be covered. One dataset includes 123 on-farm trials evaluating Headline (BASF) foliar fungicide on soybean (*Glycine max* (L.) Merr) in 2008 and 2009 across Iowa by farmers working with the Iowa Soybean Association On-Farm Network. The other dataset includes small-plot experiments conducted by university researches to evaluate the same fungicide during the same growing seasons at six Iowa State University Research and Demonstration Farms. On-farm trials were harvested by farmers' combines equipped with yield monitors and GPS and small-plot experiments by small-plot combines. Variance component analysis was used to quantify the random sources of yield variation contributed by location and blocks nested within each location and conduct power analyses for multi-location trials. Disease ratings were done in all small-plot trials. While yield responses in the two types of trials were similar (about 125 kg $ha^{-1}$), the residual random yield variation in on-farm trials tended to be smaller than that in small-plot trials but the random variation due to location effect was larger in on-farm trials. The presentation will show examples of power curves showing the numbers of trials, replications and years required to detect specific response, often <68 kg $ha^{-1}$ . The results also suggest about the different utility of two methods for evaluating fungicides, specifically, the on-farm trials for answering the question "when, where and how likely" a given fungicide works while small-plot trials for comparing multiple chemistries at the same locations and quantifying the interactive effects of application timing.

[1/] Director of Global Field Development, BioConsortia.

# IMPROVING WHITE MOLD MANAGEMENT OF SOYBEAN IN WISCONSIN

Jaime Willbur[1/], Megan McCaghey[2/], Scott Chapman[3/], Medhi Kabbage[4/], Damon L. Smith[5/]

## Introduction

White mold (Sclerotinia stem rot) is caused by *Sclerotinia sclerotiorum* and consistently ranks in the top ten diseases plaguing global soybean crops (Wrather *et al.*, 2010). In 2009, United States soybean losses due to white mold reached almost 59 million bushels and cost growers a corresponding ~$560 million (Koenning & Wrather, 2010; Peltier *et al.*, 2012). Furthermore, according to a United Soybean Board report from 2011, white mold epidemics in the Great Lakes region alone were responsible for 94% of nationwide losses to the disease and cost regional growers ~$138 million (USDA-NASS 2015). White mold is infamously characterized by its challenging fungal promiscuity and longevity, and by the subsequently devastating crop losses; Wisconsin growers justifiably rank white mold management third in significance and concern.

Disease control is limited due to the lack of complete resistance in commercial cultivars (Peltier et al. 2012) and the often incomplete or limited success of chemical applications. Rigorous investigation of white mold resistant soybean germplasm for release to breeding programs would improve commercially available resistance. Additionally, improving our understanding of the complex timing and conditions surrounding white mold development would assist in providing effective fungicide recommendations. Product selection and application timing must both be considered for successful white mold management. Furthermore, risk assessment tools may be used to more accurately predict the timing of effective fungicide applications based on weather conditions, pathogen presence, and host architecture. An improved understanding of chemical control, development of resistant germplasm, and an optimized forecasting system would improve management strategies of white mold in soybean.

## Research Objectives

1. Evaluate fungicide product efficacy and application timing for white mold control in Wisconsin.
2. Evaluate physiological resistance to white mold in soybean germplasm using a panel of representative *S. sclerotiorum* isolates.
3. Further investigate the roles of weather variables in the formation of apothecia in soybean crops. Use this information to develop and refine an improved advisory system for white mold in soybean.

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## Methods and Results

*Fungicide efficacy and timing*

In 2016, 15 fungicide applications (including a non-treated control) were evaluated for white mold control in Hancock, Wisconsin (Table 2). Small plots were established in agricultural research station fields with a previous history of white mold; plots were irrigated to promote disease development. Products were applied at either the R1, R3, or both R1 and R3 growth stages. The disease incidence and disease severity index (DSI) was determined at the R6 growth stage and yield data were collected at harvest. The best treatments tended to include Aproach at 9 fl oz applied at R1 and R3 or Endura at 8 oz applied at R1. A combination treatment of Priaxor at 4 fl oz and Endura at 6 oz applied at R1 also resulted in comparably low disease levels and high yields.

Additionally in 2016, 16 fungicide treatment timings (including a non-treated) were evaluated for white mold control at the Hancock Agricultural Research Station (Table 1). Aproach at 9 fl oz, Endura at 8 oz, and Proline at 5 fl oz were applied at the R1, R3, R4, or R5 growth stages. DSI and DI data were collected at the R6 growth stage and yield data were collected at harvest. The best treatments were those where fungicide was applied at the R1 to R3 growth stages (or a combination of R1 and R3 applications). Endura at 8 oz applied at the R3 growth stage and Aproach at 9 fl oz applied at both R1 and R3 resulted in the lowest disease levels and the highest yields.

These results are similar to findings from corresponding trials in Michigan and Iowa. These data, therefore, have been incorporated into extensive fungicide evaluations conducted in the North Central region over the past 8 years. Overall, 26 site-years were analyzed, including data from Illinois, Iowa, Michigan, and Wisconsin, to determine the most efficacious products and timings for soybean white mold management.

*White mold-resistant germplasm*

Previously, resistant soybean germplasm was generated from crosses between highly resistant experimental lines (W04-1002 or AxN-1-55) and lines exhibiting good resistance to other diseases such as brown stem rot, soybean sudden death syndrome, and soybean cyst nematode. Over the last 3 years, germplasm lines have been rigorously evaluated in white mold nurseries under high disease pressure. In 2016, seven elite lines were selected and evaluated against seven other check lines or industry standard varieties. The trial was conducted at the Hancock Agricultural Research Station in small, irrigated plots. Disease (DSI and DI), lodging, and yield data, as well as oil and protein content, were collected and evaluated for all lines. Additionally, the seven elite lines were challenged with a panel of nine representative *S. sclerotiorum* isolates in greenhouse evaluations. Stem lesion development was monitored for 14 days post-inoculation and used to evaluate the durability of germplasm line resistance. Overall, greenhouse line performance against multiple isolates was evaluated against field performance of the same lines to determine the best resistant lines for release to breeding programs. Of particular interest, line 91-38 consistently performed well in greenhouse and field evaluations. In 2016, the line exhibited low disease levels (38.9 DSI, 14% DI), moderate yield (49.8 bu/a), minimal lodging (score of 1.0, upright), and high protein (38.6%) and oil (19.2%) content (relative to averages in the Great Lakes region). Line 91-38 has been selected for public release (2018 growing season) as a food-grade soybean variety.

**Table 1.** White mold ratings and yield of soybeans treated with various fungicides (2016).

| Treatment and Rate/Acre (Crop Growth Stage at Application) | Disease Incidence (%) | Disease Severity Incidence (DSI)[z] | Yield (bu/a) |
|---|---|---|---|
| **Aproach 9.0 fl oz (R1 + R3)** | **3.7** | **20.8 cd**[y] | **82.5** |
| **Endura 6 oz (R1) + Priaxor 4.0 fl oz (R3)** | **3.5** | **17.0 cd** | **81.9** |
| **Endura 8 oz (R1) - Positive Control** | **3.9** | **20.3 cd** | **79.2** |
| **Priaxor 4.0 fl oz (R1) + Endura 6.0 fl oz (R1)** | **3.0** | **17.2 cd** | **78.5** |
| Domark 5 fl oz (R1) | 6.2 | 33.6 abc | 78.4 |
| Domark 4 fl oz (R3)+ Topsin-M 0.75 lbs (R3) | 3.0 | 21.4 cd | 78.0 |
| Priaxor 4.0 fl oz + Domark 4.0 fl oz (R1) | 7.4 | 44.7 a | 77.8 |
| Endura 6 oz (R1) | 3.6 | 18.9 cd | 77.2 |
| Domark 5 fl oz (R3) | 6.9 | 30.3 abc | 77.1 |
| Topsin-M 0.75 lbs (R1) | 2.6 | 16.1 cd | 76.2 |
| Non-treated control | 6.9 | 32.2 abc | 74.9 |
| Domark 4 fl oz (R1)+ Topsin-M 0.75 lbs (R1) | 7.1 | 35.3 abc | 74.9 |
| Cobra 6.0 fl oz (R1) + Endura 8.0 oz (R1) | 2.7 | 13.6 bcd | 72.9 |
| Vida 0.5 fl oz + Domark 5 fl oz (R3) | 1.4 | 7.8 d | 72.1 |
| Topsin-M 0.75 lbs (R3) | 3.8 | 26.4 a-d | 69.3 |
| *F*-value | 1.33 | 2.05 | 1.54 |
| *Pr>F* | 0.24 | 0.03 | 0.14 |

[z]Sclerotinia stem rot DSI was generated by rating 30 arbitrarily selected plants in each plot and scoring plants with on a 0-3 scale: 0 = no infection; 1 = infection on branches; 2 = infection on mainstem with little effect on pod fill; 3 = infection on mainstem resulting in death or poor pod fill. The scores of the 30 plants were totaled and divided by 0.9.
[y]Means followed by the same letter are not significantly different based on Fisher's Least Significant Difference (LSD; $\alpha$=0.05)

**Table 2.** White mold ratings and yield of soybeans treated with various fungicides applied at different growth stages (2016).

| Treatment and Rate/Acre (Crop Growth Stage at Application) | DI (%) | DSI[z] | Yield (bu/a) |
|---|---|---|---|
| **Aproach 9.0 fl oz (R1+R3) [Standard Check]** | **10.2 de[y]** | **30.8 f** | **77.0 a** |
| **Endura 8.0 oz (R3)** | **6.8 e** | **20.2 g** | **75.3 ab** |
| Aproach 9.0 fl oz (R3) | 15.0 b-d | 45.2 de | 72.5 abc |
| Endura 8.0 oz (R1) [Standard Check] | 14.3 cd | 37.1 ef | 68.6 bcd |
| Proline 5.0 fl oz (R4) | 21.0 abc | 66.1 abc | 68.5 bcd |
| Proline 5.0 fl oz (R3) | 15.9 bcd | 47.5 cde | 66.4 cde |
| Aproach 9.0 fl oz (R5) | 20.0 ac | 49.1 be | 66.0 c-f |
| Aproach 9.0 fl oz (R4) | 25.3 ab | 67.1 ab | 62.9 d-g |
| Endura 6.0 oz (V5) | 22.5 abc | 51.9 be | 61.7 e-g |
| Aproach 9.0 fl oz (V5) | 24.2 abc | 54.5 bcd | 61.6 e-g |
| Non-Treated Control | 25.6 ab | 62.5 a-d | 61.0 e-g |
| Endura 8.0 oz (R4) | 32.1 a | 77.0 a | 60.8 e-g |
| Endura 8.0 oz (R5) | 30.1 a | 64.5 abc | 60.3 e-g |
| Proline 5.0 fl oz (R1) | 25.2 ab | 66.3 abc | 59.7 fg |
| Proline 5.0 fl oz (R5) | 25.3 ab | 56.9 a-d | 59.0 g |
| Aproach 9.0 fl oz (R1) | 33.0 a | 68.2 ab | 57.2 g |
| *F*- value | 4.97 | 8.63 | 6.11 |
| *Pr>F* | <0.01 | <0.01 | <0.01 |

[z]Sclerotinia stem rot DSI was generated by rating 30 arbitrarily selected plants in each plot and scoring plants with on a 0-3 scale: 0 = no infection; 1 = infection on branches; 2 = infection on mainstem with little effect on pod fill; 3 = infection on mainstem resulting in death or poor pod fill. The scores of the 30 plants were totaled and divided by 0.9.
[y]Means followed by the same letter are not significantly different based on Fisher's Least Significant Difference (LSD; α=0.05)

*White mold advisory development*

Previously, a 3-variable model, considering site-specific (GPS referenced) air temperature, relative humidity, and wind speed, was developed to predict apothecial presence in soybean fields. In 2016, model validation was conducted at agricultural research stations in Wisconsin and Michigan. Small plots were scouted to monitor apothecial presence and rated to evaluate disease control. Additionally, apothecial presence and the resulting disease incidence was monitored in 20 Wisconsin grower fields to further evaluate model implementation. Grower field observations matched 89% of same day model predictions; furthermore, full-season model predictions explained 74% of overall disease observations. In addition to the development of a publically available advisory, this modeling exercise is helping to improve our understanding of the complex interaction of temperature and moisture required to make accurate white mold predictions. This understanding may also help us look at long-term forecasting in order to make disease predictions well in advance of an epidemic.

Additionally in 2016, we continued to monitor the growth and development of *S. sclerotiorum* and collected detailed data of the progression and severity of white mold disease in Wisconsin soybean fields. Virtually available weather data were used in a series of statistical models to predict disease development to generate potential models for spray advisory purposes. Based on multi-site validations of model performance, the existing model was refined to consider irrigation, row spacing, air temperature, relative humidity, and wind speed. Separate models were generated for irrigated and non-irrigated fields, using combinations of the remaining four variables, to predict the risk of infection by the white mold fungus. Continued validation of these models will occur in the 2017 field season.

## Conclusions

Successful chemical control of white mold can be achieved using appropriately timed and efficacious fungicide applications. In Wisconsin studies, Endura at 8 oz applied at R1 and Aproach at 9 fl oz applied at R1 and R3 continue to be among the best programs for control. Furthermore, treatments applied at the R1 or R3 growth stages are more effective than those applied at the R4 or R5 growth stages. Fungicide application timing has been further investigated using a predictive advisory system. Virtually available weather data have been successfully used to predict the risk of apothecial presence in a field and, therefore, can be used to accurately and effectively time fungicide applications. Additionally, the predictive model can be improved by considering basic management practices such as row spacing and irrigation. The refined apothecial models will continue to be validated in future years in both research and grower locations. These studies have resulted in the preliminary development of publicly-accessible, site-specific advisory tool. Because chemical control of white mold can be incomplete, white mold-resistant soybean varieties will be a key component of an integrated white mold management program. Rigorously evaluated resistant soybean germplasm, therefore, should be used in the development of more resistant varieties that can eventually be integrated into improved white mold management systems. Overall, appropriate fungicide selection, effective timing of application, and incorporation of promising white mold resistance will improve existing management systems.

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# INTEGRATED MANAGEMENT OF STRIPE RUST OF WHEAT IN WISCONSIN

Brian Mueller[1/], Scott Chapman[2/], Shawn Conley[3/] and Damon Smith[4/]

## Introduction

Wheat stripe rust, caused by the fungal plant pathogen *Puccinia striiformis* f. sp. *tritici,* has been an increasing problem in the central Great Plains and areas of the upper Midwest due to milder winters (Chen, 2005). Since 2000, stripe rust has become an increasing concern on winter wheat in the Midwest. In Wisconsin over the last four seasons, we have observed consistent stripe rust pressure on some varieties throughout the wheat production area of the state. In 2016, some cultivars were hit very hard by this disease. Because of the consistent occurrence of stripe rust over the last few seasons, it is reasonable to expect continued pressure from this disease in 2017.

Stripe rust can be observed on leaves and leaf sheaths and may also infect glumes or kernels if infection is severe. Stripe rust can be identified by orange/yellow pustules that typically occur in a striped pattern on the surface of the wheat leaf. Inoculum (spores) sources are most likely windblown from the southern states and infection occurs when spores land on wheat leaves. Disease is favored by prolonged periods of rain (or dew), high relative humidity, and cool temperatures ranging from 50 to 60 ºF. The major concern of stripe rust is yield loss. Management for stripe rust includes resistant varieties and fungicide applications, along with using cultural practices such as avoiding excessive fertilizer applications and removing volunteer wheat. When choosing resistant varieties, refer to Wisconsin varietal trial results. Timing of fungicide application is critical for chemical control of stripe rust. Flag leaf application (Feekes 8) is often recommended for control of stripe rust. Scouting early is an important factor when making decisions on fungicide application. Fungicide application is based on risk of disease on the emerging flag leaf. Some of these management practices are being investigated for their utility in wheat production in Wisconsin.

## Objectives

1. Evaluate stripe rust-resistant cultivars and fungicide timings in the wheat-growing region of Wisconsin for control of stripe rust.
2. Evaluate yield loss from stripe rust in soft red winter wheat.

## Method

Data used in the yield loss analysis were collected from the Wisconsin winter wheat variety trials located in Chilton, Fond du Lac, Arlington, and Sharon Wisconsin in 2016. Sites consisted of individual plots planted with different cultivars with a range of resistance to stripe rust. Stripe rust

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was evaluated by visually estimating average incidence (% plants with symptoms) and disease severity (% flag leaf with symptoms) by use of a standard area diagram. Yield (corrected to 13.5% moisture) was determined by harvesting the center 5 feet of each plot using an Almaco SPC40 small-plot combine equipped with a HarvestMaster HM800 Classic Grain gauge. Yield loss due to disease severity was analyzed by regression analysis.

The integrated management trial was established at the Arlington Agricultural Research Station located in Arlington, WI. Fungicides were applied at three growth stage timings; jointing, flag leaf emergence, and boot stage. These applications were compared to a non-treated control or a full-season fungicide application which acted as the positive control. Growth-stage applications were applied to winter wheat cultivars varying in resistance to stripe rust: resistant ('Pro 380'), moderately susceptible ('Kaskaskia') and susceptible ('Pro 420'). The experimental design was a randomized complete block with four replicates. Plots were 21 ft long and 7.5 ft wide with four-ft alleys between plots. Standard wheat production practices as described by the University of Wisconsin Cooperative Extension Service were followed. Fungicides were applied using a $CO_2$ pressurized backpack sprayer equipped with TTJ60-11002 Turbo TwinJet flat fan nozzles calibrated to deliver 20 GPA at 30psi. Stripe rust was evaluated by visually estimating average incidence (% plants with symptoms) and average severity (% flag leaf with symptoms) per plot. Yield was determined by harvesting the center five feet of each plot using an Almaco SPC40 small-plot combine equipped with a HarvestMaster HM800 Classic Grain gauge. All disease and yield data were analyzed using a mixed model analysis of variance and means were separated using Fisher's least significant difference ($P$=0.05) yield. Contrast statements were used to analyze treatment structure.

## Results and Discussion

Trial locations had an average yield potential of 130.4 bu/a. For every one percent increase in stripe rust severity a loss of 0.5 bu/a ($R^2$=0.4059) is projected, based on our model (Fig. 1). Stripe rust can result in significant yield losses in Wisconsin. Thus, integrated management strategies for stripe rust will be important for future wheat crops in Wisconsin.

In the integrated management trial, flag leaf and boot fungicide applications led to a significant reduction in stripe rust incidence for cultivars Kaskaskia and Pro 420 when compared to the non-treated control at the ($P$<0.01; Fig. 2). Jointing application resulted in no significant difference in disease compared to not treating for the cultivars Pro Seed 420 and Kaskaskia. Disease incidence scores were not significantly different among all treatments applied to the resistant cultivar Pro Seed 380. Pro Seed 380 is a highly resistant cultivar. Therefore, lack of response in disease levels by applying fungicide was expected. The presence of disease prior to flag leaf emergence and the susceptibility of Kaskaskia and Pro Seed 420 to stripe rust, resulted in elevated disease levels on those cultivars compared to Pro Seed 420. This enabled the detection of significant differences between single flag leaf and boot applications for these cultivars.

Cultivars and fungicide treatment main effects on yield were significant *(P*<0.001). There was no interaction of cultivar or fungicide treatment *(P*>0.05). Pro Seed 420 and Pro Seed 380 had significantly ($P$<0.01) higher yields than Kaskaskia (data not shown). Full season fungicide coverage led to the highest yields across all cultivars (Fig. 3). Headline applied at boot and flag leaf led to comparable yields to full season fungicide coverage.

Due to the nested treatment structure of application timing within the fungicide programs, contrast statements were utilized to investigate application timing of fungicides. Jointing applications compared to no treatment were not significant (Table 1). Jointing application showing no benefit to yield or disease control may be because fungicide protection is lost after approximately 14 days after application. Boot stage application led to significantly higher yields than jointing applications or not treating. Furthermore, Boot applications were not significantly different in yield for flag leaf applications (*P*>0.40). Complete fungicide coverage led to a 6.4 bu/a increase over the boot application. Full coverage application resulted in the highest yields and lowest disease levels but this program is not recommended because of the cost to apply that many treatments in a season. These results suggested that applying a fungicide at or near the boot stage in 2016 led to nearly optimal control of stripe rust in Wisconsin.

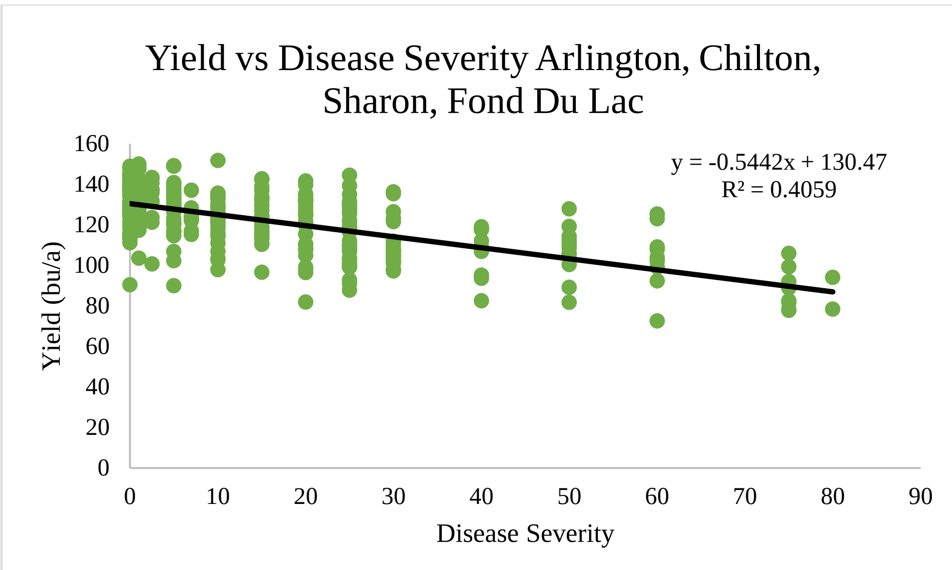


**Figure 1.** The relationship between wheat stripe rust severity and yield loss across four Wisconsin locations in 2016

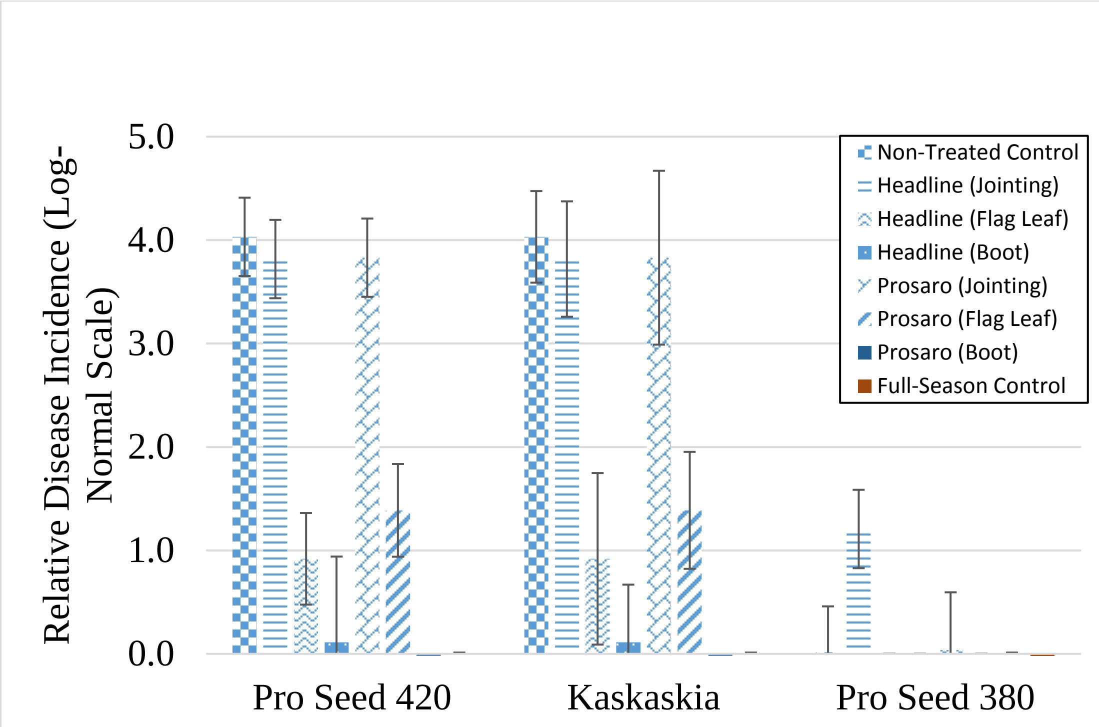


**Figure 2.** Relative disease incidence (%) by treatment for three cultivars in Wisconsin in 2016. Brackets on bars indicate the standard errors of the mean.

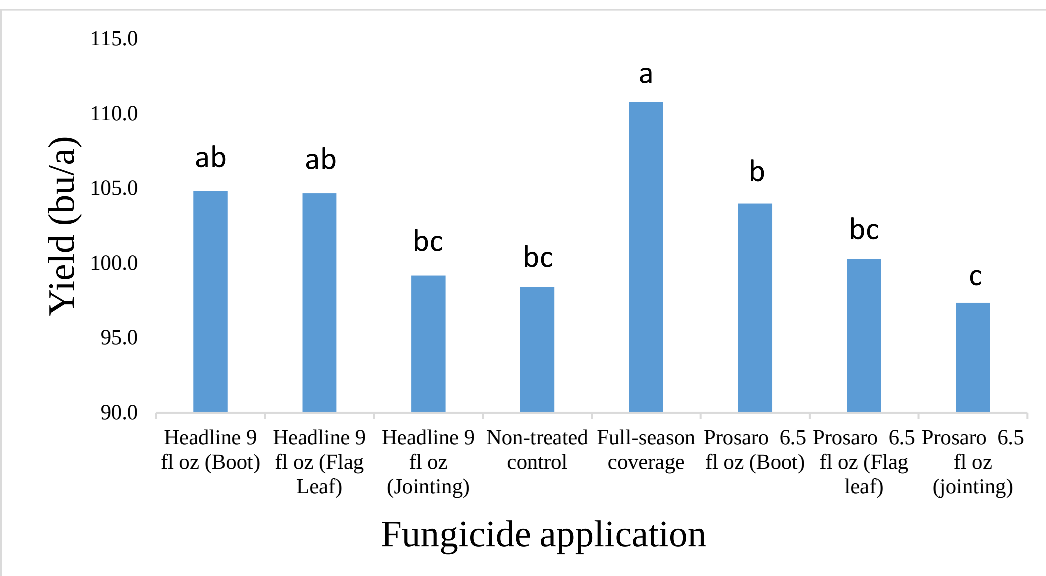


**Figure 3.** Mean yield (bu/a) for eight fungicide treatment programs on winter wheat in Wisconsin in 2016. Bars with the same letter are not significantly different based on the test of Least Significant Difference (LSD) at (*P* = 0.05).

**Table 1.** Contrast statements comparing yield (bu/a) by application timing for all fungicides used in the integrated management trial in Wisconsin in 2016.

| Treatment Timing Tests | Yield Difference (bu/a) | SE* | DF** | t Value | Pr > \|t\| |
|---|---|---|---|---|---|
| **Flag leaf vs. Jointing** | 8.4 | 4.6 | 67 | 1.83 | 0.0709 |
| **Flag leaf vs. Boot** | -3.8 | 4.5 | 66.9 | -0.85 | 0.4001 |
| **Jointing vs. Boot** | -12.3 | 4.6 | 67 | -2.67 | 0.0095 |
| **Complete Coverage vs. All timings** | 9.1 | 2.5 | 66.9 | 3.69 | 0.0005 |
| **Jointing vs. No treatment** | -0.2 | 2.9 | 67.0 | -0.05 | 0.9584 |
| **Flag leaf vs. No Treatment** | 4.1 | 2.9 | 67.0 | 1.41 | 0.1627 |
| **Boot vs. No Treatment** | 6.0 | 2.9 | 67.0 | 2.08 | 0.0416 |
| **Complete coverage vs. No Treatment** | 12.4 | 3.3 | 67.0 | 3.75 | 0.0004 |
| **Complete Coverage vs. Boot** | 6.4 | 2.8 | 66.9 | 2.29 | 0.0251 |

*SE=standard error
**DF=degrees of freedom

## Summary

Stripe rust management begins with selecting a high yielding, resistant variety appropriate for your location, based on the Wisconsin Winter Wheat Performance Trial Report. Planting a resistant variety is a key component to managing stripe rust but does not guarantee complete control. Resistance can eventually be overcome by the pathogen, which makes referring to yearly performance trial reports necessary in a successful management system. Frequent scouting is recommended in the spring, and if disease is active in the lower leaf canopy prior to flag leaf emergence, then a single fungicide application at the boot growth stage or during flag leaf emergence may provide adequate protection and prevent significant yield loss. Strobilurins, demethylation inhibitors (DMI), or a combination of these modes of action are suitable for control of stripe rust prior to wheat heading.

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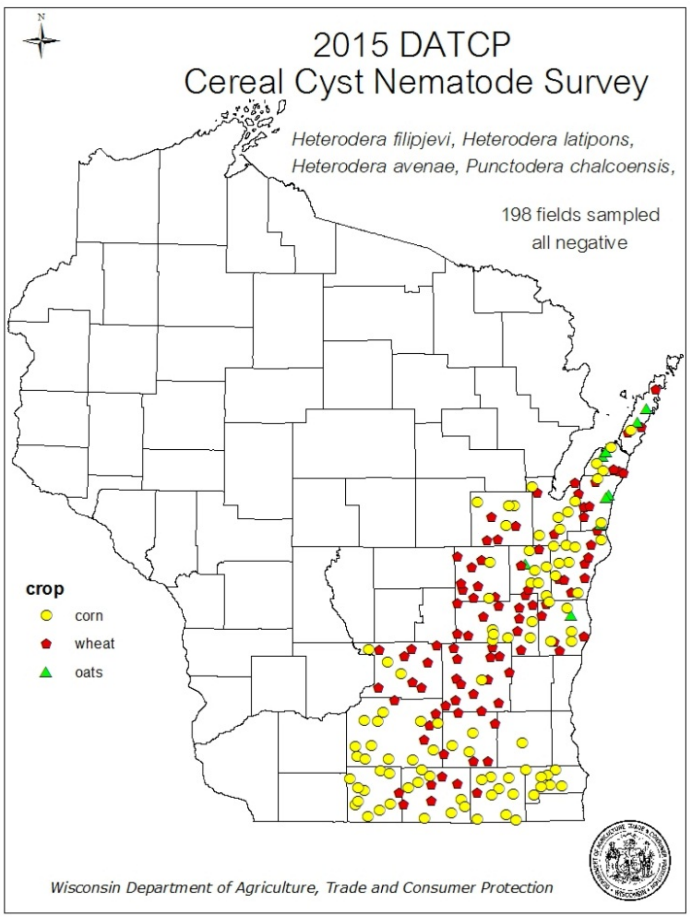
2016 WISCONSIN CROP DISEASE SURVEY

Anette Phibbs[1], Susan Lueloff[1] and Adrian Barta[2]
https://datcp.wi.gov/Pages/Programs_Services/PestSurvey.aspx

This survey was conducted to detect exotic cyst nematodes in cereal and corn producing fields of Wisconsin. The targeted nematodes were *Heterodera filipjevi*, the cereal cyst nematode; *Heterodera latipons*, the Mediterranean cereal cyst nematode; and *Punctodera chalcoensis,* the Mexican corn cyst nematode. Any of these nematodes could potentially impact crop production, management practices and trade if they were accidentally introduced into this state.

Sampling was conducted in counties that contain the majority of the wheat acreage in the state, (Brown, Calumet, Columbia, Dane, Dodge, Door, Fond du Lac, Green, Jefferson, Kewaunee, Manitowoc, Outagamie, Racine, Rock, Sheboygan and Walworth, Winnebago). Wheat is the main host for *H. filipjevi* and *H. latipons*. Corn, the host *of P. chalcoensis* is also grown in these counties.




From April 17 to November 2, 2015, the survey collected 198 soil samples (15-20 cores per field), 98 samples were collected from corn, 91 from wheat and 9 from oat fields. Soil samples were taken to Plant Industry lab for cyst extraction and identification. All soil samples tested negative for the three exotic cyst nematodes. The map shows the surveyed field locations by crop.

28% of soil samples contained cyst nematodes often found in Wisconsin fields. Soybean cyst nematode (*Heterodera glycines*) which is a common pest in soybeans, was found in 29 fields. Clover cyst nematode (*H. trifolii*) was detected in 5 fields and *Cactodera* spp. in 12 fields. Clover cysts infest clovers and legumes but not corn or cereals. *Cactodera* cysts are usually found on non-crop hosts except one. This cyst was determined to be *Cactodera rosae*, a species previously only reported on barley roots and soil in Mexico. Comparison of partial 28S rDNA sequence showed 100% homology to this species that was first described in 2008 by Cid del Prado. Morphology was confirmed by the USDA Nematologist. Our knowledge of this species is very limited at

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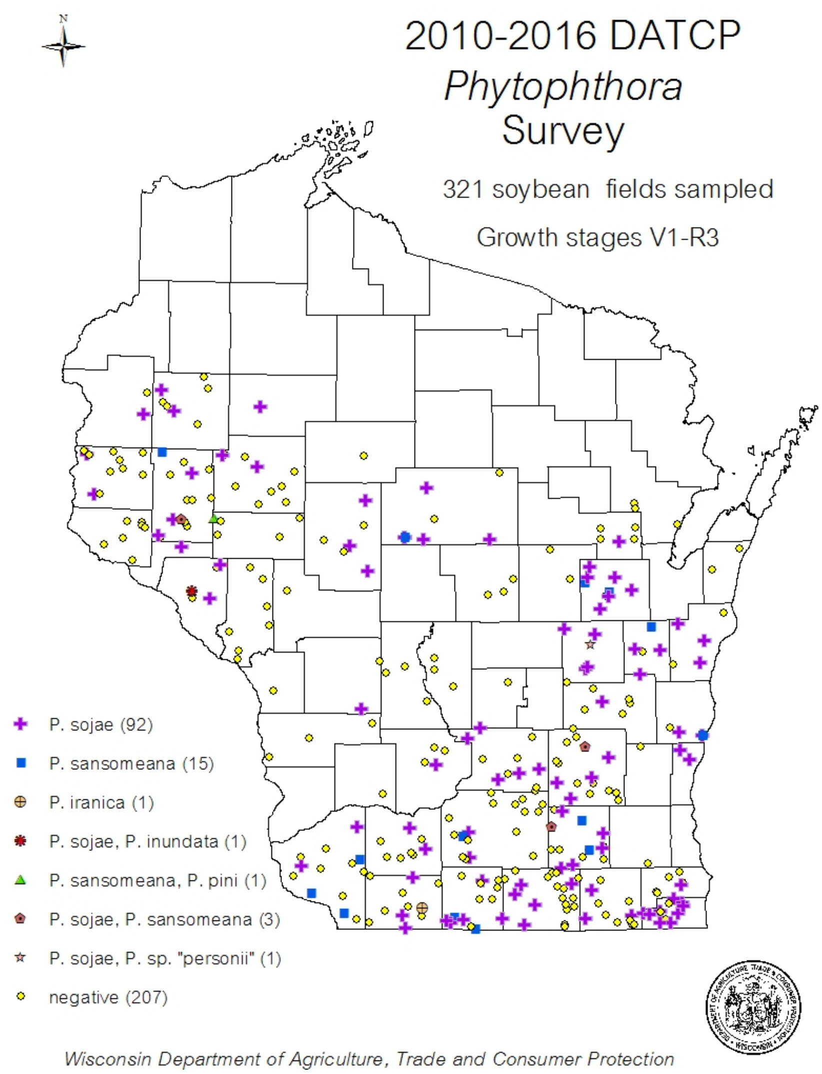
this point, including if there is any effect on cereal or corn. This is a first detection of *Cactodera rosae* in Wisconsin and possibly the US.

**The 2016 Early Season Survey for Soybean Phytophthora Root Rot** showed 32% (17 of 53) of surveyed fields tested positive for Phytophthora root rot disease caused by *Phytophthora sojae* compared to 38% in 2015. Fifty-three fields in the vegetative stages were sampled from June 7 to July 13. This fungus-like pathogen that causes soybean damping-off was detected in 12 counties: Barron, Columbia, Crawford, Dodge, Dunn, Green, Jefferson, Marathon, Outagamie, Racine, Rock, and Walworth.

Besides ***P. sojae***, that is known to occur throughout the state, this survey has been looking for Phytophthora species that are new to Wisconsin soybean production areas. Since 2012 five other Phytophthora species have been identified: *P. sansomeana*, *P. pini*, P. sp. "*personii*", *P. inundata* and *P. iranica*. ***P. sansomeana*** has been documented in soybean in 10 Wisconsin counties (Calumet, Dane, Dodge, Dunn, Eau Claire, Green, Jefferson, Outagamie, Marathon and Sheboygan). It was detected in soybean roots from a Dunn Co. field this year. At least some isolates of *P. sansomeana* have been reported to be pathogenic on soybean and corn. It has also been found on Christmas trees in Wisconsin.




*P. pini* and *P.* sp. *personii* were found in 2014, *P. inundata* and *P. iranica*, in 2015. It is not known at this time if these four species could have any significant impact on soybean production. They are associated with diseases on a variety of vegetables, hardwood trees and shrubs in other countries.

**Corn Fall Survey** and inspections screened for two new diseases, tar spot of corn (*Phyllachora maydis*) and Xanthomonas blight (*Xanthomonas vasicola pv. vasculorum*). 105 fields throughout Wisconsin were visited from Aug 5 to Sept 15, 2016.

**Tar spot** was detected in Green County on September 12, 2016 by DATCP's pest survey team and in Iowa Co, on

September 20 by UW-Madison. The USDA Mycologist confirmed this first detection of tar spot disease in Wisconsin. It is considered of minor importance at this point. The disease that only affects corn was reported on corn in Indiana and Illinois in 2015. It is better known in Mexico, Central and South America. In Mexico significant crop losses were observed when tar spot infections were colonized by another fungus *Monographella maydis*. This second fungus has not been observed in Wisconsin. Tar spot is spread on plant debris that is carried by wind and rain.

**Xanthomonas blight** was not observed in Wisconsin in 2016. Samples were examined at PIB lab and a suspect was send to the USDA identifier in Kansas where is was pronounced negative. This bacterial pathogen was confirmed on Aug. 26, 2016 in Colorado, Nebraska, Illinois, Iowa and Kansas. It was first reported in the Republic of South Africa in 1949. Symptoms are similar to gray leaf spot but since this is a bacterial disease, fungicide applications are ineffective. USDA determined Xanthomonas blight is of negligible disease importance and has no quarantine significance for domestic or international trade.

This corn survey also detected **Southern rust** (*Puccinia polysora*) in Lafayette (September 9) and Grant counties (September 15). Prior to that UW reported it in Rock Co (August 25). Southern rust is rare in Wisconsin. It does not overwinter but occasionally can be blown up from the southern US and tropics. Late season arrivals after corn is in milk stage (R3) pose less of threat to production.

**Goss's Wilt of Corn** was detected in 6 Wisconsin counties (Dane, Fond du Lac, Eau Claire, Grant, Pierce and Walworth) during seed corn field inspections in August. This bacterial disease caused by *Clavibacter michiganensis nebraskensis* was confirmed in 11 of 78 (14.1%) samples at Plant Industry lab compared to 15 of 39 (38.5%) in 2015. Stewart's wilt (Pantoae stewartii) was not detected. Northern corn leaf blight (*Exserohilum turcicum*), common rust (*Puccinia sorghi*) and anthracnose (*Colletotrichum graminicola*) were the most common diseases.

**Virus Screening of Corn** continues to show no evidence of high plains virus (HPV), wheat streak mosaic virus (WSMV) or Maize chlorotic mottle virus (MCMV) in Wisconsin. Three fields in Dane county tested positive for sugarcane mosaic virus (SCMV), formerly called maize dwarf virus (MDMV).

**Potato Late Blight** caused by *Phytophthora infestans* was reported by UW from two Wisconsin counties in 2016: Polk (tomato and potato) and Dane County (tomato). PIB lab helped to resolve an incident of potato foliage with late blight-like symptoms from Adams Co. by determining it was infected with another species of this fungus-like pathogen called *P. nicotianae*. Sporadic infections with this pathogen have been reported from Florida, Missouri, Nebraska, and Michigan. It is usually associated with tobacco, onion, tomato, infecting 90 plant families causing fruit-, leaf blight and root rot on ornamentals, fruits and vegetables. This may be a first find on potato in Wisconsin. Red Norland are considered more susceptible than Russet potato varieties.

# THE IMPERFECT WORLD OF DISEASE RESISTANCE

Mehdi Kabbage [1/]

SPACE PROVIDED FOR QUESTIONS OR NOTES

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LESION NEMATODES - PESTS OF CORN, SOYBEANS, AND EVERY OTHER CROP GROWN IN WISCONSIN[1]

Ann MacGuidwin and Kanan Kutsuwa[2]

The Root Lesion nematode, *Pratylenchus* spp., is very common in the north central United States, ranking first or second for incidence among pest nematodes in Illinois (Mekete et al., 2011), Iowa(Tylka et al. 2011), and Minnesota(Chen et al., 2012). It is the most common pest nematode recovered from samples sent to the UW Nematode Diagnostic Service in Wisconsin. The percentage of samples positive for Root Lesion ranged from 90 to 95% for 2013 to 2016 and represented the majority of the counties with corn and soybean production.

Population densities of Root Lesion can build rapidly because this pest has a very wide host range and a high capacity for surviving adverse conditions. It can feed on the outer tissues of roots or burrow into the root and feed from within. The damage Root Lesion cause to roots and the associated yield loss is related to pest density – a low abundance of nematodes usually causes little damage and a high abundance of nematodes can cause stunting and decreased yield. The population density of Root Lesion within a field is very dynamic and affected by the time of year, weather, crop, and variety. Young plants are most sensitive to nematode damage.

The UW Diagnostic Service, as well as other labs, count the nematodes recovered from a given volume of soil and either report the number directly or as the risk category associated with the count. We use a dual assay to recover nematodes from both the soil and the root pieces contained in the sample (MacGuidwin and Bender, 2012). Dead root fragments of the previous crops that are present in soil year-round are joined by living root pieces during the growing season. Assays of both the soil and root habitats for the nematode provide a more accurate estimate of pest pressure than soil counts alone or roots removed from a select few living plants during the summer.

Characterizing the disease potential of Root Lesion and predicting crop loss is a complex process because the pest population, root system, and vulnerability of the crop changes over time. Root Lesion can be recovered from soil 365 days per year, but the interpretation of the results changes with the calendar. Nematode counts in the early season can be directly related to yield loss. Counts obtained later in the season have limited usefulness to the current crop but are useful for projecting the pressure to the next year's crop. The genus *Pratylenchus* is composed of more than sixty species, so another complication arises when more than one species is present within a field. The species of greatest concern to grain, vegetable, and fruit crops in Wisconsin is *Pratylenchus penetrans*. No lab provides identification to the species level so risk assessment for clinic samples is based on the average pathogenicity within the genus.

Root Lesion nematodes interact with fungi to cause disease for some crops. The Potato Early Dying Disease (PED) caused by *Verticillium dahliae* and *Pratylenchus penetrans* is the most important example in Wisconsin. A linear dose- response relationship explains yield loss for both

[1] This research is funded, in part, by the Wisconsin Soybean Marketing Board and the Corn Marketing Board

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pathogens alone, but their combined effects are synergistic such that disease (and yield loss) can occur when they occur together at very low densities (MacGuidwin and Rouse, 1990). Many people assume that all crops are impacted by interactions of Root Lesion and various soil-borne fungi, but that assumption requires verification. Research in the MacGuidwin lab showed that the potential for an interaction even varies within a single species of fungus: one isolate of *Fusarium verticilliodes* interacted with *P. penetrans* on corn seedlings and three did not in a growth chamber study. Damage functions for Root Lesion, as well as other nematodes, will improve as research studies reveal disease complexes such as PED.

The MacGuidwin Lab is developing damage functions for *Pratylenchus penetrans* on crops important to Wisconsin. We chose this species because of its demonstrated pathogenicity to a wide range of crops and because *P. penetrans* tends to dominate in fields infested with multiple Root Lesion species. Our current focus is on the metric “nematodes per 100 cc soil (and root fragments therein)” at crop emergence. This time point was selected on the basis of published research and published functions describing the relationship between population densities in the fall and spring (MacGuidwin and Forge, 1991).

We recently published a damage function for corn using a component error modeling approach (MacGuidwin & Bender, 2012). The estimated yield loss caused by each nematode present at the time of planting was 0.0142%. Due to a high level of variability within the model, we consider this to be a general estimate better suited for demonstrating the impact of *P. penetrans* on a regional scale than predicting yield loss within a field. Using the same approach for soybean (unpublished), the estimated yield loss per nematode was 0.0257%. Research for soybean is in progress and our goal is to develop a model useful for the field scale.

One immediate outcome of our research efforts is recognition that Root Lesion is a constraint to yield of both corn and soybean. The fields we used for model development were considered “high yielding” without need for nematode management. The pest status of Root Lesion for corn has achieved moderate recognition due, in part, to commercial seed treatments. There is less awareness of Root Lesion damage to soybean. The persistence and detrimental impact of Root Lesion on both crops suggests the most successful strategy will be to think about “land management” as well as “crop management”.

One immediate outcome of our research efforts is recognition that Root Lesion is a constraint to yield of both corn and soybean. The fields we used for model development were considered “high yielding” without need for nematode management. The persistence and detrimental impact of Root Lesion on both crops suggests the most successful strategy will be to think about “land management” as well as “crop management”. To that end, we are using a systems approach to study soil factors such as organic matter, pH, etc. to better understand variables that contribute to the carry-over and increase of Root Lesion populations throughout the rotation.

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# VETERINARY FEED DIRECTIVE: A VETERINARIAN'S PERSPECTIVE

Katie J Mrdutt, DVM [1]

## Introduction

The Veterinary Feed Directive (VFD), now in effect as of January 1st, 2017, is a major change within animal agriculture. As part of the FDA's larger initiative against antibiotic resistance, the VFD aims to bring all feed medications containing medically important antibiotics under the oversight and supervision of a licensed veterinarian. With the growing demand for transparency of animal care and antibiotic stewardship in animal agriculture, the VFD is a necessary next step to meet the demands of consumers. "The actions the FDA has taken to date represent important steps toward a fundamental change in how antimicrobials can be legally used in food producing animals," said Michael R. Taylor, FDA deputy commissioner for foods. "The VFD final rule takes another important step by facilitating veterinary oversight in a way that allows for the flexibility needed to accommodate the diversity of circumstances that veterinarians encounter, while ensuring such oversight is conducted in accordance with nationally consistent principles."[5]

Food safety is a key responsibility of any food animal veterinarian. Being a highly respected resource for animal health the public looks to veterinarians to help ensure the products the animal agriculture industries produce are safe and free of drug residues. In addition, consumers continue to ask the question "Where does my food come from and how is it raised?" Veterinarians and producers have the responsibility of using currently available medications properly, to eliminate potential antibiotic residues and combat antibiotic resistance.

## History

In December of 2016, full implementation of FDA's Guidance #213 was expected to be completed significantly changing the way antibiotics have been used in animal agriculture. [2] Moving forward in 2017, these medically important antibiotics can only be used for prevention, control or treatment- judicious uses as defined by the FDA. Any use for production purposes or growth efficiency, as outline in FDA's Guidance 209, is now illegal and cannot be authorized.[3] Furthermore, all remaining legal uses will require authorization from a licensed veterinarian with a valid VCPR in order for a producer to obtain and feed VFD feeds.

As described in FDA's Guidance 152, certain classes of antibiotics are considered medically important in human medicine.[4] Shared class antibiotics considered medically important administered through the feed or water changed to VFD or Rx status, respectively, as of January 1st, 2017. See Figures 1 and 2.

## Information required on a lawful VFD[5]

Veterinary Feed Directives are written by the authorizing veterinarian. The following information should be contained on every VFD:

- veterinarian's name, address, and telephone number;
- client's name, business or home address, and telephone number;
- location at which the animals specified in the VFD are located;
- date the VFD was issued;

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- expiration date of the VFD;
- name of the VFD drug(s);
- species and production class of animals to be fed the VFD feed;
- approximate number of animals to be fed the VFD feed by the expiration date of the VFD;
- indication for which the VFD is issued;
- level of VFD drug in the feed and duration of use;
- withdrawal time, special instructions, and cautionary statements necessary for use of the drug in accordance with the approval;
- number of reorders (refills) authorized, if permitted by the drug approval, conditional approval, or index listing;
- statement: "Use of feed containing this veterinary feed directive (VFD) drug in a manner other than as directed on the labeling (extra label use), is not permitted";
- an affirmation of intent for combination VFD drugs as described in 21 CFR 558.6(b)(6); and
- a veterinarian's electronic or written signature.

The following optional information may also be seen on the VFD:

- a more specific description of the location of the animals (for example, by site, pen, barn, stall, tank, or other descriptor the veterinarian deems appropriate);
- the approximate age range of the animals;
- the approximate weight range of the animals; and
- any other information the veterinarian deems appropriate to identify the animals at issue.

Each party involved in the issuance, distribution and feeding of a VFD order all have responsibilities to create, fill and feed a VFD lawfully. Listed below are the responsibilities of each party involved.

## Veterinarian Responsibilities[5]

- must be licensed to practice veterinary medicine;
- must be operating in the course of the veterinarian's professional practice and in compliance with all applicable veterinary licensing and practice requirements;
- must write VFD orders in the context of a valid veterinarian-client-patient-relationship (VCPR);
- must issue a VFD that is in compliance with the conditions for use approved, conditionally approved, or indexed for the VFD drug or combination VFD drug;
- must prepare and sign a written VFD providing all required information;
- may enter additional discretionary information to more specifically identify the animals to be treated/fed the VFD feed;
- must include required information when a VFD drug is authorized for use in a drug combination that includes more than one VFD drug;
- must restrict or allow the use of the VFD drug in combination with one or more OTC drug(s);
- must provide the feed distributor with a copy of the VFD;
- must provide the client with a copy of the VFD order;

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- must retain the original VFD for two (2) years**, and
- must provide VFD orders for inspection and copying by FDA upon request.

**Veterinarians should check with their respective state licensing boards for state record retention requirements. In Wisconsin, veterinarians are required to maintain and store medical records for a period of three (3) years.

Producer Responsibilities[5]

As the client, a producer must:

- only feed animal feed bearing or containing a VFD drug or a combination VFD drug (a VFD feed or combination VFD feed) to animals based on a VFD issued by a licensed veterinarian;
- not feed a VFD feed or combination VFD feed to animals after the expiration date on the VFD;
- provide a copy of the VFD order to the feed distributor if the issuing veterinarian sends the distributor's copy of the VFD through the client;
- maintain a copy of the VFD order for a minimum of two (2) years; and provide VFD orders for inspection and copying by FDA upon request.

Feed Distributor Responsibilities[5]

- file a one-time notice with FDA of intent to distribute VFD drugs;
- notify FDA within 30 days of any change in ownership, business name, or business address;
- fill a VFD order only if the VFD contains all required information;
- ensure that the distributed animal feed containing the VFD drug or combination VFD drug complies with the terms of the VFD and is manufactured and labeled in conformity with the approved, conditionally approved, or indexed conditions of use for such drug;
- ensure all labeling displays the following cautionary statement: "Caution: Federal law restricts medicated feed containing this veterinary feed directive (VFD) drug to use by or on the order of a licensed veterinarian.";
- retain VFD orders for two (2) years from date of issuance;
- retain records of the receipt and distribution of all medicated animal feed containing a VFD drug for two (2) years;
- provide VFD orders for inspection and copying by FDA upon request;
- retain records of VFD manufacturing for one (1) year in accordance with 21 CFR part 225 and make such records available for inspection and copying by FDA upon request;
- obtain, as the originating distributor (consignor), an acknowledgement letter (see below) from the receiving distributor (consignee) before the feed is shipped; and
- retain a copy of each consignee distributor's acknowledgement letter for two (2) years.

**All distributors of VFD feed must notify FDA before they distribute for the first time. A distributor must also notify FDA within 30 days of a change in ownership, business name, or business address.**

An "acknowledgement letter" is a written (nonverbal) communication provided to you (consignor) from another distributor (consignee). Such letter, provided either in hardcopy or

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through electronic media, must affirm: (1) that the distributor will not ship such VFD feed to an animal production facility that does not have a VFD; (2) that the distributor will not ship such VFD feed to another distributor without receiving a similar written acknowledgment letter; and (3) that the distributor has complied with the distributor notification requirements. If you issue VFD feed only to a client under a VFD order, you will not need to have an acknowledgement letter.

## Category I/II and Medicated Feed Articles[7]

New animal drugs approved for use in animal feed are placed in one of the following two categories:

- Category I--These drugs require no withdrawal period at the lowest use level in each species for which they are approved.
- Category II--These drugs require a withdrawal period at the lowest use level for at least one species for which they are approved, or are regulated on a "no-residue" basis or with a zero tolerance because of a carcinogenic concern regardless of whether a withdrawal period is required.

A "Type A medicated article" is intended solely for use in the manufacture of another Type A medicated article or a Type B or Type C medicated feed. It consists of a new animal drug(s), with or without carrier (e.g., calcium carbonate, rice hull, corn, gluten) with or without inactive ingredients.

A "Type B medicated feed" is intended solely for the manufacture of other medicated feeds (Type B or Type C). It contains a substantial quantity of nutrients including vitamins and/or minerals and/or other nutritional ingredients in an amount not less than 25 percent of the weight. It is manufactured by diluting a Type A medicated article or another Type B medicated feed.

A "Type C medicated feed" is intended as the complete feed for the animal or may be fed "top dressed" (added on top of usual ration) on or offered "free-choice" (e.g., supplement) in conjunction with other animal feed. It contains a substantial quantity of nutrients including vitamins, minerals, and/or other nutritional ingredients. It is manufactured by diluting a Type A medicated article or a Type B medicated feed. A Type C medicated feed may be further diluted to produce another Type C medicated feed.

## Conclusion

The Veterinary Feed Directive is an important step for bringing feed medications under veterinary oversight. Veterinarians, producers and feed distributors need to all work together and communicate to make this process work within our different industries. Animal agriculture has the awesome responsibility of producing safe and healthy food for consumers and therefore need to be transparent and accountable to how we are producing food.

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References

[2] Food and Drug Administration, Center of Veterinary Medicine, Guidance for Industry #209, "The Judicious Use of Medically Important Antimicrobial Drugs in Food-Producing Animals" 13 April, 2012.

[3] Food and Drug Administration, Center of Veterinary Medicine, Guidance for Industry #213, "New Animal Drugs and New Animal Drug Combination Products Administered in or on Medicated Feed or Drinking Water of Food-Producing Animals: Recommendations for Drug Sponsors for Voluntarily Aligning Product Use Conditions with GFI #209", December, 2013.

[4] Food and Drug Administration, Center of Veterinary Medicine, Guidance for Industry #152 "Evaluating the Safety of Antimicrobial New Animal Drugs with Regard to Their Microbiological Effects on Bacteria of Human Health Concern", 23 October, 2003.

[5] Food and Drug Administration, Center of Veterinary Medicine, http://www.fda.gov/AnimalVeterinary/ucm071807.htm, Accessed 19 December, 2016.

[6] "Subchapter E ----Animal Drugs, Feeds, and Related Products" – 21 C.F.R. 558.3, (2016).

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Figure 1

# Drugs Transitioning from Over-the-Counter (OTC) to Veterinary Feed Directive (VFD) Status

Upon completion of their voluntary transition from OTC to VFD, all feed uses of the following drugs, alone and in a combination, will require a VFD as of January 1, 2017, except in cases where a sponsor chooses to voluntarily withdraw the drug application:

### *Drugs Transitioning From OTC to VFD Status*

| Established drug name | Examples of proprietary drug name(s) [$] |
|---|---|
| chlortetracycline (CTC) | Aureomycin, CLTC, CTC, Chloratet, Chlorachel, ChlorMax, Chlortetracycline, Deracin, Inchlor, Pennchlor, Pfichlor |
| chlortetracycline/sulfamethazine* | Aureo S, Aureomix S, Pennchlor S |
| chlortetracycline/sulfamethazine/penicillin* | Aureomix 500, Chlorachel/Pficlor SP, Pennchlor SP, ChlorMax SP |
| hygromycin B | Hygromix |
| lincomycin | Lincomix |
| oxytetracycline (OTC) | TM, OXTC, Oxytetracycline, Pennox, Terramycin |
| oxytetracycline/neomycin* | Neo-Oxy, Neo-Terramycin |
| penicillin[+] | Penicillin, Penicillin G Procaine |
| sulfadimethoxine/ormetoprim* | Rofenaid, Romet |
| tylosin | Tylan, Tylosin, Tylovet |
| tylosin/sulfamethazine* | Tylan Sulfa G, Tylan Plus Sulfa G, Tylosin Plus Sulfamethazine |
| virginiamycin | Stafac, Virginiamycin, V-Max |

Note: apramycin, erythromycin, neomycin (alone), oleandomycin[+], sulfamerazine, and sulfaquinoxaline are also approved for use in feed and are expected to transition to VFD status, but are not marketed at this time. If they return to the market after January 1, 2017, they will require a VFD.

[$]Type A medicated articles used to manufacture medicated feed, all products may not be marketed at this time

*Fixed-ratio, combination drug

[+]Currently only approved for production uses

### *Current VFD Drugs*

| Established drug name | Proprietary drug name(s) [$] |
|---|---|
| avilamycin | Kavault |
| florfenicol | Aquaflor, Nuflor |
| tilmicosin | Pulmotil, Tilmovet |
| tylvalosin | Aivlosin |

[$]Type A medicated articles used to manufacture medicated feed

This information is up-to-date as of August 8, 2016. As the industry transitions, CVM anticipates additional changes during the coming months to this information. Please check the link below for the most recent updates:
http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm071807.htm

Figure 2

## Drugs Transitioning from Over-the-Counter (OTC) to Prescription (Rx) Status

Upon completion of their voluntary transition from OTC to Rx, all uses of the following drugs will require a prescription from a veterinarian as of January 1, 2017, except in cases where a sponsor chooses to voluntarily withdraw the drug application:

### *Water Soluble Drugs Transitioning From OTC to Rx Status*

| Established drug name | Examples of proprietary drug name(s) |
|---|---|
| chlortetracycline | Aureomycin, Aureomycyn, Chlora-Cycline, Chloronex, Chlortetracycline, Chlortetracycline Bisulfate, Chlortet-Soluble-O, CTC, Fermycin, Pennchlor |
| erythromycin | Gallimycin |
| gentamicin | Garacin, Gen-Gard, GentaMed, Gentocin, Gentoral |
| lincomycin | Linco, Lincomed, Lincomix, Lincomycin, Lincomycin Hydrochloride, Lincosol, Linxmed-SP |
| lincomycin/spectinomycin* | Lincomycin S, Lincomycin-Spectinomycin, L-S, SpecLinx |
| neomycin | Biosol Liquid, Neo, Neomed, Neomix, Neomycin, Neomycin Liquid, Neomycin Sulfate, Neo-Sol, Neosol, Neosol-Oral, Neovet |
| oxytetracycline | Agrimycin, Citratet, Medamycin, Oxymarine, Oxymycin, Oxy-Sol, Oxytet, Oxytetracycline, Oxytetracycline HCL, Oxy WS, Pennox, Terramycin, Terra-Vet, Tetravet-CA, Tetroxy, Tetroxy Aquatic, Tetroxy HCA |
| penicillin | Han-Pen, Penaqua Sol-G, Penicillin G Potassium, R-Pen, Solu-Pen |
| spectinomycin | Spectam |
| sulfadimethoxine | Agribon, Albon, Di-Methox, SDM, Sulfabiotic, Sulfadimethoxine, Sulfadived, Sulfamed-G, Sulforal, Sulfasol |
| sulfamethazine | SMZ-Med, Sulfa, Sulmet |
| sulfaquinoxaline | S.Q. Solution, Sulfa-Nox, Sulfaquinoxaline Sodium, Sulfaquinoxaline Solubilized, Sul-Q-Nox, Sulquin |
| tetracycline | Duramycin, Polyotic, Solu/Tet, Solu-Tet, Supercycline, Terra-Vet, Tet, Tetra-Bac, Tetracycline, Tetracycline Hydrochloride, Tetramed, Tetra-Sal, Tetrasol, Tet-Sol, TC Vet |

Note: apramycin, carbomycin/oxytetracycline*, chlortetracycline/sulfamethazine*, streptomycin, sulfachloropyrazine, sulfachlorpyridazine, and sulfamerazine/sulfamethazine/sulfaquinoxaline* are expected to transition to Rx status, but are not marketed at this time. If they return to the market after January 1, 2017, they will require a prescription from a veterinarian.

*Fixed-ratio, combination drug

### *Current Rx Water Soluble Drugs*

| Established drug name | Examples of proprietary drug names |
|---|---|
| tylosin | Tylan, Tylomed, Tylosin, Tylosin Tartrate, Tylovet |

This information is up-to-date as of January 19, 2016. As the industry transitions, CVM anticipates additional changes during the coming months to this information. Please check the link below for the most recent updates: http://www.fda.gov/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/JudiciousUseofAntimicrobials/default.htm

# SANITARY TRANSPORTATION REGULATIONS

Wayne Nighorn [1/]

This rule is one of seven foundational rules proposed since January 2013 to create a modern, risk-based framework for food safety. The goal of this rule is to prevent practices during transportation that create food safety risks, such as failure to properly refrigerate food, inadequate cleaning of vehicles between loads, and failure to properly protect food. The rule builds on safeguards envisioned in the 2005 Sanitary Food Transportation Act (SFTA). Because of illness outbreaks resulting from human and animal food contaminated during transportation, and incidents and reports of unsanitary transportation practices, there have long been concerns about the need for regulations to ensure that foods are being transported in a safe manner. The rule establishes requirements for shippers, loaders, carriers by motor or rail vehicle, and receivers involved in transporting human and animal food to use sanitary practices to ensure the safety of that food. The requirements do not apply to transportation by ship or air because of limitations in the law. Specifically, the FSMA rule establishes requirements for vehicles and transportation equipment, transportation operations, records, training and waivers

**Vehicles and transportation equipment**:

The design and maintenance of vehicles and transportation equipment to ensure that it does not cause the food that it transports to become unsafe. For example, they must be suitable and adequately cleanable for their intended use and capable of maintaining temperatures necessary for the safe transport of food.

**Transportation operations**:

The measures taken during transportation to ensure food safety, such as adequate temperature controls, preventing contamination of ready to eat food from touching raw food, protection of food from contamination by non-food items in the same load or previous load, and protection of food from cross-contact, i.e., the unintentional incorporation of a food allergen.

**Training:**

Training of carrier personnel in sanitary transportation practices and documentation of the training. This training is required when the carrier and shipper agree that the carrier is responsible for sanitary conditions during transport.

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**Records**:

Maintenance of records of written procedures, agreements and training (required of carriers). The required retention time for these records depends upon the type of record and when the covered activity occurred, but does not exceed 12 months.

# FOOD SAFETY MODERNIZATION ACT:

# WHAT MUST I DO TO COMPLY?

Wayne Nighorn [1/]

Food Safety Modernization Act (FSMA) is based totally on preventative practices to help lessen the likely hood of a contaminated animal food product making its way into the market place. Most of you already have adopted practices and procedures that would put you in compliance with the CGMP's. However, in most cases it is the record keeping that needs to be updated. Recently new guidance documents for compliance with the Current good manufacturing practices (CGMP) for FSMA have been released by the FDA. These guidance documents are not in final form but are in a draft for comment. There are two main sections for compliance with the new Food Safety Modernization Act the first and foremost would be compliance with the new CGMP's.

The second part of this would be the Hazard analysis and food safety plan. Evaluating your facility for current and potential hazards is at the very heart of FSMA and the food safety plan. Hazards are biological, chemical or physical, However as we cannot change the severity of a hazard as to animal food, you can alter the probability that it would occur in your facility. This is where record keeping and a strong program for current good manufacturing practice's compliance is very helpful.

There are a lot of components to a good CGMP program so that is where we will start.

Here is the link to the Draft copy of the guidance document:

http://www.fda.gov/downloads/AnimalVeterinary/GuidanceComplianceEnforcement/GuidanceforIndustry/UCM499200.pdf

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USE OF NITRIFICATION INHIBITORS WITH MANURE

Carrie A.M. Laboski[1]

Abstract

A nitrification inhibitor temporarily delays the conversion of ammonium to nitrate. It is used to prevent nitrate losses should weather conditions conducive to N loss occur. Therefore, a nitrification inhibitor should be considering a risk management tool, not a yield enhancement tool. Several recent studies in Wisconsin have evaluated the nitrification inhibitor Instinct or Instinct II with spring or fall applied manure.

Instinct applied with spring injected dairy slurry on sandy soils significantly reduced nitrate leaching at one location but not the other. Contrasting results may have been caused by differences in soil pH and soil organic matter content at the sites. Corn yield was not affected my Instinct application at either location.

In another study, application of Instinct with surface applied dairy slurry in the fall or spring significantly increased corn silage yield, but not grain yield. Application of Instinct with fall applied manure did not affect soil nitrate or ammonium concentrations in the top two feet of soil in mid-November three weeks after application. However, in mid-April soil nitrate concentration in the 1 to 2 foot-depth were significantly lower when Instinct was applied with manure in the fall. Pre-sidedress nitrate results were not impacted by Instinct application with either fall or spring manure application. Where Instinct was applied with manure in the spring or fall, N concentrations in the crop were greater at V8 and VT as evidenced by significantly greater chlorophyll meter readings.

A five site-year study evaluated the impact of Instinct applied with injected digested, separated dairy slurry at several manure application timings {mid-October (early fall), mid-November (late fall), and April (spring)}. The effect of Instinct application on pre-sidedress nitrate concentrations to a two foot-depth were variable.

First, at two locations, Instinct applied with late fall manure significantly increased soil nitrate concentrations, suggesting Instinct was able to delay conversion of N to nitrate until spring time. At these same two locations, nitrate concentrations were lower where Instinct was applied with spring manure because Instinct was delaying conversion to nitrate; and there was no effect of Instinct when applied with manure in early fall likely because temperatures were warm enough to allow degradation of Instinct and subsequent conversion to nitrate before winter.

Second, at another location there was no effect of Instinct on spring soil nitrate concentrations regardless of when manure was applied. Third, at one location late fall applications without Instinct resulted in greater nitrate at pre-sidedress sampling compared to application of Instinct, which is completely opposite of other locations. At this site, there was no other significant effect

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of Instinct on pre-sidedress nitrate. Fourth, at the final site, both early fall and spring application of manure with Instinct increased pre-sidedress soil nitrate, but did not have an effect when applied with manure in late fall.

The variable results in these studies with regard to yield, soil nitrate concentrations, or nitrate leaching are attributed to soil properties and weather conditions. More detailed results from these studies, including impacts on corn yield, will be explored in the presentation. Please contact me for additional information.

# FALL MANURE AND COVER CROPS: WHO WINS, WHO LOSES?

Matt Ruark and Jaimie West [1/]

## Introduction

Over 1 million acres of corn silage is grown in Wisconsin. When harvested in late summer, there is a clear opportunity for cover crops to be planted. In addition, it is likely that manure will be applied after corn silage harvest allowing cover crops to provide both soil and nutrient conservation benefits. However, growers in Wisconsin climates may have concerns about trade-offs with management such as extra field work in the spring, com-petetion for soil water and nutrients, and other associated costs that can only be addressed through coordinated research and extension efforts across the state. The potential for yield loss is a real concern of Wisconsin farmers and there are quantified examples of corn yield reductions following a rye cover crop (e.g., 13 bu/ac decrease reported by Stute et al., 2009). The objectives of this study were to determine the performance of fall seeded cover crops in a corn silage/fall manure application production system in different regions of Wisconsin and to quantify effects (yield and optimal N rate) on subsequent corn crop yield. Two cover crops were evaluated winter rye (which required termination in the spring) and spring barley (which winterkills).

## Materials and Methods

The study was conducted at three locations in Wisconsin across two growing seasons: the 2015 and 2016 corn growing seasons (Tables 1 and 2). Study sites included Arlington Agricultural Research Station (ARL) in south-central Wisconsin, Lancaster Agricultural Research Station (LANC) in south-west WI, and Marshfield Agricultural Research Station (MARS) in north-central Wisconsin. All field sites were preceded by corn silage and manure was applied at a target rate of 10,000 gallons/ac. Exact rates and nutrient content is presented in Table 4. First year availability of nitrogen (N) from manure was around 100 lb/ac at each site except Marshfield, where low percent solids in the liquid dairy manure resulted in a much lower nutrient contribution. Following manure application, cover crop seed was drilled at target rates of 90 lb/ac pure live seed (PLS) for winter rye and 80 lb/ac PLS for spring barley. Cover crops were sampled immediately prior to winterkill of spring barley and again in spring before chemical termination. The subsequent spring corn was planted with a no-till drill and split plot treatments of variable N rates were applied (0, 50, 100, 150, 200, 250 lb N/ac). Nitrogen was broadcast applied as urea with Agrotain®.

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Results and Discussion

- Dry matter cover crop yield of winter rye was at least 0.5 ton/ac at all locations, with all locations in 2016 having greater than 1 ton/ac of DM biomass (Table 3)
- Winter rye always reduced soil nitrate in the upper 1' in the fall compared to no cover at Arlington and Lancaster; effects were less pronounced at Marshfield (Tables 4 and 5)
- Averaged across six site-years, winter rye led to a 16 bu/ac yield drag, while spring barley led to 7 bu/ac (Table 6).
- On average corn following winter rye required 35 lb-N/ac more nitrogen compared to without a cover crop (based on linear-plateau regression models); spring barley had a minimal effect on optimum N rate (Table 6).
- Preliminary results regarding who wins: the soil (less erosion) and groundwater (less potential leaching of nitrate)
- Preliminary results regarding who loses: the corn (lower yields) and the manure (less N credit with winter rye?)

Table 1. Study dates for 2014-2015 cropping season.

| Event | Arlington | Lancaster | Marshfield |
|---|---|---|---|
| Harvest silage | 9/8/2014 | 9/18/2014 | 9/24/2014 |
| Apply manure | 9/17/2014 | 9/23/2014 | 9/25/2014 |
| Drill CC seed | 9/18/2014 | 9/29/2014 | 9/26/2014 |
| Winterkill AGB & soil | 11/14/2014 | 11/13/2014 | 11/11/2014 |
| | | | |
| PPNT | 4/28/2015 | 4/29/2015 | 5/5/2015 |
| Burn down | 4/30/2015 | 5/1/2015 | 5/5/2015 |
| Planting | 5/8/2015 | 5/13/2015 | 5/13/2015 |
| Sidedress | 5/13/2015 | 5/14/2015 | 5/21/2015 |
| Grain harvest | 10/26/2015 | 10/22/2015 | 11/11/2015 |

Table 2. Study dates for 2015-2016 cropping season.

| Event | Arlington | Lancaster | Marshfield |
|---|---|---|---|
| Harvest silage | 9/11/2015 | 9/9/2015 | 9/15/2015 |
| Apply manure | 9/15/2015 | 9/16/2015 | 9/17/2015 |
| Drill CC seed | 9/23/2015 | 9/23/2015 | 9/21/2015 |
| Winterkill AGB & soil | 11/10/2015 | 12/11/2015 | 11/4/2015 |
| | | | |
| PPNT | 4/15/2016 | 4/13/2016 | 4/19/2016 |
| Burn down | 4/18/2016 | 4/15/2016 | 4/29/2016 |
| Planting | 5/6/2016 | 4/25/2016 | 5/6/2016 |
| Sidedress | 6/9/2016 | 6/10/2016 | 6/21/2016 |
| Grain harvest | 10/25/2016 | 11/1/2016 | 11/11/2016 |

Table 3. Aboveground dry matter (DM) biomass and N uptake in aboveground biomass collected at winterkill or spring before termination.

| | | Winter 2014 | | Winter 2015 | | Spring 2015 | | Spring 2016 | |
|---|---|---|---|---|---|---|---|---|---|
| Location | Cover | DM | N uptake | DM | N uptake | DM | N uptake | DM | N uptake |
| | | lb/ac | lb-N/ac | lb/ac | lb-N/ac | lb/ac | lb-N/ac | lb/ac | lb-N/ac |
| ARL | Sp. Barley | 783 | 42 | 737 | 40 | * | * | * | * |
| | Winter Rye | 583 | 25 | 798 | 42 | 2464 | 83 | 3249 | 100 |
| LAN | Sp. Barley | 265 | 14 | 1958 | 82 | * | * | * | * |
| | Winter Rye | 303 | 14 | 1249 | 50 | 1582 | 36 | 2565 | 63 |
| MAR | Sp. Barley | *na* | *na* | 492 | 25 | * | * | * | * |
| | Winter Rye | *na* | *na* | 743 | 37 | 1025 | 23 | 2259 | 49 |

* = Cover crop did not survive winter or biomass was minimal.

Table 4. Soil nitrate measurements in cover crop treatments at winterkill 2014 and preplant 2015.

| | | Winter | | Spring | |
|---|---|---|---|---|---|
| Location | Cover | 0-1’ | 1-2’ | 0-1’ | 1-2’ |
| | | mg $NO_3$-N / kg | | | |
| ARL | None | 27.3 | 6.6 | 20.7 | 23.0 |
| | Rye | 10.9 | 4.4 | 2.2 | 7.7 |
| | Sp. Barley | 6.8 | 3.8 | 13.9 | 17.2 |
| LAN | None | 12.1 | 6.2 | 11.4 | 4.6 |
| | Rye | 8.1 | 4.6 | 1.1 | 2.4 |
| | Sp. Barley | 6.6 | 3.9 | 8.4 | 3.4 |
| MAR | None | 4.3 | *NA* | 5.4 | 2.9 |
| | Rye | 4.7 | *NA* | 5.3 | 2.1 |
| | Sp. Barley | 5.7 | *NA* | 8.1 | 3.6 |

Table 5. Soil nitrate measurements in cover crop treatments at winterkill 2015 and preplant 2016.

| Location | Cover | Winter 0-1’ | Winter 1-2’ | Spring 0-1’ | Spring 1-2’ |
|---|---|---|---|---|---|
| | | mg $NO_3$-N / kg | | | |
| ARL | None | 19.3 | 14.1 | 6.3 | 7.2 |
| | Rye | 4.7 | 4.5 | 1.0 | 0.8 |
| | Sp. Barley | 7.3 | 8.2 | 8.0 | 6.8 |
| LAN | None | 8.7 | 19.1 | 6.4 | 6.6 |
| | Rye | 1.7 | 0.9 | 1.7 | 1.1 |
| | Sp. Barley | 9.1 | 5.6 | 13.4 | 7.3 |
| MAR | None | 10.4 | 1.2 | 6.7 | 3.5 |
| | Rye | 9.3 | 1.0 | 2.2 | 0.9 |
| | Sp. Barley | 8.6 | 1.0 | 2.7 | 1.3 |

Table 6. Corn yield plateaus based on linear-plateau regression models following no cover crop, winter rye, or spring barley. The yield difference and optimum N rate difference is relative to the no cover crop treatment. A negative yield difference value implies a yield decline with cover crops and a positive optimum N rate difference implies more N was required to achieve the yield plateau.

| Site | Year | Cover | Yield plateau | Yield diff. | Optimum N rate diff. |
|---|---|---|---|---|---|
| | | | bu/ac | bu/ac | lb-N/ac |
| ARL | 2015 | None | 191 | | |
| | | Winter Rye | 174 | -17 | 38 |
| | | Sp. Barley | 192 | 1 | 28 |
| ARL | 2016 | None | 252 | | |
| | | Winter Rye | 231 | -21 | -12 |
| | | Sp. Barley | 241 | -11 | -33 |
| LAN | 2015 | None | 196 | | |
| | | Winter Rye | 196 | 0 | 21 |
| | | Sp. Barley | 185 | -11 | 5 |
| LAN | 2016 | None | 260 | | |
| | | Winter Rye | 230 | -30 | 102 |
| | | Sp. Barley | 252 | -8 | 0 |
| MAR | 2015 | None | 195 | | |
| | | Winter Rye | 181 | -14 | 21 |
| | | Sp. Barley | 194 | -1 | 16 |
| MAR | 2016 | None | 241 | | |
| | | Winter Rye | 227 | -14 | 42 |
| | | Sp. Barley | 232 | -9 | 11 |
| | Average | Winter Rye | | -16 | 35 |
| | | Sp. Barley | | -7 | 5 |

United States Department of Agriculture

U.S. Dairy Forage Research Center

# Airborne pathogens from dairy manure aerial irrigation and the human health risk

*by Mark A. Borchardt and Tucker R. Burch*

Application of liquid dairy manure by traveling gun or center pivot irrigation systems is becoming more common because it offers several potential benefits: reduced road impacts from hauling, optimal timing for crop nutrient uptake, and reduced risks of manure runoff and groundwater contamination.

However, irrigation could also increase the risk of airborne pathogen transmission from manure to humans and livestock compared to other application methods. This concern about airborne pathogens prompted the Wisconsin Department of Natural Resources to fund field research on this topic. This fact sheet is a summary of that study, the first study to use measured concentrations of airborne microorganisms during irrigation of dairy manure on working farms to estimate human health risk.

Setting up the equipment in the field to measure microorganism transport during irrigation.

## Pathogens in dairy manure

Dairy manure, like the fecal excrement from any domesticated or wild animal, can contain pathogens capable of infecting humans. Six pathogens that can be found in dairy manure and are frequently associated with human health effects include: *Salmonella, E. coli, Campylobacter jejuni, Listeria monocytogenes, Cryptosporidium parvum,* and *Giardia lamblia*. These all cause acute gastrointestinal illness with diarrhea, abdominal pain, fever, nausea, and vomiting. In some cases illness can progress to a systemic infection involving other organ systems.

It is important to recognize that the number and types of pathogens in dairy manure can be highly variable from herd to herd and even in the same herd through time. Thus, exposure to dairy manure does not always equate to exposure to human pathogens. On the other hand, the absence of pathogens in a specific dairy herd at a specific point in time does not equate to the universal absence of health risk from exposure to dairy manure. The risk assessment described in this fact sheet accounted as best as possible for varying infection susceptibilities in the exposed population and varying pathogen presence in dairy manure.

## Study summary

Airborne microbial concentrations, some of which may be pathogenic, decline with distance but can still be measurable at 700 feet downwind from irrigation depending on wind velocity and the initial concentration of the microorganism in manure.

Using quantitative microbial risk assessment, we estimate the risk for acute gastrointestinal illness for exposure to airborne pathogens 500 feet downwind from dairy manure irrigation is on the order of *1 in 100,000* to *1 in 100* per irrigation event.

The risk estimate depends primarily on pathogen type, pathogen prevalence on dairy farms, downwind distance from the irrigation equipment, and the number of irrigation events during a growing season.

Also, it is important to recognize the risk values reported herein are medians of the risk distribution; users of this report might decide to use lower or higher percentiles of the risk distributions.

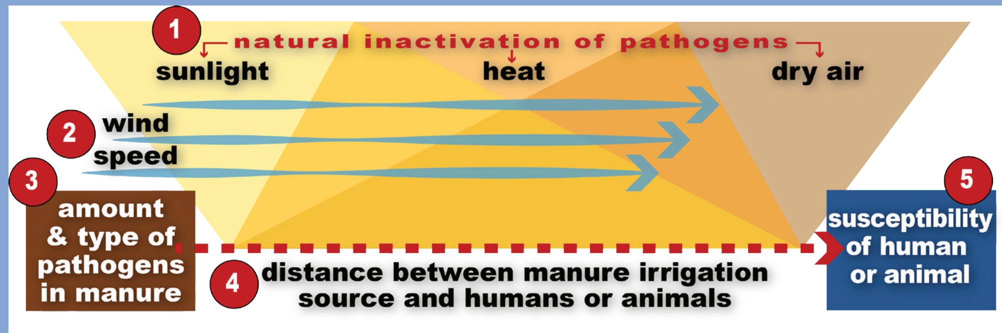


**Figure 1.** Factors affecting the chance of pathogens in irrigated manure becoming airborne and infecting humans or animals. The risk increases with wind speed and decreases with the distance downwind

## Wisconsin study

The Wisconsin study described in this fact sheet had two primary objectives. The first objective was to identify weather variables (e.g., wind speed, solar radiation, and relative humidity) most important for airborne pathogen transport during manure irrigation. The second objective was to estimate the risk of illness for people by using microbial risk assessment computer models.

At the foundation of this effort was an extensive, largest of its kind, field sampling for airborne microorganisms during 23 irrigation events (8 trials by center pivot and 15 trials by traveling gun) in 2012 through 2014. Air samples were analyzed for culturable bacteria in 13 trials and for microorganism genetic markers in 23 trials.

Weather data were collected every 30 seconds during each trial -- wind direction and speed, air temperature, solar radiation, relative humidity, and precipitation, which was always zero.

In two additional trials we measured airborne transport of microorganisms during conventional manure application by a tanker with a high splash-plate.

## Study findings

***Airborne bacteria detection frequencies.*** Not surprisingly, bacteria that normally live in the gut tract of cattle (*Bacteroides*, gram negative bacteria, *E. coli*, and *Enterococci*) were present in manure 100% of the time. In addition, *Campylobacter jejuni* also was present in the study manure. While the bacteria listed above were detected frequently in manure samples, they were detected less frequently in downwind air samples. The greatest difference was for non-pathogenic *E. coli*, which was detected in 100% of manure samples versus 11% of air samples, while the smallest difference was for *Bacteroides*, which were detected in 100% of manure samples versus 86% of air samples.

***Airborne bacteria concentrations.*** Like detection frequencies, concentrations of the bacteria in air decreased with increasing distance downwind from manure irrigation. In general, the concentration of the bacteria with the highest survival rate (most likely to cause illness) decreased approximately 30% for every 100-foot increase in downwind distance.

## Weather variables

Why are bacteria detections and concentrations in air so much less than in manure? Four well-known processes are responsible. 1) When liquid manure is released through an irrigation nozzle, very few bacteria become aerosolized and suspended in the air. 2) Gravitational settling of manure aerosols onto surfaces, like plants and soil, as they move through the air removes aerosol-associated bacteria from the air stream, reducing their concentration further downwind. 3) Dilution by the wind scattering and dispersing manure aerosols and bacteria into the larger atmosphere also reduces bacteria concentrations. 4) Lastly, inactivation by warm temperatures, low humidity, and sunshine kills the bacteria, reducing their numbers in air (Figure 1).

In this study, the most important weather variable in determining downwind microbe concentrations was wind speed. Two non-weather variables that were as important as wind speed in predicting microbe concentrations downwind from manure irrigation were distance downwind and the microbial concentration in the manure source.

## Human health risk

Despite environmental processes that inactivate airborne pathogens, airborne pathogens can still be measured downwind from manure irrigation. The question then becomes: "Do these concentrations pose a risk to public health?"

The prevalence and concentration of pathogens in manure is always changing. In order to make conclusions about the potential health risk, we analyzed the data under four different scenarios that differ in their assumptions and therefore lead to different levels of precaution toward protecting public health.

The four scenarios are shown in Figure 2. We compared two rates of prevalence: 1) the typical prevalence of a pathogen in manure as reported in existing national data; and 2) a worst case scenario in which a pathogen is present in 100% of manure. And we used two different microorganisms in the analysis, one that has a high rate of survival in the environment and is more likely to transmit a disease, and one that has a low rate of survival and is unlikely to result in disease transmission. If you assume the pathogen is present in all manure and has a high rate of survival, the estimated health risk is much higher than if you assume the pathogen is present at typical levels and has a low rate of survival.

Then we compared the risk level determined for each scenario against water quality standards already in use by the EPA: 1) acceptable level of illness risk for drinking water, 1 infection/10,000 people/year; and 2) acceptable level of risk for recreational water, 32 illnesses/1,000 swimmers/exposure event. As seen in Figure 3, risk from manure irrigation is generally between the acceptable risk levels for drinking water and recreational water.

There are two caveats to consider. The reported risk levels are for a single manure irrigation event. However, manure can be irrigated multiple times on a field during a growing season and each time people are exposed to irrigated manure the risk of illness increases. Second, the reported risk levels are medians of the outputted risk distributions (i.e., 50% of the risk estimates are lower and 50% are higher). Risk managers may wish to use a summary statistic more conservative toward protecting public health (e.g., 75th percentile).

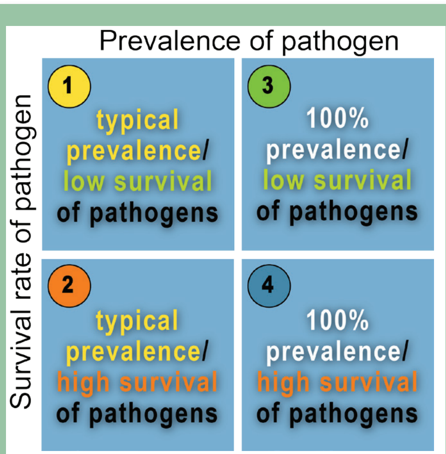


**Figure 2.** Four scenarios used in the risk assessment. Number 1 has the least conservative assumptions and Number 4 the most conservative assumptions. Policy makers must decide the level of precaution needed.

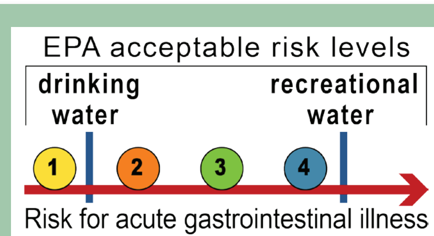


**Figure 3.** The risk level of the four scenarios in Figure 2 are compared with the EPA acceptable risk levels for two benchmarks, drinking water and recreational water. With the least conservative risk scenario (#1), the risk of being infected by pathogens in irrigated manure is just under the accepted risk for drinking water. However, in the most conservative risk scenario (#4), the risk from manure irrigation is close to the acceptable risk level for recreational water. The figure illustrates relative risk and is not drawn to scale.

## Comparison of spreading and the two different irrigation methods

***Conventional tanker versus irrigation.*** On two dates we measured airborne transport of pathogens and microbial surrogates during dairy manure application by conventional tanker. There was no clear pattern in the differences in downwind microbe concentrations during manure application by tanker or irrigation. For some comparisons there was no statistical difference between application methods, and for other comparisons sometimes the tanker produced significantly lower air concentrations and sometimes irrigation produced significantly lower air concentrations. With only two tanker trials, it is not possible to determine definitively which application method creates the fewest airborne microbes.

***Traveling gun versus center pivot irrigation.*** Comparing traveling gun versus center pivot manure irrigation methods, there are no statistical differences in the probabilities of detection or levels of concentration of airborne bovine *Bacteroides* or gram negative bacteria. The traveling gun method did result in a significantly lower probability of detection and concentration of enterococci bacteria in air. Overall, however, there was no clear pattern of differences between traveling gun and center pivot manure irrigation methods in the downwind transport of microbes.

### What producers can do to reduce the health risk from irrigated manure

Four actions provide the biggest payoff in reducing the risk of airborne disease transmission from dairy manure irrigation.

1) Improve herd health and prevent pathogens from being present in manure in the first place.
2) If pathogens are present, use practices, such as anaerobic digestion or manure storage greater than three months,  to reduce their concentrations.
3) Irrigate under low wind speed conditions.
4) Maximize the distance between irrigated manure and people living downwind.

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**Citation:**
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# CONCLUSIONS FROM THE MANURE IRRIGATION WORKGROUP

Becky Larson and Ken Genskow [1/]

The Wisconsin Manure Irrigation Workgroup was convened in Spring 2013 by University of Wisconsin-Extension (UWEX) and University of Wisconsin-Madison (UW-Madison) College of Agricultural and Life Sciences at the request of Wisconsin Department of Natural Resources (WDNR) and Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP). The workgroup was asked to review a broad set of issues associated with manure irrigation and to develop guidance and recommendations for state agencies, local governments, and citizens seeking to understand this expanding technology. The workgroup has no formal authority and expects that any public policy action by local or state governments related to workgroup recommendations would involve appropriate public participation and input.

After hosting two public presentations and input sessions in May 2013, the workgroup met 16 times between July 2013 and September 2015. Throughout its duration, the workgroup maintained open channels for public input and comments through a website and email. Over this same time period, an independent but related study (funded by the WDNR and United States Department of Agriculture-Agricultural Research Service (USDA-ARS)) was being conducted to quantify the risk of illness associated with airborne pathogens from manure irrigation. The timeline and results for that study influenced the timing of final conversations and recommendations from the workgroup.

The workgroup reviewed a range of issues related to manure irrigation including the benefits and concerns around the practice that led to the workgroup formation, discussions of health and environmental risk, review of manure as a material, manure management, and existing rules and regulations associated with various aspects of manure irrigation. Decisions and recommendations made by the workgroup were based on a consensus seeking process. For many aspects of guidance and recommendations, the workgroup did achieve consensus. In particular, the workgroup reached consensus about recommendations for baseline conditions that should be in place if manure irrigation practices are used. The workgroup reached lower levels of agreement (near consensus or close-to-near consensus) for recommendations related to setback distances for different land uses under various combinations of conditions (such as wind speed, wind direction, etc.).

Consensus baseline recommendations for all uses of manure irrigation practices are that operators must:

- ► Follow all existing relevant state and local laws regarding animal waste and nutrient management

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- ► Have and follow a NRCS CPS 590 Nutrient Management Plan
- ► Take appropriate steps to minimize drift
- ► Ensure no overspray of irrigated manure
- ► Have suitable means of supervising/controlling the equipment (e.g., active supervision, automatic sensors/controls, etc.)
- ► Have suitable means of determining relevant weather information (to include: wind speed, wind direction, and temperature)
- ► Have means of preventing contaminated backflow if equipment is connected to water sources
- ► Ensure that no human waste or septage is added to (or processed with) the manure.

Additional recommendations apply depending on whether and how the manure is processed. Those include issues related to time of day, wind speed, total number of applications per year, and equipment (such as nozzles that produce larger droplet sizes).

Recommendations for setback distances generally do not reflect consensus among all group members. Setback distance refers to distance from the edge of the area wetted by irrigated manure. They included distances of zero feet to property lines for forests, adjacent agricultural lands, and road right-of-way. Minimum setback distances of 100 feet were recommended (at near consensus or close-to-near consensus) for property lines of public recreational areas, including property lines for schools or playgrounds, and distances ranging from as high as 750 feet to as low as 250 feet (with additional conditions) for dwellings and occupied buildings. In all cases, setback distances to an occupied building would take precedence over setback distance to a property line. The full set of baseline conditions and setback distances are described in Chapter 5, along with degree of consensus.

This workgroup represents a compilation of science and knowledge vetted through the varied perspectives of workgroup members. Although a comprehensive review of all concerns was beyond the resources of this group, many issues were examined. The emphasis was placed on understanding additional risk incurred when land application of manure is conducted with irrigation practices in comparison to conventional manure application practices. As noted, the outcome of this group does not establish policy for any jurisdiction in Wisconsin. It is intended to serve as a resource for citizens and elected officials engaged in discussions about appropriate next steps for their communities around the issue of manure irrigation. Details of the workgroup findings can be found in the report which is available for download at http://fyi.uwex.edu/manureirrigation/.

# FERTILIZER MARKET UPDATE

Kathy Mathers [1/]

SPACE PROVIDED FOR QUESTIONS OR NOTES

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[1/] The Fertilizer Institute.

# MANAGING EQUIPMENT DURING HARVEST TO MINIMIZE LEAF AND YIELD LOSS

Dan Undersander [1/]

How was the quality of alfalfa you harvested this year? Weather often has a large impact. However, harvest management can have a huge effect of drying rate and quality of the harvested forage. Now is the time to evaluate how this year went and to plan for what changes might be implemented next year.

We should consider that leaves have a Relative Forage Quality (RFQ) of about 550 while stems have a RFQ of 70 to 80. Thus, if we want quality forage we must focus on harvesting leaves. Figure 1, from a study of four rake types in three states, shows the effect of leaf percentage on RFQ of the harvested forage. Leaf percentage accounted for 71% of variation in forage quality!

If the alfalfa is growing well, we should expect about 45 to 50% leaves when it is harvested at the bud stage. This shows up in Figure 2 when interns in a Land O Lakes by Winfield program monitored some fields through harvesting. The fields averaged about 45% leaves in the standing alfalfa before cutting, the leaf percentage fell slightly through mowing and conditioning (about 2%) and then fell dramatically in the harvesting process (about 13%). These were fields harvested for haylage where we would expect fewer losses than when alfalfa is harvested for hay. The chopping for haylage harvesting resulted in an average loss of about 40 points RFQ due to leaf loss.

What can be done to minimize leaf loss? Consider the following:

(1) Evaluate the alfalfa stands – did you start with 45% or more leaves or did many fall to the ground prior to mowing? If the latter, then consider, especially under cool, wet conditions, first determine if all varieties showed the same leaf loss – some varieties have more leaf disease resistance than other varieties. Also, consider that an application of fungicide at early regrowth stages may be beneficial. Evaluate carefully as fungicide is an expense that can be beneficial but may not always be needed.

(2) Check after mowing and conditioning. Generally, we have seen small leaf loss at this stage but the following should be kept in mind:

(a) A flail/impeller conditioner will result in increased leaf loss of alfalfa compared to a roller conditioner.

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(b) A wide swath will enhance drying rate and reduce nonfiberous carbohydrate loss. NFC is 100% digestible to animals. The loss also results in a drop of RFQ. Putting cut alfalfa into a wide swath will also mean the yield of next cutting is increased because the field is driven for harvesting sooner so with less regrowth and, if crop is to be irrigated, that can begin sooner. For larger operations we are recommending triple mowers rather than self-propelled because the latter only make swaths that will fit between the wheels. The yield loss from respiration during drying and from next cutting due to delayed irrigation can be significant.

(3) Consider that every time you move the forage prior to harvest results in a leaf loss.

(a) Wetter forage results in less leaf loss when moved. So rake/merge above 40% moisture if pssible.

(b) Try to rake/merge only as each operation prior to harvest results in additional leaf loss e.g., tedding, windrow inverting.

(c) Rolling forage across the ground results in leaf loss.

(i). Move forage to middle with large rake rather than to one side to reduce moved distance and rolling of the hay.

(ii) Mergers result in less leaf loss than rakes since they pick up the forage and move it on a conveyer belt.

(d) Thus a recommended procedure would be to mow, rake/merge when at 40 to 60% moisture, and harvest. In the Midwest and Northeast, haylage made with wide swaths can often be harvested the same day it is cut. In the West, hay can be harvested in 2 to 3 days rather than 5 to 7.

(4) Minimize leaf loss during harvest. If the windrow is a size that is near capacity of the baler or chopper, then harvesting is more efficient in terms of fuel and labor. The larger windrow also results in less leaf loss at the harvester (either baler or chopper) pickup during the harvest. Also look behind the harvester: is there a layer of leaves falling on the ground behind the bale chute or from between the belts of a round baler, is there a green cloud around the chopper wagon or truck? Each of these are signs of leaf losses that result in reduced harvested forage quality. A little toughness on the hay/haylage may reduce these losses.

Leaf loss cannot be eliminated, it can, however, be minimized. By being sensitive to the concept of “harvesting leaves” rather than “harvesting hay” one can observe where leaf loss in occurring in your operation and take steps to reduce losses. In some cases, different machinery may be called for but in most cases equipment adjustment and timing of use may make significant differences.

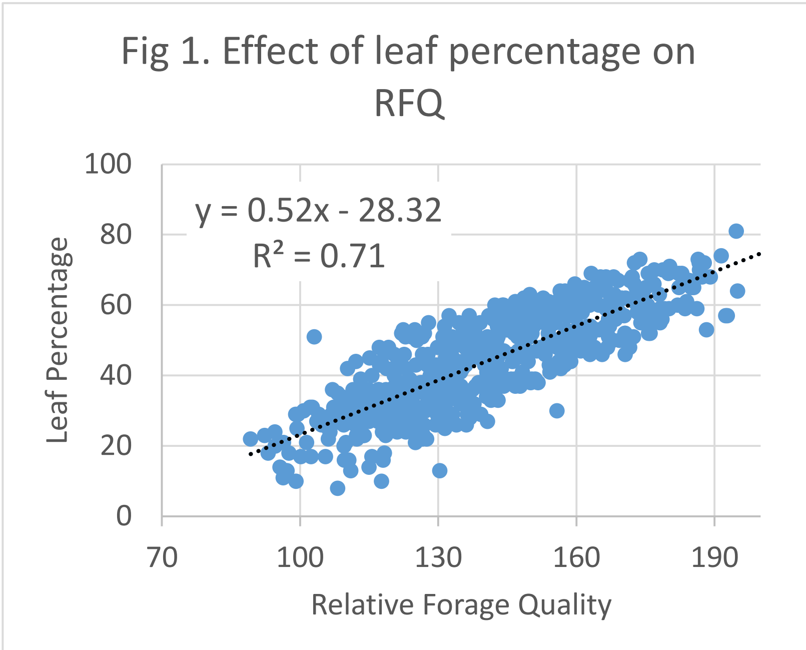
Fig 1. Effect of leaf percentage on RFQ
y = 0.52x - 28.32
R² = 0.71
Leaf Percentage
100
80
60
40
20
0
70
100
130
160
190
Relative Forage Quality

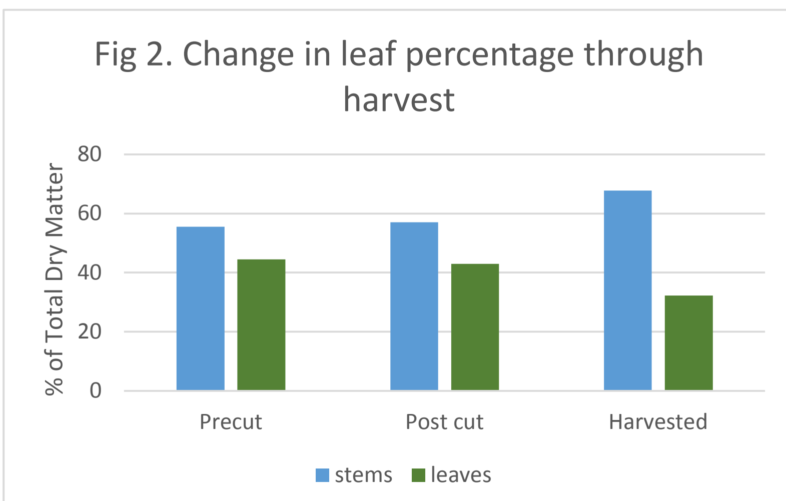
Fig 2. Change in leaf percentage through harvest
% of Total Dry Matter
80
60
40
20
0
Precut
Post cut
Harvested
stems
leaves

# MANAGING FOLIAR FUNGICIDE APPLICATIONS IN REDUCED-LIGNIN ALFALFA SYSTEMS

Damon Smith[1/], Scott Chapman[2/], and Brian Mueller[3/]

## Introduction

In 2015, an alfalfa research trial was established at the Arlington Agricultural Research Station in Arlington, WI. Two cultivars of alfalfa (DKA44-16RR - Conventional Roundup Ready®; HarvXtra – Reduced-lignin, Roundup Ready ®) were sprayed with seven fungicide treatments and compared to a non-treated control. Yield, quality, and return on investment of the treatments were evaluated under two cutting duration schemes (30-day vs. 40-day) for both cultivars. Results of the entire study can be found at: [http://fyi.uwex.edu/fieldcroppathology/files/2015/11/2015-DLS-MFA-FINAL-REPORT.pdf](http://fyi.uwex.edu/fieldcroppathology/files/2015/11/2015-DLS-MFA-FINAL-REPORT.pdf). In the 2015 study (seeding year), both cultivars responded to fungicide in a similar way (second crop specifically). In the 30-day cutting duration, fungicide application resulted in little discernable difference in disease level, defoliation, or quality compared to not treating with fungicide. Return on investment (ROI) calculations indicated that no positive return was achieved if the hay was sold, or was kept on the farm and fed to dairy cows, for the 30-day duration of cut. For the 40-day duration, significant differences in fungicide treatments were identified for disease levels, defoliation, and quality compared to the non-treated controls. These differences resulted in positive ROI (using the Milk 2006 model) for the second crop where the fungicides Headline® and Quadris® were used, under the scenario where hay would be kept on the farm and fed to dairy cows. If hay was sold, no positive ROI was identified for either treatment for this crop.

Considering these results, we continued this study in a second year using the same established stand of alfalfa. We investigated the first, second, and third crops in 2016. We considered these three crops together in this analysis to examine success of using fungicide in a 30-day cutting interval system, or a 40-day cutting interval system.

## Objectives

The objectives of this project are:

1. Assess the utility of applying fungicides (labeled and non-labeled) to an <u>ESTABLISHED STAND</u> of reduced-lignin alfalfa by evaluating foliar disease pressure, defoliation, yield, and quality for both 30-day and 40-day cutting intervals for the combined 1st, 2nd, and 3rd crop.
2. Determine the return of investment (ROI), using hay price and milk price, when various fungicides (labeled products) were applied to conventional or reduced-lignin alfalfa.

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## Materials and Methods

A field trial was previously established at the Arlington Agricultural Research Station (AARS) located in Columbia and Dane Counties in Wisconsin in spring of 2015. Two alfalfa varieties, one conventional variety and one reduced-lignin variety, were seeded on 17 April 2015. Plots were 10 feet wide and 20 feet long. In 2016, seven fungicide treatments (same treatments as in the 2015 trial) were applied to both alfalfa varieties using a 10-foot wide hand-held boom attached to a $CO_2$ pressurized backpack sprayer at a rate of 20 GPA. Fungicides were applied to each crop when alfalfa was six inches tall. Details of the fungicide treatments can be found in Table 1. A non-treated control was also included for a total of eight treatments. Treatments for the first crop were applied on 22 April 2016. On 20 May 2016 first crop (30-day cutting interval) was conducted by using a 30-inch wide small plot flail chopper to harvest one strip from one 5-ft section of each plot (randomly chosen section). Dry-matter yield, foliar disease severity, defoliation and forage quality samples were collected at the time of harvest. Eleven days later (31 May 2016), another 30-inch wide strip was harvested (40-day cutting interval) from the other 5-ft section of each plot. All yield, quality, and disease data were again collected. All remaining alfalfa was then removed from the entire trial on 2 June 2016. Thus, the second crop was established. Fungicide treatments were applied to the second crop on 13 June 2016. The second crop 30-day cutting interval was conducted on 1 July 2016 while the 40-day cutting interval was conducted on 11 July 2016. All procedures and data acquisition were conducted in the same manner as on the first crop and the field was cleared on 11 July to establish the third crop. A third application of fungicide was applied on 19 July 2016. The third crop 30-day cutting interval was conducted on 11 August 2016 while the 40-day cutting interval was conducted on 22 August 2016. All procedures and data acquisition were conducted as described previously.

The experimental design was a split-split plot with four replicates. Alfalfa variety was considered the whole plot, fungicide treatment the sub-plot, and cutting treatment the sub-sub plot. All yield, quality, and disease data were compiled together for the entire season (e.g., average disease severity for the season, average season defoliation, total yield, etc.) and analyzed using standard mixed-model analysis of variance and means separated for treatment effects within each variety using the test of least significant difference.

## Results

Applying fungicide over the course of the three crops resulted in significant ($P$<0.01) reductions in average severity for both alfalfa cultivars in the 30-day cutting interval (Table 2) and DKA44-16RR in the 40-day cutting interval (Table 3). There was no significant difference in average disease severity among fungicide treatments or the non-treated control for HarvXtra subjected to the 40-day cutting interval. Typically, Priaxor and Quadris treatments offered the most significant reduction in foliar disease severity compared to the non-treated control, where differences in disease were observed.

While differences in disease severity were detected among fungicide treatments for both cultivars for the 30-day cutting interval, this did not result in a significant difference ($P$>0.05) in defoliation during this cutting interval (Table 2). For the 40-day cutting interval, a significant ($P$=0.04) reduction in average defoliation was observed for all fungicide treatments compared to the non-treated control for both cultivars (Table 3).

Significant difference ($P$<0.05) in dry-matter yield was observed among all treatments for both cultivars subjected to both cutting intervals (Tables 2 and 3). For the 30-day cutting interval

Priaxor and Fontelis alone provided the highest yield, while Priaxor and Quadris applications resulted in the highest yields for the 40-day cutting interval.

Interestingly, application of fungicide did not provide a significant ($P$>0.05) increase in RFQ over the non-treated control for either cultivar subjected to 30-day or 40-day cutting intervals (Tables 2 and 3). However, for the 40-day cutting interval, HarvXtra provided significantly higher ($P$=0.02) RFQ values compared to DKA44-16RR regardless of fungicide treatment. No differences in RFQ were noted between cultivars for the 30-day cutting interval.

Application of fungicide did not result in a significant ($P$>0.05) increase in total milk production over the non-treated control for either cultivar subjected to the 30-day cutting interval (Table 2). For the 40-day cutting interval, application of fungicide did result in significant ($P$<0.01) increases in total milk production for both cultivars. However, the HarvXtra cultivar tended to give marginally higher ($P$=0.08) total milk production for the 40-day cutting interval. For DKA44-16RR subjected to the 40-day cutting interval, Priaxor resulted in the highest overall milk production (Table 3). For HarvXtra subjected to the 40-day cutting interval, highest milk production was achieved with Quadris fungicide followed by alfalfa treated with Priaxor fungicide.

Using hay pricing to calculate return on investment (ROI), Headline, Priaxor and Quadris fungicide used on either cultivar subjected to the 30-day cutting interval generally resulted in negative ROI (Table 4). Two exceptions were identified where Priaxor provided a slight positive ROI for DKA44-16RR subjected to the 40-day cutting interval, while Quadris provided a positive ROI for the HarvXtra cultivar subjected to the 40-day cutting interval.

Using milk pricing resulted in a larger number of positive ROI cases. For DKA44-16RR subjected to the 30-day cutting interval, both Priaxor and Quadris provided positive ROI estimates (Table 5). No positive ROI estimates were observed for HarvXtra subjected to the 30-day cutting interval. Using milk pricing to calculate ROI for the 40-day cutting interval resulted in positive ROI for both cultivars and all fungicides except for Headline applied to DKA44-16RR (Table 5).

## Conclusions

Previous research where fungicide has been applied to alfalfa in Wisconsin has resulted in infrequent cases where fungicide resulted in a significant increase in yield or a positive return on investment, because subjecting alfalfa to timely cutting (e.g., 30-day cutting intervals) usually results in plants with low foliar disease, undetectable defoliation, and extremely high quality. Plants under this optimal production system typically don't respond to fungicide application, or respond infrequently.

Subjecting alfalfa stands to longer cutting intervals (e.g., 40-day cutting interval) results in more disease pressure, detectable defoliation, and an inherent reduction in overall quality. Applying fungicide to alfalfa stands subjected to these longer cutting intervals appears to result in a higher likelihood of positive ROI. Combining reduced-lignin alfalfa with fungicide application on alfalfa stands subjected to long cutting durations may further increase the likelihood and magnitude of positive ROI in Wisconsin.

Table 1. Fungicide treatments applied to both conventional and reduced-lignin alfalfa on an established stand in Wisconsin, 2016.

| Fungicide product (active ingredient) | Rate per acre |
|---|---|
| Aproach (picoxystrobin)[1,2] | 6 fl oz |
| Aproach (picoxystrobin)[1,2] | 12 fl oz |
| Fontelis (penthiopyrad) | 1.5 pt |
| Aproach (picoxystrobin)[1] + Fontelis (penthiopyrad) | 6 fl oz + 14 fl oz |
| Priaxor (pyraclostrobin + fluxapyroxad)[2] | 4 fl oz |
| Headline (pyraclostrobin)[2] | 6 fl oz |
| Quadris (azoxystrobin)[2] | 6 fl oz |

[1]Denotes an ‘experimental’ treatment, not yet labeled for use on alfalfa in Wisconsin in 2016
[2]Treatment included the adjuvant, Induce 90 SL, at 0.3% v/v.

Table 2. Season-long average disease severity, average defoliation, total yield, RFQ, and total estimated milk production of conventional or reduced-lignin alfalfa treated with fungicide or not treated and harvested on a 30-day cutting interval in Wisconsin in 2016.

| | DKA44-16RR | | | | | HarvXtra | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Disease severity (%)[a,f] | Defoliation (%)[b] | Total yield (tons/a)[c,f] | RFQ[d] | Total milk production (lbs/a)[e] | Disease severity (%)[a,f] | Defoliation (%)[b] | Total yield (tons/a)[c,f] | RFQ[d] | Total milk production (lbs/a)[e] |
| Priaxor (4 fl oz) | 2.7 c | 0.2 | 2.9 a | 212.8 | 9441.6 | 2.8 c | 0.5 | 2.9 ab | 227.8 | 9561.9 |
| Fontelis (1.5 pt) | 5.2 b | 1.1 | 2.8 ab | 208.8 | 9144.0 | 3.5 bc | 0.4 | 2.9 a | 224.6 | 9684.2 |
| Quadris (6 fl oz) | 5.7 ab | 1.2 | 2.8 ab | 209.5 | 9030.5 | 5.0 ac | 0.4 | 2.7 bc | 219.0 | 8890.0 |
| Aproach (12 fl oz) + Fontelis (14 fl oz) | 4.4 bc | 1.0 | 2.8 ab | 209.2 | 8958.5 | 4.5 ac | 0.5 | 2.7 bc | 222.3 | 8982.2 |
| Aproach (12 fl oz) | 5.8 a | 1.1 | 2.8 ab | 212.4 | 8923.0 | 4.5 ac | 0.9 | 2.7 bc | 229.8 | 9072.4 |
| Headline (6 fl oz) | 4.8 bc | 0.6 | 2.8 ab | 208.8 | 8872.6 | 4.9 ac | 1.0 | 2.8 ac | 221.3 | 9305.6 |
| Non-treated | 7.9 a | 2.8 | 2.6 b | 216.9 | 8710.8 | 6.7 a | 0.9 | 2.8 ac | 217.6 | 9419.3 |
| Aproach (6 fl oz) | 5.6 b | 0.7 | 2.7 b | 208.2 | 8526.4 | 5.7 ab | 1.2 | 2.6 c | 229.3 | 8930.6 |
| *Pr>F* | <0.01 | ns | 0.04 | ns | ns | <0.01 | ns | 0.04 | ns | ns |

[a]Average disease severity of crops 1-3.
[b]Average defoliation of crops 1-3.
[c]Total dry-matter yield for crops 1-3.
[d]Average RFQ of crops 1-3.
[e]Total milk production of crops 1-3 as estimated by the Milk 2006 model.
[f]Means with the same letter are not significantly different based on the test of least significant difference (LSD) at $P$=0.05.

Table 3. Season-long average disease severity, average defoliation, total yield, RFQ, and total estimated milk production of conventional or reduced-lignin alfalfa treated with fungicide or not treated and harvested on a 40-day cutting interval in Wisconsin in 2016.

| | DKA44-16RR | | | | | HarvXtra | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Disease severity (%)[a,f] | Defoliation (%)[b,f] | Total yield (tons/a)[c,f] | RFQ[d] | Total milk production (lbs/a)[e,f] | Disease severity (%)[a] | Defoliation (%)[b,f] | Total yield (tons/a)[c,f] | RFQ[d] | Total milk production (lbs/a)[e,f] |
| Quadris (6 fl oz) | 12.3 bc | 12.9 bc | 2.8 bc | 137.3 | 7103.2 b | 12.4 | 12.1 ab | 3.0 a | 164.0 | 8606.0 a |
| Priaxor (4 fl oz) | 8.2 c | 7.3 c | 3.0 a | 140.0 | 7836.7 a | 9.7 | 10.2 b | 3.0 a | 158.9 | 8431.2 ab |
| Aproach (12 fl oz) + Fontelis (14 fl oz) | 15.2 b | 14.8 b | 2.7 bc | 137.3 | 6926.4 b | 13.5 | 12.3 ab | 2.9 ab | 159.2 | 8142.8 abc |
| Aproach (12 fl oz) | 11.8 bc | 12.3 bc | 2.7 bc | 142.3 | 7072.0 b | 10.8 | 12.5 ab | 2.9 ab | 160.7 | 8087.5 abc |
| Headline (6 fl oz) | 14.3 b | 12.9 bc | 2.8 bc | 137.4 | 7210.7 b | 10.4 | 13.4 ab | 2.8 b | 157.2 | 7935.9 bcd |
| Fontelis (1.5 pt) | 14.8 b | 14.2 b | 2.9 ab | 138.6 | 7357.9 ab | 12.4 | 12.7 ab | 2.8 b | 157.4 | 7759.3 cd |
| Aproach (6 fl oz) | 13.6 b | 12.5 bc | 2.7 bc | 138.7 | 6866.0 b | 13.8 | 17.5 a | 2.8 b | 152.7 | 7744.1 cd |
| Non-treated | 20.1 a | 21.5 a | 2.7 bc | 137.7 | 6873.5 b | 13.4 | 14.8 ab | 2.8 b | 150.8 | 7457.6 d |
| *Pr>F* | <0.01 | <0.01 | <0.01 | ns | <0.01 | ns | <0.01 | <0.01 | ns | <0.01 |

[a]Average disease severity of crops 1-3.
[b]Average defoliation of crops 1-3.
[c]Total dry-matter yield for crops 1-3.
[d]Average RFQ of crops 1-3.
[e]Total milk production of crops 1-3 as estimated by the Milk 2006 model.
[f]Means with the same letter are not significantly different based on the test of least significant difference (LSD) at $P$=0.05

Table 4. Hay return on investment when applying 3 applications of Headline, Priaxor, or Quadris Fungicide to conventional (DKA44-16RR) and reduced-lignin (HarvXtra) alfalfa in Wisconsin, 2016[a].

| | DKA44-16RR | | | | HarvXtra | | |
|---|---|---|---|---|---|---|---|
| | Headline (6 fl oz) | Priaxor (4 fl oz) | Quadris (6 fl oz) | | Headline (6 fl oz) | Priaxor (4 fl oz) | Quadris (6 fl oz) |
| 30-day cutting Interval | ($29.28) | ($5.01) | ($8.22) | | ($68.92) | ($49.15) | ($56.86) |
| 40-day Cutting Interval | ($37.65) | $4.62 | ($12.09) | | ($46.65) | ($8.88) | $14.91 |

[a]ROI based on dry matter yield of prime grade hay and a June - August 2016 average price of $180 per ton. Headline, Priaxor, and Quadris season programs were calculated to be $60, $54, and $35, respectively. These estimates DO NOT incorporate a custom application fee.

Table 5. Milk return on investment when applying 3 applications of Headline, Priaxor, or Quadris Fungicide to conventional (DKA44-16RR) and reduced-lignin (HarvXtra) alfalfa in Wisconsin, 2016[a].

| | DKA44-16RR | | | | HarvXtra | | |
|---|---|---|---|---|---|---|---|
| | Headline (6 fl oz) | Priaxor (4 fl oz) | Quadris (6 fl oz) | | Headline (6 fl oz) | Priaxor (4 fl oz) | Quadris (6 fl oz) |
| 30-day cutting Interval | ($33.51) | $66.46 | $18.06 | | ($78.87) | ($30.39) | ($121.75) |
| 40-day Cutting Interval | ($4.62) | $104.72 | $3.23 | | $18.60 | $106.43 | $154.50 |

[a]ROI based on milk per acre produced for each treatment and June – August 2016 average milk price of $16.47 cwt. Headline, Priaxor, and Quadris season programs were calculated to be $60, $54, and $35, respectively. These estimates DO NOT incorporate a custom application fee.

# GMO VERSUS NON-GMO LOW LIGNIN TRAITS: WHAT'S THE DIFFERENCE?

Yoana C. Newman [1]

## Introduction

Alfalfa has long been recognized as a forage crop with high nutritive value, digestibility, and intake potential to support high milk production. Because of this and many other agronomic characteristics, such as tolerance to drought and nitrogen fixation, it has been quoted as the 'queen of forages' and 'dairy's most nearly perfect feed'. As close as alfalfa is to a perfect forage, there is room for progress. Decades of breeders' experience in traditional plant breeding and advances in biotechnology have allowed for new opportunities. The achievement of reduced lignin alfalfa is certainly one of the milestones in forage quality research. Significant advances have been reached in alfalfa production and forage quality by increasing forage digestibility through reduction, not elimination, of lignin in plant tissue. Given the relatively recent presence in the market and the ongoing incorporation of this trait into commercial varieties, only time will confirm the reach of this innovation whether through biotech or traditional breeding methods. This leads to a few questions: What have been the approaches to reducing lignin in germplasm? What is the difference between genetically modified (GMO) or biotech alfalfa, and non-GMO or non-biotech? Can these technologies co-exist? The information presented highlights the distinction between these two types, their applications, and importance.

### Difference between GMO and non-GMO low lignin traits

There have been two approaches to reducing lignin in alfalfa. The first approach is a genetically engineered alfalfa that uses manipulation of the plant's DNA. The new varieties thus obtained are then genetically modified organisms (GMO) or transgenic. Commercialization of genetically engineered alfalfa must meet government deregulation from environmental risk status (McGinnis et al., 2012).

Lignin, with contents of 6 to 9%, has long been recognized as one of the major factors limiting digestibility of cell walls in alfalfa. Lignin reduces availability of nutrients due to negative associations in chemical, physical, and nutritional occurrences (Marten et al., 1988). As the plant matures, this complex organic natural polymer forms in the cell wall mainly from three primary precursors. These have been identified as coniferyl, sinapyl, and p-coumaryl alcohols (Jung and Deets, 1993). Several enzymes associated with the different precursors are involved in the natural biosynthesis of lignin. Through genetic engineering, the goal toward reduced lignin has been to down-regulate segments of the enzymatic pathways thus partially suppressing some of these enzymatic pathways. The product is the reduced lignin trait called HarvXtra™ . The HarvXtra™ trait is stacked with the glyphosate tolerant trait (Roundup Ready®) in current commercial varieties from industry [Forage Genetics International, Pioneer (S&W), Monsanto, and partnering technology companies, and research foundations]. Genetic modification is a long-standing method used by some breeders and plant scientists to improve agricultural products. The integration of the reduced lignin trait into multiple proprietary breeding lines is the ultimate goal.

The second approach to reduced lignin alfalfa is through conventional breeding efforts. Through this methodology, a 7 to 10% reduction in lignin has been reported. The development of new improved varieties does not rely on genetic engineering, but rather on the use of field population improvement programs and selection cycles to obtain parent plants with the desired

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reduced lignin and other desired agronomic traits. In addition to reduced lignin, other traits include high yield, and disease resistance against main alfalfa diseases like anathracnose, aphanomyces, bacterial wilt, fusarium wilt, verticillium wilt, and phytophotora root rot. Because this process does not use transgenics, this reduced lignin product is regarded as a non genetically modified technology (NON GMO) that can be used in organic production operations, and also in grass mixtures. The major marketer of this reduced lignin NON GMO technology is Alforex Seeds (DowAgroSciences, Woodland, CA). They have worked and produced reduced lignin lines with dormancy 3 (Hi-Gest 360) and dormancy 6 (Hi-Gest 660).

Can these technologies co-exist?

Because alfalfa is an obligate outcrossing crop and a bee-pollinated plant, the use of GMO alfalfa raises several concerns associated with technical, legal, environmental and public perceptions (Putnam and Orloff, 2013). There are limitations and risks associated with the new GMO alfalfa, whether it is the Roundup Ready® or the HarvXtra™ trait. One of such concerns is the transfer of an unwanted trait from a field growing GMOs to a field growing organic crops or NON GMOs. For example, gene flow is a concern during seed production from small alfalfa hay fields to seed production farms. To mitigate this possibility, best management practices (BMP) have been suggested that establish isolation distances that match the travelling distances of bees. Another suggested BMP is to grow only one type (GMO or NON GMO seed) to guarantee the lack of gene flow from flowering hay to seed field.

Sensitive export markets and rejections of GMO use by organic producers bring another limitation to the GMO technologies. The sensitive export markets and organic producers appreciate the NON GMO condition (Putnam et al., 2016). The risk of losing certification from organic producers is legitimate as is the sensitive export markets. Many of the reasons that set limitations for GMO like the use of glyphosate tolerant trait preferred by many growers, are the justification for other growers to prefer the NON GMO alfalfas. Within this paradigm, respect for diverse alfalfa production is a must, and the process of coexistence has been advocated among different producers. Through coexistence a mutual respect for diverse agricultural systems is acknowledged, and this requires communication and scientific knowledge.

Reduced lignin alfalfa through either technology offers the direct benefits associated with high digestibility, high yield, and flexibility of harvest. Each technology has advantages and disadvantages for growers.

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# IS THERE A YIELD PENALTY TO LOW LIGNIN ALFALFA?

Dan Undersander and Ken Albrecht [1/]

The GM reduced lignin trait has been released commercially in conjunction with Monsanto Company under the brand name of HarvXtra alfalfa.

One study in Wisconsin and Pennsylvania evaluated the trait with and without grass. HarvXtra was seen to have higher fiber digestibility than a conventional line in both the seeding year and the first production year. There was no yield drag due to the reduced lignin trait. Further, if the HarvXtra trait harvest was delayed 10 days to have similar quality to conventional varieties, the HarvXtra trait was always significantly higher in yield.

One six-state study evaluated change in nutritive value over time of HarvXtra alfalfa compared with conventional varieties in six states (KS, MI, OH, PA, CA, WI) in 2015. HarvXtra-008 was consistently lowest in lignin (ADL) on all dates at all sites, higher in neutral detergent fiber digestibility (NDFD, +49.6 g/kg) and lower in neutral detergent fiber (NDF, -29.6 g/kg) and ADL (- 9.0 g/kg) than the other two cultivars across locations and dates. This represents a 10% increase in NDFD, 10% decrease in NDF, and 18% decrease in ADL across locations and sampling dates. Although HarvXtra-008 did not appear to have a slower rate of decline in nutritive value over time than the other two cultivars, it was consistently superior in nutritive value on all dates sampled in the seeding year. Yield of the reduced lignin trait was similar to conventional lines if harvested at 28 days. While the yield was about 4% less than conventional lines for harvests at 33 and 38 days, when compared to conventional lines harvested at earlier dates (to have similar forage quality) yield of HarXtra was higher. The lower yield than conventional varieties at later harvest could also be a function of the specific varieties chosen for comparison.

The reduced lignin alfalfa provided farmers with the following choices:

(1) Higher quality forage (if harvested at same time as in the past).
(2) Greater yield (if delay harvest for same quality as in the past), yield increases about 160lb DM/day.
(3) Greater flexibility (to choose either #1 or #2, but not both) depending on the weather.

For farmers at very high levels of milk production the choice will be higher forage quality. Farmers will benefit from the improved energy content but mainly from increased dry matter intake where a 10% increase in NDFD would be expected to equal 4*.55/milk/day = 2.2 lb of milk/day. However, this milk increase would only be expected if alfalfa is cut on

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normal schedule, cow dry matter intake increases, body condition score is good, and cows are in early lactation.

Note that manure will also be reduced if forage quality increases.

We believe that the greatest benefit to many dairymen will be the increase in yield resulting from a 5- to 7-day harvest delay to get the same forage quality as in the past. Our data show that alfalfa increases an average of 160 lb DM/acre/day around harvest. Thus, delaying harvest will result in 800 to 1100 lb more yield per cutting. This can particularly benefit farmers who are cutting on a 28-day schedule and have unused growing season left at the end of the summer (e.g., if fourth cutting is taken 20 August but could wait to early September to take the last cutting).

The delayed harvest should also increase plant health resulting in improved persistence and earlier spring greenup.

Reduced lignin varieties will also benefit farmers who plant grass with the alfalfa. First cutting is of greatest concern as grass species produce stems and tend to mature sooner than alfalfa. So, harvest should generally be timed to the grass rather than the alfalfa but if delayed by rain the higher fiber digestibility of reduced lignin alfalfa will benefit final forage quality. Grasses tend to stay vegetative on later cuttings, so the maturity of the alfalfa would determine the cutting timeline and reduced lignin alfalfa would have an even wider harvest window.

# ESTABLISHING ALFALFA IN SILAGE CORN

John H. Grabber[1]*, Mark J. Renz[2], Heathcliffe Riday[1], William R. Osterholz[2], Joseph G. Lauer[2], and Peter A. Vadas[1]

According to recent agricultural statistics, alfalfa was planted on 0.44 million acres and harvested from 2.2 million acres and corn silage was planted and harvested from 1.0 million acres per year in Wisconsin. Because both crops are often grown in rotation, alfalfa could be interseeded at corn planting to serve as a dual-purpose crop for providing groundcover during corn silage production and forage during subsequent growing seasons. Unfortunately, this system has been unworkable because competition between the co-planted crops often leads to stand failure of interseeded alfalfa. Recent Wisconsin studies demonstrated that properly timed foliar applications of prohexadione-calcium on appropriate alfalfa varieties increased plant survival of interseeded alfalfa by up to 300%. When successfully established, first year dry matter yield of interseeded alfalfa was two-fold greater than conventionally spring-seeded alfalfa. Other studies revealed that interseeded alfalfa reduced fall and spring runoff of water and phosphorus by 60% and soil erosion by 80% compared to cropland containing only corn silage residues and weeds. Once established, alfalfa is also known to be highly effective for reducing nitrate leaching into groundwater. Assuming an average establishment success rate of 80%, a 5% reduction in corn silage yield, and a prohexadione application cost of $40 per acre, a preliminary economic analysis suggests alfalfa establishment by interseeding followed by full alfalfa production the following year could improve net returns of producers by about 30% ($130 per acre) compared to alfalfa conventionally spring seeded after corn silage. These improvements in crop yields and profitability and in soil and water conservation are powerful incentives for continuing work to develop reliable and workable corn-interseeded alfalfa production systems for use on farms in Wisconsin and other northern states where alfalfa cannot be successfully established in the fall after corn silage harvest.

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# MAXIMIZING MILK PRODUCTION ON WISCONSIN PASTURES: LESSONS FROM THE PADDOCK

Chelsea Zegler[1], Mark Renz[2] and Geoff Brink[3]

## Introduction

Wisconsin has the largest number of organic dairies in the United States with over 450 dairy farms that represents more than 25% of the nation's certified organic dairy farms (USDA NASS, 2014). Despite the large amount of organic dairy operations in Wisconsin, interest in expansion of existing and new operations exist due to consumer demand for organic milk (Greene and McBride, 2015). With the challenges that expanding operations face (e.g. purchasing land), interest in maximizing pasture performance exist. Previous research has shown that pasture productivity, forage quality, soil fertility and pasture management are all critical to maximizing milk production, but these factors have been observed to vary widely across farms. We visited pastures from organic dairies throughout Wisconsin to assess productivity and determine what facets measured could be improved to maximize milk production.

## Methods

We evaluated key variables across twenty organic dairies in the Upper Midwest during 2013 and 2014. At each farm, two paddocks were chosen and visited just prior to a grazing event in June and September. During each visit, pasture species composition, productivity and nutritive value were estimated. As species differed dramatically from farm to farm, they were grouped into planted (improved) and unplanted (not-improved) grasses and legumes. Soil fertility measurements in each paddock were collected in October. Forage productivity and nutritive value were used to estimate milk production within each paddock. Management practices were collected by asking producers about their average pasture management over the last five years. This allowed for integration of what has happened over time as past practices often impact current pasture composition and performance. A classification and regression tree (CART) was used to prioritize factors affecting potential milk production from pastures in June and September separately.

## Results/Discussion

June and September classification and regression trees found factors in each category associated with potential milk production. Although there were differences between timings, common factors were found that explained a large portion of the variability.

*Species composition:* More than 40% improved legume cover and less than 70% cover of unimproved grass cover were both associated with higher milk production in both June and September (Fig.1 and 2). Improved legume cover exceeding 40% in June increased milk production by 97%. While unimproved legumes also improved milk production, improved varieties were much more important. This is likely due to active breeding of varieties to fix more

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atmospheric nitrogen and have increased yield and persistence compared to unimproved legumes like wild white clover. Unimproved grass cover less than 70% in June and September increased milk production by more than 75%. Common unimproved grasses found on farms included Kentucky bluegrass and quackgrass. These species have been shown to produce less yield and have greater NDF concentrations compared to improved varieties. Unimproved grasses also have the potential to reduce establishment and development of legumes, which was identified as an important factor in milk production. Fortunately our results suggest that unimproved grasses do not have to be completely eradicated, just must be managed to not dominate a sward.

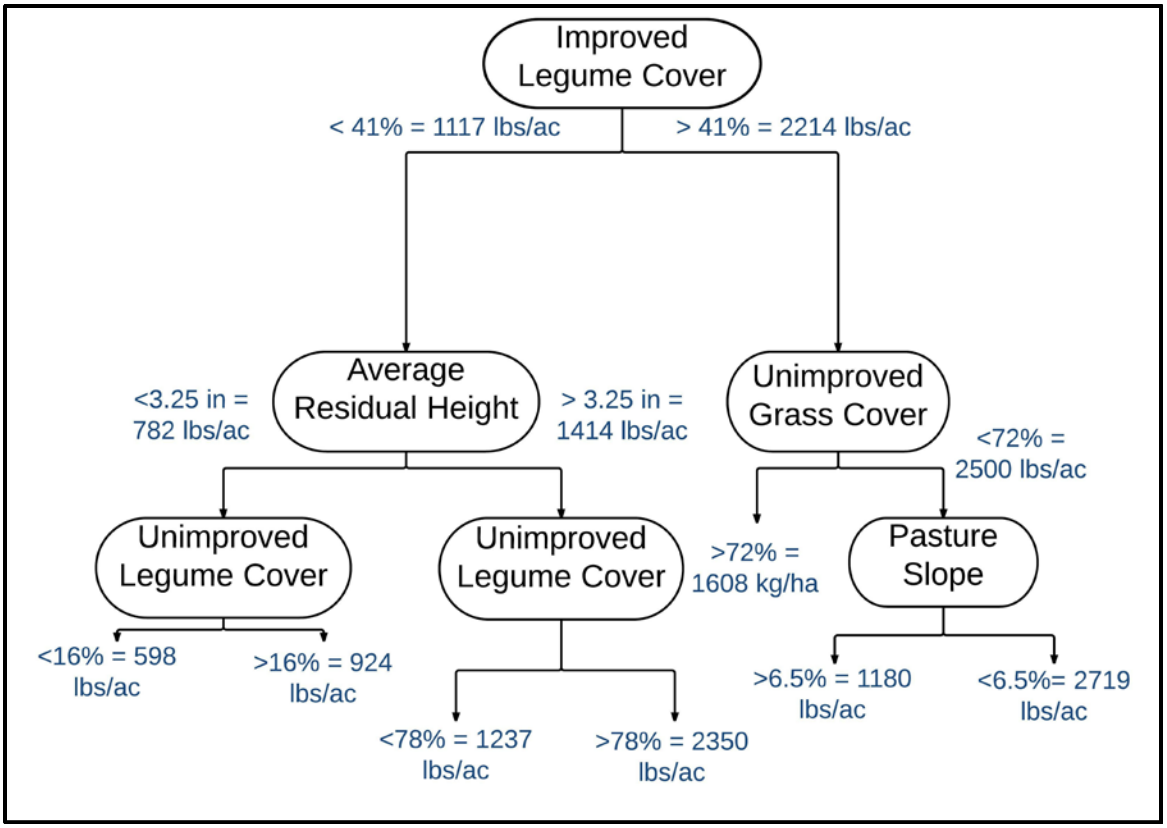


Figure 1. Classification and regression tree results for factors most associated with potential milk production from Upper Midwest pastures for a June grazing event.

*Grazing management*: Residual sward height was a grazing management factor that was associated with more milk production in both June and September. In June, maintaining a residual sward height of at least 3.25 inches throughout the year almost doubled potential milk production. Adequate residual height is necessary for improved grass species persistence and can increase the annual number of grazing events. In September, maintaining a residual sward height of 3.75 inches at the end of the grazing season was important for milk production. Residual sward height at the end of the season is particularly important for winter survival and spring regrowth of legumes and grasses.

*Soil characteristics*: Pasture slope was the only soil factor found as important for potential milk production in June and September. Although pasture slope cannot easily be changed, our results suggest producers utilize lands with less slope for pastures, which are traditionally used for other agronomic crops (e.g., corn, soybean, alfalfa). Although no soil fertility factors were important in explaining potential milk production, factors like soil pH are essential for the survival of legume populations and therefore should be considered. Although soil fertility was not identified as an important variable it may be more a significant factor on some pastures. Research was designed to determine statewide issues, not problems for specific pastures. This should be taken into consideration when using this information.

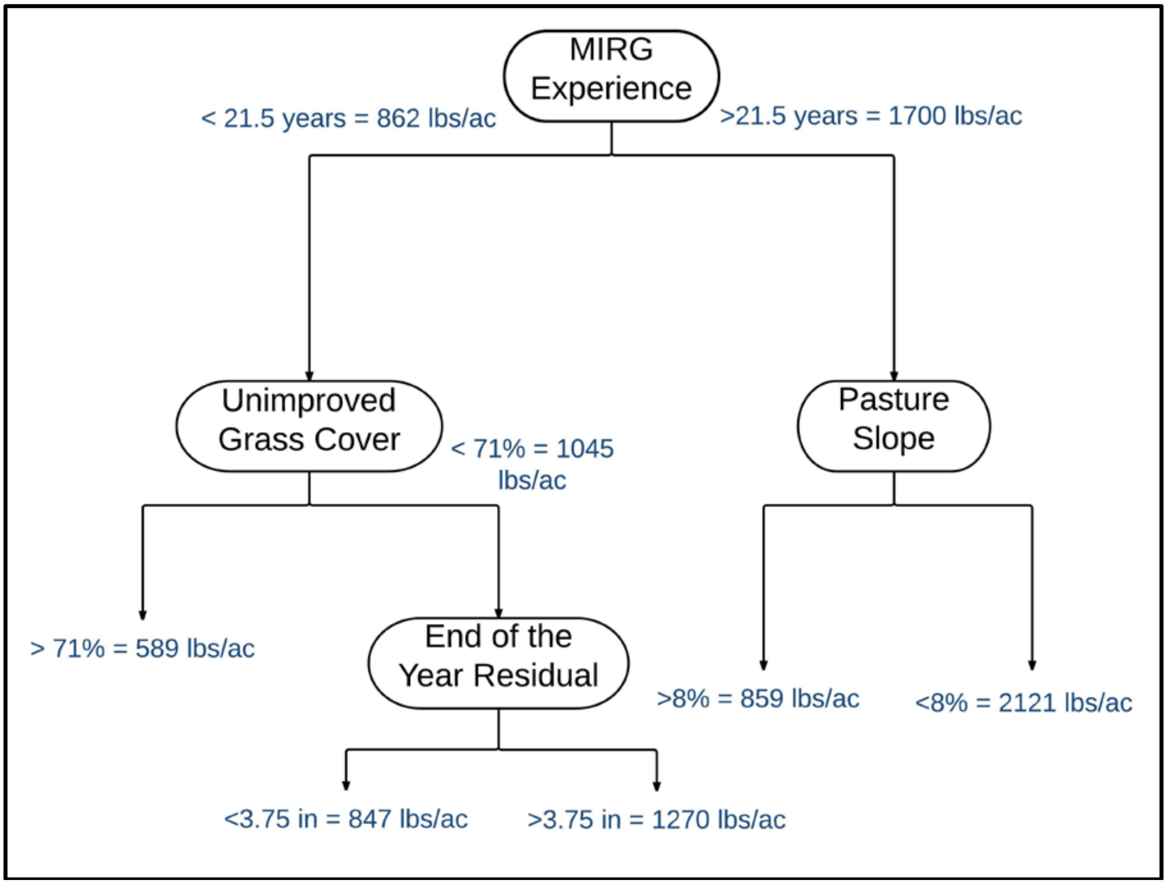


Figure 2. Classification and regression tree results for factors most associated with potential milk production from Upper Midwest pastures for a September grazing event.

## Conclusions

Our results suggest that improvements can be made on organic dairy farm pastures for milk production. Results of this research suggest that in order to maximize milk production on temperate organic pastures, producers should place high priority on maintaining a high proportion of improved legumes, an adequate residual sward height, and suppressing unimproved grass cover. Although this research was done on organically certified pastures, we believe these results are also applicable in other pastures that are not certified.

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# DON'T FOLLOW OUR LEAD: OUR EXPERIENCES WITH OFF-TARGET MOVEMENT OF DICAMBA IN MISSOURI LAST SEASON

Kevin Bradley [1/]

In 2016, the majority of the cotton acreage in the southeastern portion of Missouri was planted with dicamba-tolerant (DT) varieties. A limited number of DT soybean varieties were also planted throughout the state. However, during the 2016 growing season, the Environmental Protection Agency had not approved any dicamba herbicide formulations for post-emergence application to DT cotton or soybean. Although investigations are ongoing, apparently a subset of growers made illegal applications of dicamba to their DT cotton and/or soybean, which resulted in off-target movement of dicamba to a variety of sensitive crops, including large acreages of non-DT soybean. In southeastern Missouri alone, over 125 dicamba injury complaints were filed with the Missouri Department of Agriculture. These injury complaints occurred on over 40,000 acres of soybean, 1,000 acres of cotton, 700 acres of peaches, 400 acres of purple hull peas, 200 acres of peanuts, 32 acres of watermelon, 9 acres of cantaloupe, 6 acres of alfalfa, 2 acres of tomatoes, and on numerous homeowner's gardens, trees, and ornamental bushes. Some of the primary factors that contributed to the off-site movement of dicamba will be discussed, as well as the impacts that this situation has had and will continue to have on Missouri agriculture.

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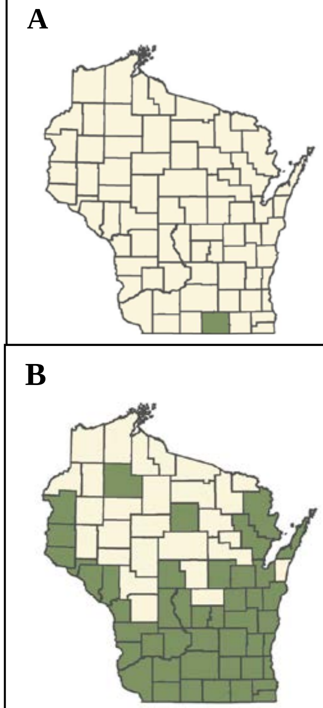
Weed ID Website: http://weedid.missouri.edu

# PAST AND CURRENT STATUS OF PIGWEED DISTRIBUTION THROUGHOUT WISCONSIN

Mark J. Renz[1] & Tracy Schilder[2]

Wisconsin is home to 13 species of Pigweeds (plants in the genus *Amaranthus*). Of these species, two (red-root pigweed and smooth pigweed) are widespread in Wisconsin and have historically plagued farmers as competitive weed species. With the rapid increase in herbicide resistance, concern exists with respect to the spread of two particular pigweeds that have historically been called uncommon: common/tall waterhemp (*Amaranthus tuberculatus*) and Palmer amaranth ( *Amaranthus palmeri*). These species are of higher priority to prevent spread compared to other pigweeds as they have been found to develop resistance to multiple herbicides and be more competitive.

Figure 1. Wisconsin Herbarium Records of palmer amaranth (A) and waterhemp (B) as of December 2016. www.wisflora.herbarium.wisc.edu

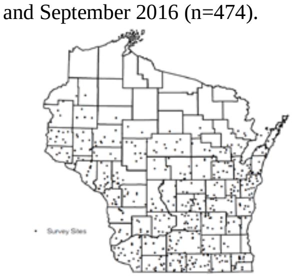



Herbarium records for waterhemp and palmer are limited throughout the state (see www.wisflora.herbarium.wisc.edu). As of December 2016 only one record of Palmer amaranth exists in the Wisconsin herbariums (see figure 1A). Due to proactive reporting from others, additional locations have been documented in Wisconsin (Sauk, Iowa, Grant County; Drewitz et al. 2016). In contrast over 200 records of waterhemp exist throughout the southern and eastern parts of the state with the first report before 1900 (see figure 1B). In addition to these counties, waterhemp has been documented to exist in Polk, Chippewa, Eau Claire, Jackson, and Monroe County (Hammer et al. 2016). Herbarium records along with confirmed reports indicate that waterhemp is widespread while palmer is rarely present in Wisconsin. This information, while valuable, contradicts many of the reports we receive on status of these species in agronomic fields. As concern exists on the spread of these species, we conducted a survey of these two species in Wisconsin corn and soybean fields.

## METHODS

Surveys were conducted by WI Department of Trade and Consumer Protection (DATCP). DATCP staff visited 257 corn, 168 soybean, 45 wheat, three oat, and one potato field (n=474 total) between the end July and September of 2016. Fields were selected randomly as part of other surveys that DATCP conducts annually (e.g. corn earworm, soybean aphid) (figure 2). The field edge, center of the field and margin were visually surveyed for the presence of waterhemp, Palmer amaranth, or other pigweed species. Presence and level of infestation were recorded.

Figure 2. Sites surveyed for pigweeds between the end of July and September 2016 (n=474).



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## 2016 SURVEY RESULTS

*Waterhemp:* Populations were found in 26 fields from the survey (5% of fields sampled) in each region of Wisconsin (Figure 3). While the percent of fields infested with waterhemp varied by region, the survey found northcentral (13%), northwestern (11%) and southcentral (10%) all had more than 10% waterhemp. Crop in the field didn't appear to impact the survey as corn only had 7% of fields infested with waterhemp and soybeans 5%. No waterhemp was found in fields of oats, potatoes, or wheat.

Figure 3. Sites where waterhemp was discovered from 2016 surveys.

*Palmer amaranth:* No fields were found that were positively identified to have Palmer amaranth as a result if this survey.

Figure 4. Sites where other pigweed species were discovered from 2016 surveys.

*Other pigweed species:* Populations of other pigweeds that were NOT palmer amaranth or waterhemp were found in 15 fields as a result of this survey (3% of fields sampled). Unlike waterhemp, it was NOT found in the northwestern, northcentral or northeastern regions. In contrast is was common in the eastern central (19%), and southcentral regions (11%) as more than 10% contained other pigweeds. Crop in the field didn't appear to impact results as corn (4%) and soybeans (3%) both had similar levels of infestation.

## COMPARISON OF 2016 SURVEY RESULTS WITH 2012-13

Several other weed surveys have been conducted in corn and soybean fields over the past decade. We will focus on the survey conducted by Recker et al. (2014) in 2012-13 as the timing of the survey was identical to the 2016 survey (July-September). The 2012-13 survey found 5% of fields infested with waterhemp and 9% of other pigweed species. This survey effort did find one field infested with Palmer amaranth (Dane county). Thus results on waterhemp presence suggest that spread of this plant to new fields has not occurred as presence was 5% in both surveys. While no fields were found with Palmer amaranth compared to one in 2013, the number of infested fields remains very low. Interestingly the presence of other pigweed species (excluding palmer and waterhemp) did differ as the 2016 survey found only 3% while the 2012-13 survey found 9%. Differences could be due to the years when the surveys were conducted, methodology, or even the difference in area surveyed. Nevertheless results suggest that waterhemp, palmer amaranth, and pigweed populations in general are not infesting a higher percentage of fields in Wisconsin over the past 3-4 years.

## SUMMARY

Palmer amaranth and waterhemp are both present in Wisconsin annual cropping systems, but contrary to belief we did not document an increase of infested fields. This is likely due to the large number of agronomic fields present in comparison to our sample size. Thus randomly sampling of fields alone will not be an effective method to detect early populations, but this in combination with monitoring by farmers, crop consultants, and agribusiness is our best hope to prevent potential future spread. Using this approach verified reports of Palmer amaranth have been documented in Sauk, Iowa, Grant County. In addition, waterhemp has also been verified in in Polk, Chippewa, Eau Claire, Jackson, and Monroe County. Although our surveys suggest that more fields are not appear becoming infested with these species, we have yet to analyze the density of populations within infested fields. If these densities of these escaped weed species are increasing, this would raise the potential for spread in the future.

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HERBICIDE-RESISTANT COMMON WATERHEMP AND PALMER AMARANTH IN WISCONSIN

Nathan Drewitz, Devin Hammer, Shawn Conley, and Dave Stoltenberg[1]

## Introduction

The spread of common waterhemp (*Amaranthus rudis*) and Palmer amaranth (*Amaranthus palmeri*) has become an increasing concern in Wisconsin (Hammer et al. 2016b). Both species are well-known for their competitive ability, abundant seed production, and propensity for developing herbicide resistance. Herbicide-resistant common waterhemp was first confirmed in Wisconsin in 1999, when a population was found to be resistant to ALS-inhibitors. More recently, glyphosate resistance was confirmed in two waterhemp populations in west-central Wisconsin (Butts and Davis 2015a).

The first occurrence of Palmer amaranth in Wisconsin was documented in 2013 (Davis and Recker 2014). This population was subsequently confirmed to be resistant to glyphosate (Butts and Davis 2015b). Since that time, Palmer amaranth has been found in three additional counties in Wisconsin. Responding to the increasing concern of Wisconsin growers, we have investigated several instances of suspected herbicide-resistant common waterhemp and Palmer amaranth. Our methods and findings are described below.

## Methods

Seed heads of putative herbicide-resistant (R) plants were collected from 11 common waterhemp and two Palmer amaranth populations in several Wisconsin counties in 2014 and 2015. Six common waterhemp populations were sampled from Chippewa, Outagamie, Sheboygan, and Waupaca counties in 2014, and five populations were sampled from Crawford, Lafayette, and Walworth counties in 2015. Palmer amaranth populations were sampled in Iowa County in 2014 and Grant County in 2015. Seeds were dried, cleaned, stratified for 6 weeks (common waterhemp only), planted, and germinated in the greenhouse for whole-plant herbicide dose-response experiments.

Dose-response experiments included R and known herbicide-susceptible (S) populations treated with the herbicides specified below. All herbicide treatments included recommended adjuvants. The experimental design was a RCB with five to 10 replications. Experiments were repeated one or more times. Glyphosate was applied to 4- to 6-inch tall plants at eight rates ranging from 0 to 12.4 lb ae acre$^{-1}$ (16 times the labelled rate). Imazethapyr was applied to 4- to 6-inch tall plants (Palmer amaranth only) at six rates ranging from 0 to 6.25 lb ai ac$^{-1}$ (100 times the labelled rate). Thifensulfuron was applied to 4-inch tall plants (Palmer amaranth only) at seven rates from 0 to 0.039 lb ai ac$^{-1}$ (10 times the labelled rate). Tembotrione was applied to 4- to 6-inch tall plants (Palmer amaranth only) at seven rates from 0 to 0.82 lb ai ac$^{-1}$ (10 times the labelled rate).

Shoot dry biomass was collected 28 days after treatment (DAT), dried, and weighed. Comparisons between R and S populations were made based on the effective herbicide dose that reduced shoot biomass by 50% ($ED_{50}$) using “R” statistical software.  Some populations were

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tested at the University of Illinois Plant Clinic (UIPC) using molecular screening methodology (Bell et al. 2013).

## Results

Glyphosate resistance was confirmed in common waterhemp populations from 16 Wisconsin counties based on results from greenhouse dose-response experiments and screening results from UIPC (Figure 1). The majority of plants across these populations survived the labelled rate of glyphosate (0.77 lb ae $acre^{-1}$) (Hammer et al. 2016a). Responses of populations from Crawford and Lafayette counties are shown in Figure 2. The population from Monroe County was found to be resistant to glyphosate and PPO-inhibiting herbicides making it the first confirmed case of multiple resistance to these two herbicide sites of action (SOAs) in Wisconsin (Figure 1).

The Iowa County Palmer amaranth population displayed a high-level of resistance (> 150-fold) to imazethapyr (Figure 3) and a low-level of resistance (4.9-fold) to thifensulfuron (Drewitz et al. 2016). The Iowa County Palmer amaranth population was also found to have a low-level of resistance (7.0-fold) to tembotrione (Figure 3). These results confirm the first instance of multiple herbicide resistance in Wisconsin Palmer amaranth (Figure 1). The Iowa County population was sensitive to glyphosate. The Grant County population was sensitive to all herbicide SOA's tested.

***Figure 1.*** Common waterhemp and Palmer amaranth herbicide resistance in Wisconsin from 2013 to 2016.

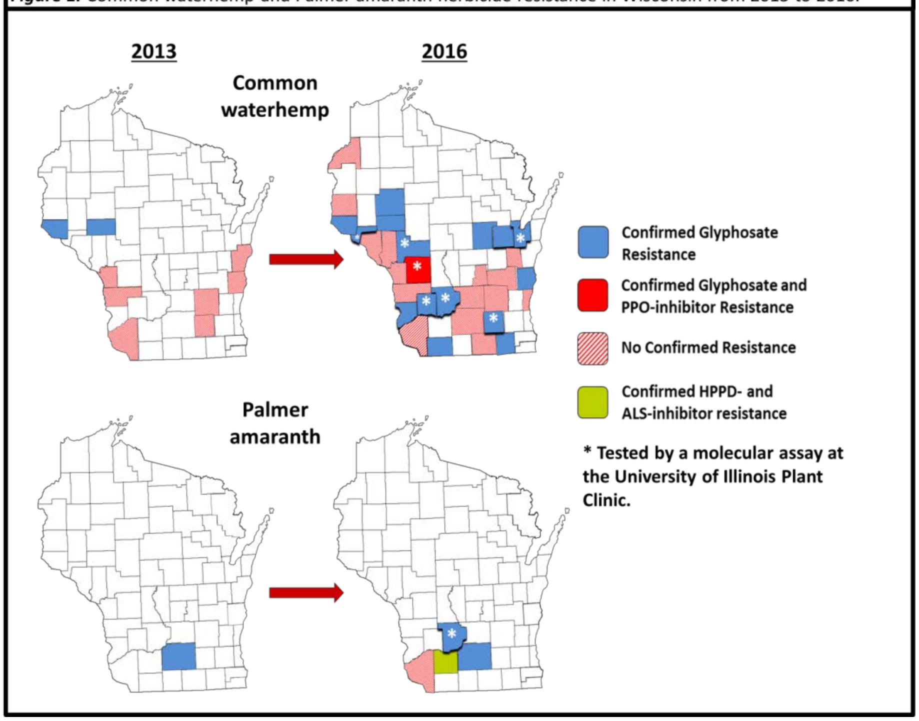


***Figure 2.*** Response of common waterhemp populations from Crawford and Lafayette counties to glyphosate 28 DAT. Plant response to glyphosate at the labelled rate (0.77 lb ae acre$^{-1}$) is shown in the photograph.

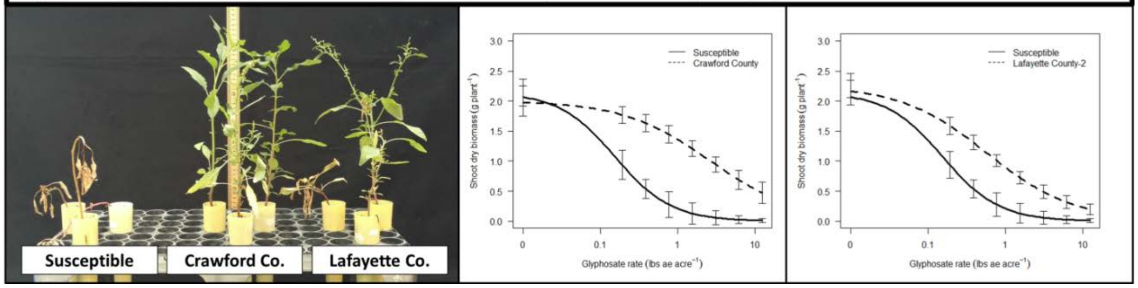
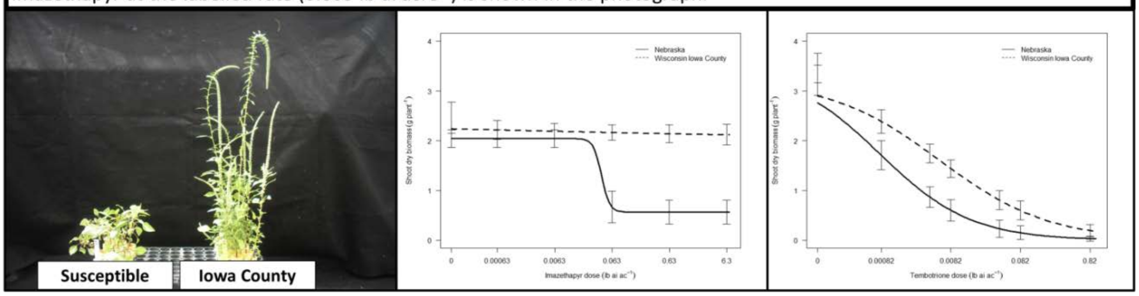



***Figure 3.*** Response of Palmer amaranth from Iowa County to imazethapyr and tembotrione 28 DAT. Plant response to imazethapyr at the labelled rate (0.063 lb ai acre$^{-1}$) is shown in the photograph.




## Conclusions

Our findings indicate that the distribution of common waterhemp and the occurrence of glyphosate resistance (including one population with multiple resistance to PPO-inhibitors) have increased rapidly in Wisconsin. Although the distribution of Palmer amaranth appears to be limited to four counties in southern and southwestern Wisconsin, the confirmation of glyphosate resistance in two populations, and multiple resistance to ALS- and HPPD-inhibitors in another population, have serious management implications for Wisconsin growers. It is critical that diverse resistance management strategies be implemented to reduce the spread, persistence, and impact of these and other herbicide-resistant species.

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Hammer D, Drewitz N, Conley S, Stoltenberg D (2016a) Common waterhemp (*Amaranthus rudis*): Confirmed herbicide resistance and spread across Wisconsin. Wisconsin Crop Manager 31:161-163 http://ipcm.wisc.edu/wcm/ Posted October 26, 2016

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# TRYING NOT TO GET LOST IN THE WEEDS: MANAGEMENT OF WATERHEMP IN CORN AND SOYBEAN PRODUCTION SYSTEMS

Kevin Bradley [1/]

In the United States, herbicide-resistant weed populations have evolved rapidly in response to the selection pressures imposed upon them in agricultural production systems. In recent years, glyphosate-resistant weeds have increased dramatically and are now estimated to occur on more than half of the corn, soybean, and cotton acreage. In Missouri, we were the first in the U.S. to discover a glyphosate-resistant waterhemp population in 2005. Since that time, waterhemp has progressively worsened in our state and has become the most troublesome species that our growers contend with each year. Multiple-resistant waterhemp populations now occur on three-quarters of the acres in the state. To date, the primary way that farmers have responded to the problem of glyphosate resistance in weeds has been to rely on alternative herbicides other than glyphosate. However, due to the increasing problem of multiple herbicide resistance, it seems clear that this practice alone will not prove successful, and that a multi-faceted approach will be required. In this session we will discuss some of these integrated approached and some of the recent successes we have had with managing this very problematic weed species in Missouri.

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Weed ID Website: http://weedid.missouri.edu

PREVENTING COVER CROPS FROM BECOMING YOUR NEXT WEED PROBLEM

Daniel H. Smith[1/]

## Introduction

Wisconsin growers are increasingly interested in utilizing cover crops. Prior to cover crop establishment a plan to terminate the cover crop is necessary. Proper and timely termination should prevent competition to the following grain or forage crop. Proper and timely termination is dependent on the species of cover crop and the following crop to be grown. The species of the cover crop impacts ease of control, seed production potential, and growth rate. Termination can occur through environmental conditions such as frost or through a cultural, mechanical, or chemical method, such as tillage or herbicide application. The termination plan should meet the grower's goals for the cover crop, crop rotation, and to prevent the cover crop from becoming a future weed problem.

Table 1. Termination guidelines for successful termination of commonly used cover crop species.

| | | Winterkill | Crimping | Mowing | Tillage | Herbicide |
|---|---|---|---|---|---|---|
| Nonlegumes | Annual Ryegrass | Maybe | No | No | Yes[1] | Glyphosate[2] 16 -32 fl oz $ac^{-1}$ |
| | Buckwheat | Yes | Yes | Maybe | Yes | |
| | Oats | Yes | Yes | Yes | Yes | |
| | Sorghum-sudangrass | Yes | No | No | Yes[1] | |
| | Spring Barley | Yes | No | Yes | Yes | |
| | Winter Wheat | No | Yes | Yes | Yes[1] | |
| | Winter Rye | No | Yes | Yes | Yes[1] | |
| Brassica | Mustards | Yes | No | No | Yes | Glyphosate[2] 16-32 fl oz $ac^{-1}$ |
| | Radish | Yes | No | No | Yes | |
| | Rapeseed | Maybe | No | No | Yes | |
| | Turnips | Yes | No | No | Yes | |
| Legumes | Berseem Clover | Yes | No | No | Yes[1] | Glyphosate[2] 16-32 fl oz $ac^{-1}$ + Growth Regulator 8-16 fl oz $ac^{-1}$ |
| | Cowpeas | Yes | No | Maybe | Yes | |
| | Crimson Clover | Maybe | No | No | Yes[1] | |
| | Field Pea | Yes | No | Yes | Yes[1] | |
| | Hairy Vetch | No | Yes | No | Yes[1] | |
| | Red Clover | No | No | No | Yes[1] | |
| | Sunn Hemp | Yes | Yes | Yes | Yes | |
| | Sweet Clover | Maybe | No | No | Yes[1] | |
| | White Clover | No | No | No | Yes[1] | |

[1]Tillage Note- Tillage may require multiple passes and should fully incorporate the cover crop.
[2] Glyphosate formulation- 4.5 lb acid equivalent per gallon.

## Cover Crop Species

The species of cover crops greatly influences the ease of termination and seed production potential. Cover crops that may not always overwinter in Wisconsin like crimson clover and annual ryegrass should be used only when a plan is in place to control overwintering plants. Annual ryegrass, also known as Italian Ryegrass has shown herbicide resistance in the U.S and this should be considered in the management plan. When cover crops are allowed to produce seed, future weed problems can arise. A good example of a quick seed producer is buckwheat, which should be closely monitored

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and terminated prior to seed production. Vetch species should be used with caution in no-till production to prevent planting difficulties.

Herbicides Considerations

The cover crop species and weed species present at termination timing should be used as a guide for determining the herbicide product. The size of the cover crop and weed species should be considered to insure both will be controlled by the herbicide application. The following crop should be compatible with any plant back restrictions. Weather conditions may alter the efficacy of the herbicide.

Herbicides and Weather

Weather conditions prior to, during, and following herbicide application can impact the efficacy of the herbicide. When terminating cover crops with a herbicide, and in particular glyphosate, the cover crop should be actively growing. The day time minimum temperature should be 55°F and a minimum night time low temperature of 40°F. Applications should occur during daylight hours and at least four hours prior to sunset. Always read and follow pesticide label instructions.

Cover Crop Vs. Forage Crop

A crop is classified as a cover crop when no biomass is harvested. A cover crop becomes a forage crop when biomass is harvested for forage value. A cover crop can be used for forage value, however most pesticide labels do not provide the plant back restriction time required from pesticide application to grazing or harvest for cover crops, only forage crops. These restrictions may make harvesting a cover crop for forage value illegal. Crop rotation restrictions will vary in length and should be examined for all pesticides and crops in the rotation. A cover crop that will not be harvested for any value can be legally established following any herbicide application, however the grower takes all responsibility for cover crop injury or failure that may result.

Winter rye is often harvested for forage value and questions arise when termination treatments should be applied. Pre-harvest herbicide treatments are often illegal. Harvesting winter rye without another termination treatment is effective, however after Feekes 9 a second termination method is needed. Post-harvest glyphosate treatments are effective and legal methods of terminating winter rye and these applications can occur immediately following harvest with no reduction in efficacy.

Termination and Crop Insurance

Current cover crop termination rules for crop insurance in Wisconsin follow USDA NRCS guidelines. For non-irrigated fields, these rules require that cover crops be terminated within 5 days of planting the insured crop. For irrigated fields, these rules require that cover crops be terminated based on the cropping system and conservation purpose, but prior to crop emergence. Also, if the cover crop is part of a no-till system, termination can be delayed up to 7 days from the above requirement, but still must be terminated prior to crop emergence. Thus a no-till field has up to 12 days after planting to terminate a cover crop, or until the crop emerges, whichever comes first. In drier than normal years, farmers are encouraged to terminate earlier than required to conserve soil moisture and to consider later termination in wetter than normal years.

Further Information

Cover Crops in Wisconsin
    http://fyi.uwex.edu/covercrop/
Termination of Winter Rye and Annual Ryegrass using Glyphosate
    http://ipcm.wisc.edu/download/pubsPM/AnnualRye_WinterRye_Glyphosate.pdf
Cover Crops and Crop Insurance in Wisconsin
    http://www.aae.wisc.edu/pdmitchell/CropInsurance/CCandInsurance2016.pdf

PALMER AMARANTH: AN UNIVITED GUEST TO CONSERVATION PLANTINGS

Meaghan J.B. Anderson[1] and Bob Hartzler[2]

## Introduction

Palmer amaranth was initially discovered in Harrison County, Iowa in August 2013 in a fallow crop field. Following that discovery, five more infestations were discovered in Page, Fremont, Muscatine, and Lee counties in 2013 and 2014. In July 2016, two landowners, both professional agronomists, detected Palmer amaranth in fields planted this spring to native seed mixes for conservation purposes. One discovery was in a quail habitat (CP 33) conservation planting in Muscatine County and the other was in a pollinator habitat (CP 42) conservation planting in Madison County. Since those initial discoveries in conservation plantings, Palmer amaranth was confirmed in an additional 41 Iowa counties in 2016 (Fig. 1). At least 35 of those counties are on the map as a result of the unintentional seeding of Palmer amaranth with native seed for conservation purposes.

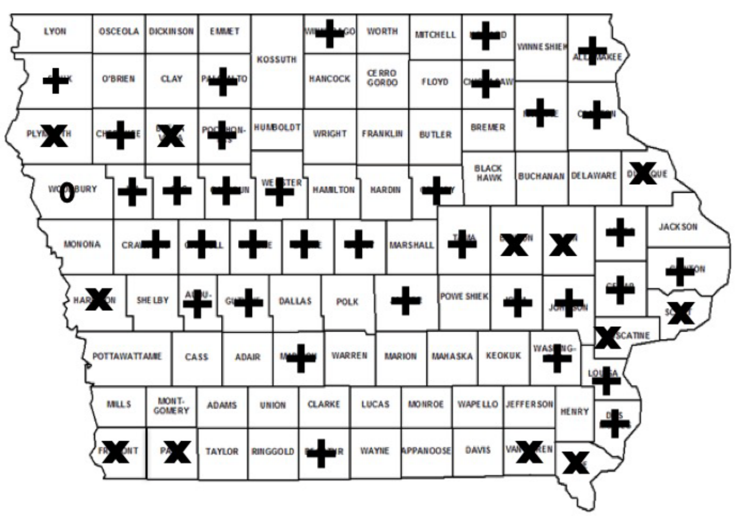


Figure 1. Counties with confirmed Palmer amaranth infestations, Oct. 2016. 'X' indicates first detection via conventional agricultural practices, '+' indicates first detection via conservation planting. Several counties are known to have both means of introduction. Woodbury County infestation was found on a railroad siding.

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[2] Professor and Extension Weed Scientist, Dept. of Agronomy, 1126C Agronomy Hall, Iowa State University, Ames, IA, 50011

## Discussion

In 2016, there was a tremendous increase in planting of native seed mixes across Iowa due to government programs like the Conservation Reserve Program (CRP). Pollinator habitat (CP 42) was one of the more popular programs due to cost share for establishment, signing incentives, and annual rental payments competitive with cash rent rates. Other programs such as wildlife food plots, native grass and forb plantings, and permanent wildlife habitat also encouraged planting of native seed mixes. In Iowa, approximately 200,000 acres were planted with native seeds in 2016, and some counties had up to 200 fields entered into these programs. Pollinator habitat required as little as 0.5 acres for enrollment, allowing these to be easier incorporated into landscapes, even within crop fields.

The primary means of introduction of Palmer amaranth in conservation plantings has been use of native seed mixes contaminated with Palmer amaranth seed. We have obtained samples of several of the seed mixes used in fields with Palmer amaranth infestations, isolated *Amaranthus* spp. seed in the seed mix, and confirmed the plants as Palmer amaranth following greenhouse grow-outs. Seed tags obtained from some Iowa landowners with Palmer amaranth in newly-seeded conservation plantings indicated the seed mixture had 0.00% weed seed. This indicates there is not only an issue with weed seed movement in seed mixes but also problems with seed testing procedures.

We have visited the largest Iowa producer of native seeds, inspected their production fields, and were unable to find Palmer amaranth. The huge increase in demand for seed of native prairie plants in 2016 resulted in local seed producers being unable to meet this demand. Most Iowa producers purchased seed of several species from outside vendors. The producers believe that these imported seed were the source of the Palmer amaranth.

Introduction of Palmer amaranth via contaminated native seed has occurred in other states as well. Ohio documented contaminated seed native seed mixes as a problem in 2014; the native seed contaminated with Palmer amaranth was imported from Texas. Both Illinois and Minnesota identified new conservation plantings this summer where Palmer amaranth was introduced, but the number of new introductions in those states appear to be a fraction of that in Iowa during 2016 (Fig. 2). Minnesota identified black-eyed Susan seed imported from Texas was the source of Palmer amaranth in seed mixes used in their state.

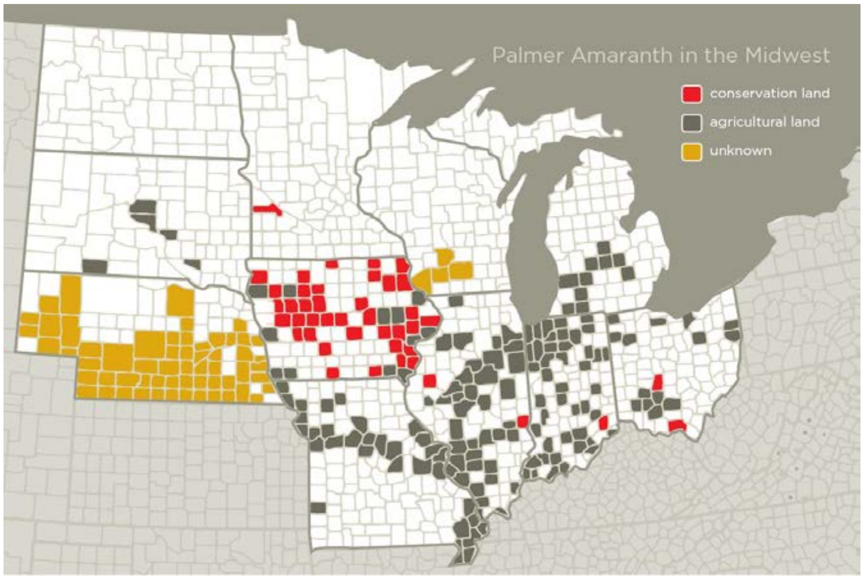


Figure 2. Weed scientists across the Midwest are finding Palmer amaranth. Grey counties indicate Palmer amaranth was first found in an agricultural field, whereas red indicates it was first found in conservation program land. Yellow signifies the source of introduction was not identified. Credit: Julie McMahon, University of Illinois.

While we have confirmed Palmer amaranth in 35 counties due to conservation plantings, we are confident the number of introductions is much higher, and we have no idea how many fields in individual counties might have had Palmer amaranth introduced. We are working with FSA and NRCS to notify participating landowners of the problem, and hope to conduct a random survey of the 2016 conservation plantings during 2017 in an attempt to answer these questions.

Since few Iowa farmers have drills appropriate for planting native species, most planting is done by custom operators. Drills typically are not cleaned when moving from job to job, and carryover seed is often left in the drill. This undoubtedly increased the number of fields to which Palmer amaranth was introduced. An example of this was provided by one participating landowner. This person enrolled 8 acres in pollinator habitat and 54 acres in a grass-based CRP program. The pollinator habitat was planted first, and the remaining seed was left in the drill when moving to the grass planting. They hand rogued 300 Palmer amaranth from the 8 acre pollinator habitat and 50 from the 54 acre CRP field. This suggests that approximately 1-2 acres of pollinator habitat seed was left in the drill when moving between fields. We fear this type of equipment contamination probably greatly increased the number of fields where Palmer amaranth was introduced.

Other states have also reported the presence of Palmer amaranth and other weed seed in bird seed, hay, animal feed, equipment movement, and movement of Palmer amaranth seed via migrating waterfowl. The many paths of Palmer amaranth movement will require a higher level of management for those near high-risk areas or using any type of feed from an area known to have Palmer amaranth.

Palmer amaranth is now undoubtedly a permanent component of the Iowa flora, however steps can be taken to minimize the risk contamination of native seed poses to Wisconsin agriculture. Landowners should purchase locally-produced seed whenever possible and communicate with producers to ensure seed produced out-of-state does not come from known high-risk areas.

# CYBER-CRIME TRENDS: A STATE OF THE UNION

Mark Eich [1/]

Hackers have learned to profit from their activities. While breaches at large companies like Target, Home Depot and Sony dominate the news this threat is significant for the small business as well. Virtually every industry segment is affected, indeed, any business that stores personal financial information on the network or conducts online cash management is a potential target. Payment fraud targeting wire transfers, automatic clearing house payments, and credit cards is increasing at an alarming rate. Historically, hacking has been a high risk issue only for banks, but attackers are now targeting all businesses in an effort to access bank funds via online payment methods.

This session will describe the threat landscape, discuss regulatory efforts to address the threat, and provide insight on how business leaders can effectively address this emerging threat.

Discussion Topics:

- What is cyber crime?
- Payment fraud trends and tactics hackers are using
- How and why hackers are targeting you
- Overview of recent cyber crime litigation issues
- Common information security weaknesses
- Solutions to help minimize risk

Who Should Attend
This session is designed for business owners, CEOs, CFOs, controllers, finance managers, and other decision makers.

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# MILLENNIALS TALK ABOUT MILLENNIALS: WHAT YOU SHOULD KNOW ABOUT THE EVOLVING WORKFORCE – PANEL

Kristen Faucon [1/], Aaron Cole [2/], and Anne Moore [3/]

SPACE PROVIDED FOR QUESTIONS OR NOTES

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# EMERGENCY/CRISIS/MANAGEMENT: AN OUNCE OF PREVENTION

Paul Rutledge [1/]

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# WISCONSIN VEGETABLE WEED MANAGEMENT UPDATE

Jed Colquhoun, Daniel Heider and Richard Rittmeyer[1]

While weed management across the Wisconsin vegetable acreage was generally quite good in the 2016 season, regulatory and resistance issues continue to loom and threaten management options in the very near future.

On the regulatory updates front, in September 2015 we learned that diquat would undergo federal registration re-evaluation as part of a required process carried out every 15 years by the Environmental Protection Agency (EPA). Diquat has been a mainstay for potato vine desiccation for many years, speeding up vine kill and enhancing skin set and reducing disease risk. Several restrictions were originally proposed by EPA in the diquat re-registration process, including limitations to the rate and number of applications, but by far the proposed application timing restrictions were most concerning for potato growers. The EPA draft risk assessment indicated that diquat use might need to be limited to fall and winter months, effectively eliminating use as a potato vine desiccant in our production region. The potato industry and research community entered many public comments reflecting the potential negative impact of such a restriction. Final decisions are still pending based on this input, but our voices have been heard. Our comments were justified with data from our recent vine desiccation research. Additionally, we've been investigating several alternative vine desiccation systems that will speed up vine kill and enhance skin set. Our work has targeted early season potato vine desiccation as the most challenging scenario, when vines remain healthy and actively growing.

For years, we've preached about avoiding weed resistance to herbicides and showed "gory" examples from other parts of the world. Well, we no longer need to travel far to show dramatic examples – unfortunately, we can just look in our back yard. In Wisconsin, we now have confirmed glyphosate resistance in horseweed, giant ragweed, Palmer amaranth and common waterhemp, with suspected cases involving additional species. Confirmed resistance to glyphosate is now quite widespread in species such as common waterhemp. Additionally, populations of this weed species have also been found in Wisconsin with resistance to multiple herbicide modes of action in a single plant. In vegetable crops, this makes our efforts to secure new weed management tools even more critical so that we can overcome resistance by diversifying our portfolio.

In response to widespread global glyphosate resistance in weeds, agronomic crops including soybean, cotton and corn with resistance to synthetic auxin herbicides such as 2,4-D and dicamba are in various stages of the approval and introduction process. In August 2016, the EPA issued a compliance advisory noting allegations of dicamba misuse on early commercial introductions of resistant soybean and cotton across 10 states (there were no legal uses of dicamba across the top of soybean or cotton during the 2016 growing season). Crop damage allegedly from off-target dicamba was reported on thousands of acres of nearby crops that ranged from melons and tomatoes to peaches. We can learn from this unfortunate situation as synthetic auxin-resistant soybean seed will increase in availability next growing season. Keep in mind that off-target herbicide movement happens in a number of ways that include volatility, spray drift at the time of application and tank contamination, and many of our broadleaf specialty crops are susceptible to these products.

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Our vegetable research in the 2016 growing season included potato, sweet potato, celery, carrot, onion, snap bean, lima bean, pumpkin and mint, among other crops. In several of these crops we have newer potential herbicides that are approaching registration and will greatly increase our weed management options. Our recent work in carrots is summarized below as an example.

Carrot growers remain challenged with a broad spectrum of weed species in a relatively uncompetitive crop and currently have few management options to remedy the situation. Furthermore, linuron, one of the more effective control options in carrots, is restricted in use on coarse-textured, low organic matter soils where the crop is often grown. With this in mind, our research over the past two years has been conducted to: 1) identify herbicide programs that provide season-long control; 2) evaluate preemergent herbicides on cereal nurse crops interseeded among carrots for wind erosion control; and, 3) identify carrot varieties that suppress weeds with rapid emergence and establishment.

Much of our work has focused on prometryn herbicide (trade name: Caparol or Vegetable Pro) as an alternative to linuron. In general and compared to linuron, prometryn has more potential for carrot injury (particularly when carrots have emerged but have fewer than 3 leaves) and takes longer to control weeds, so be patient! When applied pre-emergence at a product rate of 2.0 pints of product per acre, prometryn only controlled about 50% of common ragweed and about 85% of the early redroot pigweed and common lambsquarters. With those gaps in mind, many growers have chosen to use pendimethalin pre-emergence followed by prometryn post-emergence. In field observations, the standing oat nurse crop was injured by 2.0 pints prometryn product per acre but recovered enough to provide wind protection. Season-long redroot pigweed control remains a challenge in many fields.

Additionally, several carrot varieties were also evaluated for their ability to: (1) maintain yield in the presence of weeds; and, (2) suppress weeds through rapid establishment and canopy development. For example, ‘Bolero’ established a broad crop canopy sooner than most other varieties and maintained 95% of the weed-free carrot yield when weeds were present. In contrast, ‘SFF’ variety established slowly and never achieved full ground cover in canopy development. As a result, weed biomass was greater than in any other variety and the yield of the weedy carrots was only 72% of the weed-free yield. Carrot variety emergence and canopy development rates can be an important consideration in an integrated weed management program and require no additional crop inputs.

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

# SUSTAINABILITY IN UW SPECIALTY CROP PRODUCTION

Paul Mitchell and Deana Knuteson [1/]

Agricultural sustainability means different things to different people. In reality, it is only in hindsight that we can know what is actually sustainable. How can anyone really know how we should farm today to ensure that we will be able to still be farming 100 or more years from now? Differences in strategies for dealing with this uncertainty are at the root of much of the debate and disagreement surrounding agricultural sustainability. Here we are not going to overview or summarize this debate and some of the main strategies, but rather focus on results – what have we accomplished at UW and in Wisconsin for research and related activities. First, we briefly describe the conceptual framework we use for agricultural sustainability assessment. Second, we present specific results for Wisconsin potato growers and Midwestern processing green bean and sweet corn growers. Finally, we overview some research in progress.

## Conceptual Framework for a Practical Agricultural Sustainability Program

This framework was developed based on the experiences of the authors and multiple stakeholders with Healthy Grown® and agricultural sustainability programs over the years, based on numerous discussions and debates among many stakeholders in a variety of contexts; we are merely the summarizers of this collective knowledge, not the originators.

First and foremost, farmers prefer a grass-roots approach that actively engages them in the design and management of an agricultural sustainability program. Farmers bear the brunt of the economic outcomes of their sustainability choices, plus many of the environmental and social outcomes on their farms and in their communities, and so should be an integral part of program design. Their active participation and leadership helps ensure a practical program that is balanced among the three components of sustainability and that can be reasonably implemented by a large portion of growers. Furthermore, farmers generally want a practice-based approach to agricultural sustainability because it is consistent with many other agricultural programs, but the practices to be adopted must be science-based with demonstrated benefits. As a result, this approach requires scientific experts and farmers to collaborate to ensure that practices are both practical and enhance sustainability.

Farmer effort to satisfy value-chain sustainability requirements will be consistent with the value they realize. Existing sustainability programs are generally cost centers for farmers – they are expected to complete assessment paperwork as a cost of doing business or for market access. Thus farmers want a cost-effective sustainability program. Because most farmers sell to multiple buyers and grow multiple crops, they also want a harmonized

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program that is acceptable to the entire food supply chain and uses a whole-farm approach. A harmonized whole-farm approach will improve the efficiency of assessment, as much of the information needed is often similar, regardless of the crops or market. Most farmers also want a program that incorporates the non-crop lands on their farms that they manage and that generate important sustainability benefits, an aspect missing from crop-oriented sustainability assessments.

Farmers also desire a program that is regionally appropriate and flexible, so that it can adapt to changing technology and a rapidly evolving marketplace. Most farmers are also uncomfortable reporting detailed information about their operations to corporations, government agencies, or other third parties. Their concerns include maintaining personal privacy and confidential business information regarding methods of production, costs, and profits. They do not want their information used against them by the media or various activists, or by corporations to extract gain. Farmers want a sustainability program to collect only necessary data and to maintain confidentiality. Also, farmers desire a program that enhances communication with the supply chain and consumers, so that the general public becomes more aware of their long-term commitment to sustainability and their stewardship accomplishments. Finally, farmers want a program that is educational, not a program that tells then to adopt certain practices or achieve certain outputs with no explanation as to why these are desirable.

Over the years, several people in Wisconsin and the region have devoted a lot of energy and effort to develop a program to satisfy these requirements. Potatoes and processing vegetables have been the focus of a lot of this effort, as have cranberries and soybeans. The process of developing a practical agricultural sustainability program begins with forming a leadership team that includes farmers, as well as university faculty and private crop consultants, and representatives from the value chain (processors, distributors, handlers, and retailers), plus government agencies and NGOs. The team identifies overall goals and desired outcomes for the sustainability program and then acquires and allocates resources to begin developing and implementing the program. These steps should be known to those familiar with the development and establishment of the Healthy Grown® program.

The process begins with the working group taking sustainability priorities and outcomes that are general and national in scope and regionalizing them by identifying specific practices appropriate to local production systems that are both practical to adopt and will help achieve the more general national goals. The output created is a regionally-appropriate self-assessment tool of science-based practices with demonstrated sustainability benefits that are relevant to farmers – in other words, a list of good farming practices for that region and cropping system.

The farmer association then works with individual farmers to measure their practice adoption based on this self-assessment tool. These self-assessment data are pooled over all farmer members and analyzed to establish a best-practices frontier in order to evaluate how the farmer members are doing as a group. Next, the farmer association uses the population summary of these data to identify practices to target for outreach and education for its members and to determine knowledge gaps that need further research. The association then implements these plans, which may include helping farmers change plans and integrate new practices into their operations. Finally, the cycle returns to its beginning as the leadership team re-evaluates the self-assessment tool, the data collection and analysis, and the effectiveness of outreach and research, potentially updating or adjusting any of these in order to improve the overall program.

From the perspective of a farmer, you fill out a quick on-line survey of the practices you use on your farm, then receive personalized feedback on how the practices you use compare to the practice your fellow farmers use, with specific practices identified that you could adopt to improve and become more like the "best" farmers in your state or region. These comparisons and recommendations are delivered to farmers using a personalized scorecard with a sustainability dashboard. Key to being effective is the creation of a self-assessment tool that makes sense to the farmer members and getting good participation in the data collection, hence the focus on farmer engagement and maintaining data anonymity and confidentiality. Peer-pressure is used in a positive way and combined with education to encourage adoption of good farming practices. In simple terms, this program is a way for a grower association and an industry to operationalize continuous improvement – a process to identify where they need to improve both individually and as a group and a way to help make positive changes happen.

## Data Analysis

The practice adoption data from the sustainability self-assessment are analyzed using innovative algorithms developed at UW. The raw adoption data from the self-assessments are first pre-processed using non-negative, polychoric principal component analysis, a mathematical process that reduces the number of variables, makes them continuous, and removes correlation among them. Next, common-weight data envelope analysis is used to generate individual farmer sustainability scores – a number between 0 and 1 that indicates how intensely each farmer adopts the good farming practices in the self-assessment relative to his peers. The process determines a weight or "points" for each practice in the original self-assessment, with the weights depending on the adoption profile of all the farms in the assessment. The process generates two main types of output. First is the distribution of sustainability scores for farms, showing how intensely the group of farms adopts the good farming practices in the original self-assessment. Second is a personalized grower scorecard that shows how each farmer compares to his peers in the different aspects of sustainability (sustainability dashboard), with specific recommendations of practices the grower can adopt to most improve his score based on the practice weights.

This analysis process was developed specifically for sustainability assessment, so that farmers could measure their current status and document improvement over time. A simple analogy helps make the essence of the process clear. The self-assessment tool is like a "test" with the farmers as "students" with the students/farmers helping to write the test they want to use to assess themselves. The analytical process "grades" this test on a curve, with best students getting a 1.0 and everyone else graded relative to these top students. The distribution of the scores shows how the "class" does as a whole, while each student's individualize report indicates where they did well and where they need to improve to keep up with the rest of the class.

## Wisconsin Potato and Vegetable Results

We have conducted two sustainability self-assessments for Wisconsin's potatoes and processing vegetable growers. These self-assessments were developed in consultation with UW extension and research specialists, crop consultants, processing company field mangers, with farmer leadership from the WPVGA and the Midwest Food Processing Association. In January 2013, 44 green bean growers and 67 sweet corn growers from Wisconsin, Minnesota and Illinois completed a self-assessment, in total representing about 10% of the planted acres in the region for each crop. In October and November of 2013, 71 Wisconsin potato growers completed a potato self-assessment, representing 90% of the acres in the state. The processing vegetable assessment contained questions about use of almost 180 practices, while the potato assessment asked about use of almost 160 practices.

The focus was to determine farmer use of good management practices with documented positive outcomes, such as integrated pest management, basing nutrient applications on soil and plant tissue tests, and comparable labor and farm business management practices. The specific practices on each assessment are available from the authors. The processing vegetable assessments were collected by farmers completing paper copies, while the potato assessment was completed using a web-based survey tool. Summaries of results based on simple data averages are available online (http://wisconsinpotatoes.com/growing/sustainable-practices/; http://nisa.cals.wisc.edu/wp-content/uploads/2013/11/SCRIreport_2page_FINAL.pdf). For example, 97% of the potato farmers used soil sampling to determine crop nutrient needs, 90% rotate insecticide modes of action to manage pest resistance, and 70% plant winter cover crops, with 87% using living windbreaks.

The potato assessment analyzed all practices at once and only focused on generating a summary of the farmer population. The processing vegetable assessments not only generated a population summary, but also individualized grower scorecards that were sent to the growers anonymously in April 2015. The practices for the processing vegetable assessments were separated into ten different categories (see example scorecard for the list). The 10-20 practices in each sustainability category were then analyzed separately, to give each farm a score for each category, and then data envelope analysis was used over the scores for the ten categories to give a single grand sustainability score for each farm. The figures below show the distribution of the grand scores for the Midwestern sweet corn and green bean growers and the Wisconsin potato growers, and then the example grower scorecard for one random Wisconsin green bean grower and the associated recommended practices for each sustainability category.

## Discussion and Interpretation

The average sustainability score was 0.939 for Wisconsin potatoes, 0.905 for Midwestern sweet corn growers, and 0.887 for Midwestern green bean growers, while the respective minimum scores are 0.759, 0.700, and 0.744. These high averages and minimums imply that in general, these potato and vegetable growers are fairly similar in terms of practice adoption and most growers adopted most or many of the practices considered good farming practices. Average growers adopt these good farming practices at a level of about 90% as intense as the best growers among their respective groups, with the lowest only getting to as low as 70%.

The plots of the score distributions show there are some differences among the crops. Many potato growers are tightly clumped at scores near the maximum of 1.0, with only a few growers in the lower tail. Sweet corn scores are similar, but have a smaller clump of scores near the maximum of 1.0 and a thicker distribution for the lower tail. However, scores for green bean growers show little clumping and are fairly evenly distributed between the maximum and minimum. All three of these distributions are rather tight. Similar assessments for Wisconsin cranberry growers and for Wisconsin and Illinois soybean growers (not shown) have lower averages and longer tails, implying that these potato and vegetable growers are more similar in terms of practice adoption.

An advantage of the analytical process used to derive these scores is that it can identify the specific practices that contribute most to farmer scores. The analysis of the potato practice adoption data did not separate practices into categories or develop specific recommendations. However, the five practices with the largest weights in the potato analysis were: (1) following guidelines for nutrient management applications, (2) using insect scouting to determine when to treat, (3) maintaining irrigation and water use records, (4) attending science-based field days and educational meetings to learn about farm, crop, and ecosystem management, and (5) having the ability to trace product from field to the distribution chain. Around 90% of Wisconsin potato farmers completing this assessment use these practices already, so that those farmers with lower scores likely were not using one of more of these practices.

The assessment data for sweet corn and green beans were analyzed in more detail. The figures show the grand scores for the whole farm, but for each of the ten sustainability categories, distributions like below were generated (i.e., 20 plots). This is too much information to digest, and so the "sustainability dashboard" was created. For each sustainability category, the band runs from 0 to 1. The red star and vertical bar indicate the farmer's score, while the darker horizontal bar indicates the score range for the middle half of the farmers (the $25^{th}$ to the $75^{th}$ percentile), which we call the industry average range. For example, the farmer has a score in community sustainability just above the average range, with most farmers receiving high scores overall, but over a fairly wide range. On the other hand, for ecosystem restoration sustainability, the farmer has a score just below the average range, with low scores typical among all farmers, while for production management, the scores are on average higher and fall in a narrow average range.

Another advantage of the grower scorecard is a set of personal practice recommendations – two practices for each sustainability category that the farmer does not use, but if adopted, would most improve his score for that category. These farmer-specific recommendations take more effort to create, but are a key element motivating adoption of new practices to drive continuous improvement in an industry. Grower scorecards were sent to cooperating growers this spring (later than we had hoped) through the Midwest Food Processors Association, so some Wisconsin processing vegetable growers should have received these cards in the mail. We would appreciate any feedback growers may have.

## What's Next?

At this time, we have various research papers in progress to get the algorithms published in the peer-reviewed literature as a way to validate the process and develop academic credibility. The only paper published at this time describes the fundamental algorithms, with the application to Wisconsin cranberry farmers. In review is a paper on Wisconsin and Illinois soybeans that shows the impact on the industry score distribution if low-scoring farmers adopt more practices. Another in review describes desirable program characteristics, grower scorecards and the algorithms for doing the analysis using separate categories, using green beans and sweet corn as the empirical example. This was presented at a conference in the Netherlands and in this article. Finally, we have a paper started on the impact of increasing the sustainability score on the optimal cost of production. This paper will be the first attempt to get at the tradeoff between increasing sustainability and economic outcomes. This paper proves that we can conceptually and empirically estimate this tradeoff and we will be seeking funding to collect more data, maybe from Wisconsin potato and vegetable growers! Sustainability is an area of active research for us and we expect more research and outreach to come that will help make a practical agricultural sustainability program a reality for farmers.

NITROGEN USE EFFICIENCY IN MODERN SNAP BEAN PRODUCTION SYSTEMS

Matt Ruark and Jaimie West[1/]

## Introduction

Current University of Wisconsin-Extension guidelines recommend 60 lb-N/ac for snap bean grown on soils less than 2% organic matter, which are most soils in the Central Sands of Wisconsin. However, the typical rate that snap bean growers apply is much greater than this rate. In addition, it is possible that rates lower than 60 lb-N/ac may be economically optimal for some varieties. Snap beans are a legume and some, but not all, varieties nodulate, meaning they have the ability to fix nitrogen (N) from the atmosphere. This will result in different N response curves and perhaps different N recommendations for different snap bean varieties. It is often assumed that when we fertilize legumes with N, the added N replaces the amount of fixed N in a one-to-one manner – but this is rarely true. In fact, we know little about the tradeoffs between N application and nodulation in snap beans. The objectives of this paper are to review the state of knowledge of snap bean response to N fertilizer and evaluate the different ways nitrogen use efficiency can be determined.

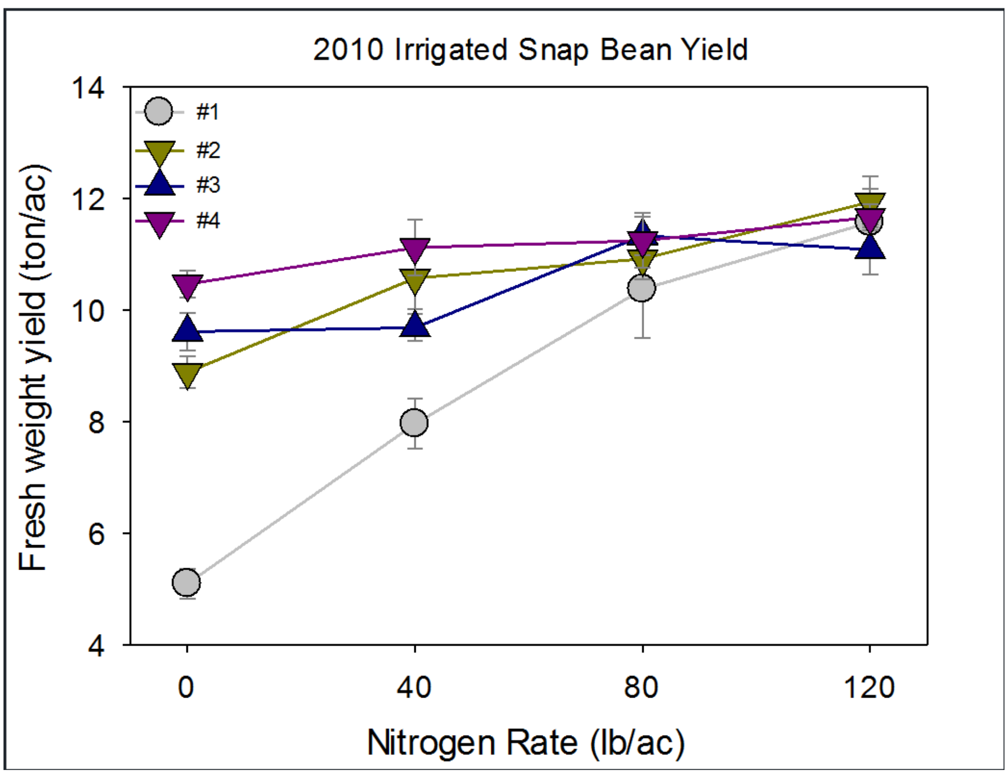


Figure 1. An example of the difference in snap bean yield response to N fertilizer by variety. Variety #1 was non-nodulating and varieties #2, #3, and #4 were nodulating.

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Previous Research and Results

Previous research (2010-2012) was conducted in Plover, WI to assess snap bean variety response to N fertilizer as well as N uptake and use efficiency. Four varieties were tested, one of which (#1) was a non-nodulating variety. In Figure 1, it can be clearly seen that this variety had a much larger response to N fertilizer compared to the nodulating varieties, which had quite a bit of N supply when no N was added. However, the nodulating varieties did have an economically valuable yield increase when N fertilizer was applied indicating that nodulation was not enough to provide agronomically optimal amounts of N. Although up to 40 lb-N/ac could be added before it significantly affected the N balance of the production system (Fig. 2).

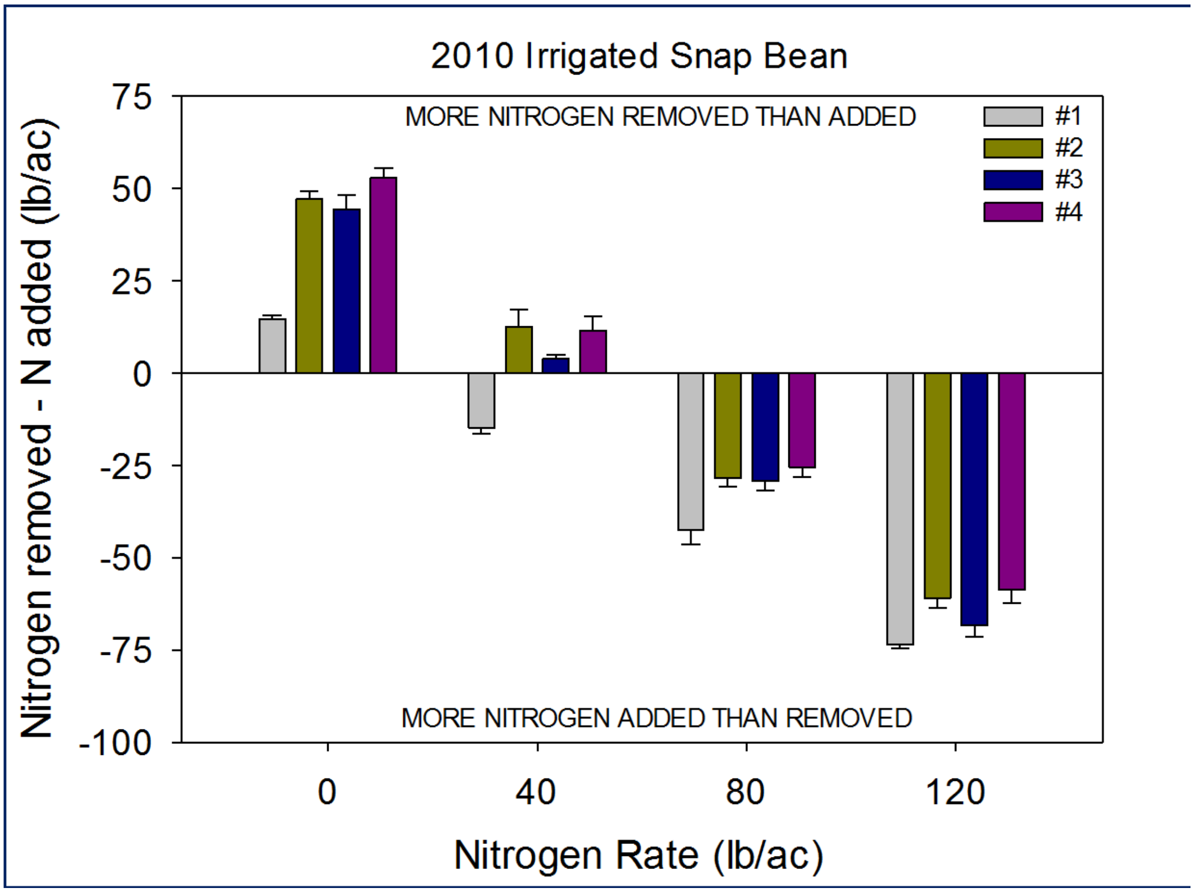

Figure 2. The nitrogen balance for the four varieties (N removed with pods minus N applied with fertilizer) across different N rates.

The N taken up by nodulating varieties of snap bean can come from three sources: the soil, fertilizer, and from biological N fixation (BNF) (i.e. the N produced by N fixing bacteria). The N derived from BNF will have a different isotopic signature (15N) compared to other sources of N and we can use this measurement to calculate how much suppression of N fixation occurs when N fertilizer is applied. Preliminary data (Fig. 3) indicates three things: (1) Whole plant N uptake increases with additional N applied, (2) N derived some soil says consistent across N application rates, and (3) the addition of N fertilizer clearly suppressed N fixation, but not completely. For example, when 40 lb-N/ac was applied, BNF was reduced by 31 lb-N/ac. When 80 lb-N/ac was applied, BNF was reduced by 49 lb-N/ac. At the N rate of 120 lb/ac, BNF was suppressed completely. This is interesting information for growers as it would indicate that N fertilizer additions clearly suppresses BNF and that the N use efficiency of the applied fertilizer remains high. This study is being continued to address this effect across different yield potential scenarios. The previous work has all been conducted under extremely high yielding conditions, well above the average yield for the state of Wisconsin.

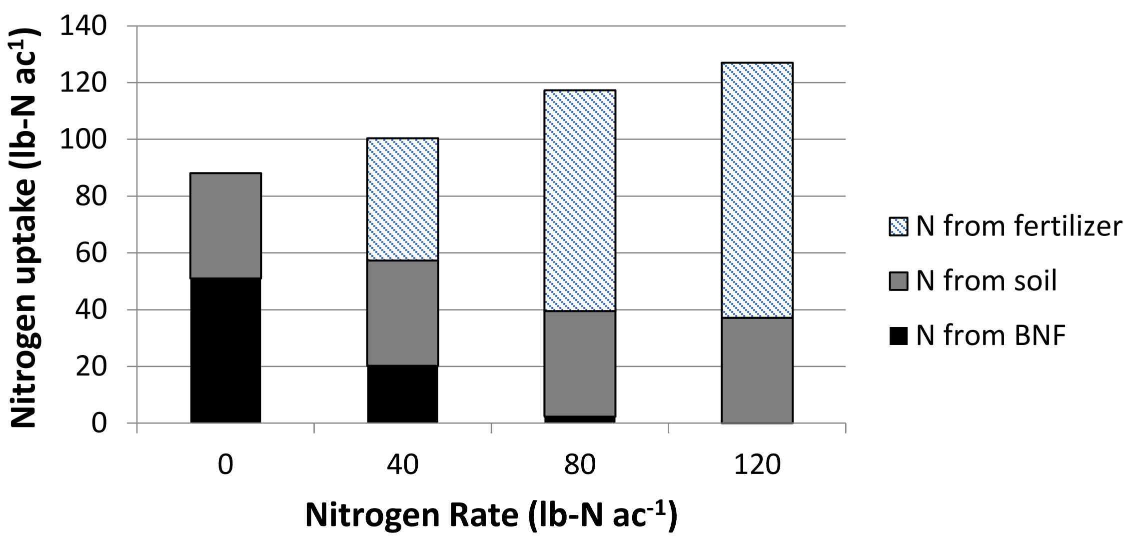


Figure 3. Nitrogen uptake of one nodulating variety of snap bean in 2011 as determined by 15N analysis.

VEGETABLE DISEASE UPDATE

Amanda Gevens [1/]

SPACE PROVIDED FOR QUESTIONS OR NOTES

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# NEONICOTINOID INSECTICIDES AND IPM IN PROCESSING VEGETABLES

Russell L. Groves[1], Kathryn J. Prince[1], and Benjamin Z. Bradford[1].

Abstract

Production and processing of specialty crops in Wisconsin are very important to both state and national agricultural industries. And key among these processing crops in Wisconsin include sweet corn, succulent snap beans, field peas and potatoes. In addition, the vast majority of these commercial, contract acres receive an at-plant in-furrow, or seed treatment of a Group 4A insecticide (neonicotinoid). Increasingly, producers rely heavily on this single class of insecticides for control of early season pests including Colorado potato beetle, seed maggots, potato leafhopper, and bean leaf beetles (NASS 2006). Reported at-plant applications of these neonicotinoid seed treatments have occurred on nearly 90% of all acres reported and reflect statewide use rates in many other grain crops. In the 2014 and 2015 growing season, the in-plant concentrations of thiamethoxam (Cruiser® 5FS) were monitored using an ultra-performance liquid chromatographic mass spectrometry procedure in both leaf and floral tissues at varying stages after emergence from the soil. Beginning in 2008, the Wisconsin Department of Agriculture, Trade, and Consumer Protection began testing for neonicotinoids in groundwater test wells in the state, finding one or more compounds in dozens of test wells, with most detections occurring in the Central Sands and Lower Wisconsin River Valley agroecosystems. In 2011, our laboratory began similar testing and detection levels were confirmed in a portion of high-capacity, overhead, center- pivot irrigation systems applying this contaminated groundwater to flowering irrigated crops (cucumber, snap beans, alfalfa) throughout the cropping season Since our testing began, we have confirmed a total of 298 samples from 92 unique high-capacity irrigation wells which have tested positive for the presence of thiamethoxam (the most water-soluble and widely used neonicotinoid in the area). Furthermore, an analysis of the spatial structure of these well detects suggests that the level of contamination is extremely variable from the landscape scale down to the individual field scale, and that the amount of contamination at a particular well can shift by one or two orders of magnitude from year to year and even within a growing season. The high degree of observed spatial and temporal variability in thiamethoxam detections underscores the need to investigate the relationship between individual well detections and together with both land and insecticide usage patterns in the vicinity of each well.

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PHOSPHORUS AND POTASSIUM RESPONSE IN NO-TILL CORN AND SOYBEAN PRODUCTION

Carrie A.M. Laboski and Todd W. Andraski[1]

## Introduction

Current UWEX fertilizer recommendations and plant analysis interpretation guidelines were developed prior to the release of GMO corn. There is some concern amongst University soil fertility specialists and industry agronomists that corn and soybean response to P and K fertilizer applications may be different with modern corn hybrids and soybean varieties. In addition, in the UW recommendation system, an estimate of the amount of nutrients removed in the harvested portion of the crop is used to determine the fertilizer recommendations based on soil test levels (Laboski and Peters, 2012). If crop removal rates have changed in modern hybrids is it essential to determine current removal rates and use those numbers in fertilizer recommendations.

This study is designed to provide initial information on corn and soybean yield and nutrient concentration response to applied P and K fertilizer for modern hybrids and varieties in Wisconsin. This information will be the first step in determining how to approach a broader P and K calibration study across Wisconsin in the future. The objectives of this study are to: 1) assess corn yield response to P and K fertilizer applications; and 2) assess the effect of P and K fertilizer applications on corn plant nutrient concentrations at V4, V10-12, VT-R1, and grain for corn and R1, R3, R5, and grain for soybean; and 3) evaluate effects of P and K fertilizer application on soil test levels. This paper will report on objectives 1 and 3.

## Materials and Methods

A P and K response study was established at the University of Wisconsin Agricultural Research Station at Arlington (43.323098, -89.343959) on a Saybrook silt loam. The field selected had very low soil test P and K levels (Table 1) and had been cropped to alfalfa/grass for the previous five or more years. A no-till soybean-corn rotation was established in 2011 on Field 602S and in 2012 in Field 602C. Initial treatments in 2011 included a complete factorial of all combinations of four rates (0, 30, 60, and 90 lb/a) of $P_2O_5$ as triple superphosphate (0-46-0) and four rates (0, 40, 80, 120 lb/a) of $K_2O$ as potash (0-0-60) with four replications. Additional treatments of 160 lb $K_2O$/acre at the four P rates were included beginning in 2012 to make certain we had encompassed a non-limiting K rate. For these treatments, we added additional P and K in 2012 to equal the two-year application rate total (adjusted for soybean grain removal in 2011). In all subsequent years, the same rates of P and K were broadcast in each plot prior to planting.

Table 1. Initial soil test level at the time of plot establishment.

| Soil Test | Field 602S (est. 2011) | Field 602C (est. 2012) |
|---|---|---|
| pH | 7.1 | 7.1 |
| OM, % | 3.8 | 4.0 |
| Bray 1 P, ppm | 8, very low | 1, very low |
| Bray 1 K, ppm | 59, very low | 48, very low |

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Each plot was 10 ft. wide by 30 ft. long and trimmed to 25 ft. Both crops were planted in 30-inch rows. All crop management practices followed University of Wisconsin Extension recommendations.

In the spring prior to initial establishment of the plots, composite 6-inch soil samples were collected from each replication. In subsequent years, each plot was soil sampled to 6 inches prior to fertilizer application in the spring. Soil samples were dried at 90ºF and ground to mass a 2-mm sieve prior to analysis. Grain was harvested from the center two rows of each plot using a plot combine. Whole plant corn biomass was collected at physiological maturity. Corn grain yield is reported at a 15.5 % moisture content and soybean grain yield at 13% moisture content.

Data were subjected to an analysis of variance using PROC MIXED and regression analysis using PROC REG and PROC NLIN (SAS Institute, 2002). Phosphorous and K rate treatments were treated as fixed variables, whereas replication was treated as a random variable. Significant differences among treatment means were evaluated using Fisher's LSD test for mean separation at the 0.10 probability level unless otherwise noted.

## Results and Discussion

### Grain Yield

Visual differences in K treatments were observed each year for both corn and soybean. However, there were no apparent differences in P treatments for either crop in any year.

Corn grain yield ranged from 46 to 152, 28 to 233, 27 to 243, 4 to 242, and 31 to 285 bu/a in 2012, 2013, 2014, 2015, and 2016, respectively. Low yields in 2012 were a result of drought conditions which persisted throughout the growing season. There was a significant yield response to K application in each year (Table 2 and Figure 1). Based on means separation of the main effect of K application, the lowest K application rate with yields not significantly different than the highest yield was observed at 120, 120, 80, 120, and 80 lb $K_2O$/a in 2012, 2013, 2014, 2015, and 2016 respectively. There was no significant effect of P application on yield in 2012, 2013, or 2016. In 2014, there was a significant interaction between P and K where there was no yield response to P at K application rates of 0 or 40 lb $K_2O$/a and there was a significant P response at K rates greater than or equal to 80 lb $K_2O$/a (Figure 2). The optimum P application rate based on regression was 50 lb $P_2O_5$/a. Averaged across all P rates, soil test K levels in the spring were 65 ppm or greater where P responses occurred and 60 ppm or less where no P response was observed. In 2015, there was no significant interaction between P and K; however, there was a significant yield response to P with an optimum P application rate of 60 lb $P_2O_5$/a. Soil test K levels averaged across all P rates were 62 ppm or greater where P response occurred.

Corn biomass yields ranged from 3.63 to 7.41, 2.60 to 10.89, 2.80 to 12.08, 1.64 to 11.57, and 2.33 to 11.78 T DM/a in 2012, 2013, 2014, 2015, and 2016 respectively. There was a significant yield response to K application in each year (Table 3). Based on means separation of the main effect of K application, the lowest K application rate with biomass yields not significantly different than the highest yield was observed at 80, 120, 80, 80, and 80 lb $K_2O$/a in 2012, 2013, 2014, 2015, and 2016 respectively. There was no significant effect of P application on biomass yield in any year. However, in 2014, 2015, and 2016 biomass yield generally increased with P application (main effect).

Soybean yield ranged from 34 to 58, 9 to 23, 36 to 73, 28 to 60, 23 to 62, and 41 to 80 bu/a in 2011, 2012, 2013, 2014, 2015, and 2016 respectively. Low yields in 2012 were a result of drought conditions which persisted throughout the growing season. Yield increased significantly with K application in each year (Table 4). Based on means separation of the main effect of K application, the lowest K application rate with yields not significantly different than the highest yield was observed at 120, 120, 40, 80, 120, and 80 lb $K_2O$/a in 2011, 2012, 2013, 2014, 2015, and 2016 respectively. In 2013, any K application rate significantly increased yield over no K application, and there were no significant yield differences between K application rates. This observation may be a subsequent effect of the drought in 2012 which resulted in low K removal in corn grain. There was no soybean yield response to applied P in any year, except 2016 (Table 3). In 2016, soybean yield response occurred where spring average soil test K was at least 78 ppm. Spring soil test K levels average over 78 ppm K for some K treatments in 2013, 2014, and 2015 though no P response was observed. The P response in 2016 may be related to very favorable growing conditions throughout the season.

<u>Soil Test Results</u>

Consecutive applications of P and K fertilizer have altered soil test levels during the course of this experiment. Soil samples collected in spring 2015 prior to treatment application demonstrate this effect (Tables 5 and 6). In both fields, soil test P levels increased significantly with P application rate and decreased significantly with K application rate (Table 5). The reduction in soil test P levels with increasing K application rates is a result of greater yields and P removal, which occurred at higher K application rates. Soil test K levels increased with increasing K application rate (Table 6). In Field 602C, after three consecutive fertilizer applications, there was no effect of P application on soil test K. This was also observed for Field 602S after three consecutive fertilizer applications (spring 2014, data not shown). After four consecutive fertilizer applications on Field 602S, P application significantly affected soil test K levels. Soil test K was significantly lower at the 90 lb $P_2O_5$/a application rate compared to all other P application rates. This observation is attributed to the fact that the first corn yield response to P in this project was observed on this field (602S) the previous growing season. Larger corn yields at high rates of P resulted in more removal of K.

## Summary

Yield response to K resulted in yield increases over the no K control from 6 to 27 fold for corn grain and 1.8 to 2.3 fold for soybean. Soybean responded to P application only in 2016, even though soil test levels P were low throughout the study period. Corn yield increased with P application once soil test K levels increased to at least 65 ppm, except in 2016. These data clearly demonstrate that K is more limiting to corn and soybean production than P. It also demonstrates that soybeans relative need for P is less than corn.

In recent years, soil test K levels have been declining on many Wisconsin farms. Lower available K may result in not only lesser crop production but also a more rapid increase in soil test P levels where manure or fertilizer P is applied because lower production results in lower crop removal of P.

## Acknowledgment

The authors gratefully acknowledge Wisconsin Soybean Marketing Board and DuPont Pioneer for funding this research.

## References

Laboski, C.A.M. and J.B. Peters. 2012. Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin. UWEX Publication A2809

Table 2. Corn grain yield in 2014 (Field 602S) and 2015 (Field 602C) after four consecutive years of P and K fertilizer applications and in 2016 (Field 602S) after five consecutive years of P and K fertilizer applications.

| $P_2O_5$ rate | Field 602S, est. 2011 † | | | | | | Field 602C, est. 2012 ‡ | | | | | | Field 602S, est. 2011 ¶ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $K_2O$ rate, lb/a | | | | | | $K_2O$ rate, lb/a | | | | | | $K_2O$ rate, lb/a | | | | | |
| | 0 | 40 | 80 | 120 | 160 | mean | 0 | 40 | 80 | 120 | 160 | mean | 0 | 40 | 80 | 120 | 160 | mean |
| lb/a | -------------- 2014 Yield, bu/a -------------- | | | | | | -------------- 2015 Yield, bu/a -------------- | | | | | | -------------- 2016 Yield, bu/a -------------- | | | | | |
| 0 | 40 C | 156 B | 194 b A | 192 c A | 190 A | 155 b | 12 | 76 | 165 | 196 | 187 b | 127 b | 42 | 218 | 254 | 246 | 245 | 201 |
| 30 | 28 C | 150 B | 215 ab A | 211 b A | 204 A | 162 ab | 6 | 96 | 180 | 213 | 198 b | 139 ab | 31 | 202 | 272 | 261 | 259 | 205 |
| 60 | 27 C | 152 B | 230 a A | 235 a A | 210 A | 171 a | 10 | 95 | 182 | 218 | 242 a | 150 a | 31 | 214 | 271 | 284 | 273 | 214 |
| 90 | 36 D | 157 C | 205 b B | 243 a A | 208 B | 170 a | 4 | 66 | 175 | 217 | 229 a | 138 ab | 32 | 201 | 260 | 285 | 273 | 210 |
| mean§ | 33 d | 154 c | 211 ab | 220 a | 203 b | | 8 d | 84 c | 176 b | 211 a | 214 a | | 34 c | 209 b | 264 a | 269 a | 262 a | |

† $P_2O_5$ rate $p = 0.02$. $K_2O$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.08$. CV = 11%.
‡ $P_2O_5$ rate $p = 0.09$. $K_2O$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.56$. CV = 19%.
¶ $P_2O_5$ rate $p = 0.16$. $K_2O$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.19$. CV = 9%.
§ Mean $K_2O$ values or values within a given $K_2O$ rate followed by the same lowercase letter or values within a given $P_2O_5$ rate followed by the same uppercase letter are not significantly different at the 0.10 probability level.

Table 3. Corn biomass yield in 2014 (Field 602S) and 2015 (Field 602C) after four consecutive years of P and K fertilizer applications and in 2016 (Field 602S) after five consecutive years of P and K fertilizer applications.

| $P_2O_5$ rate | Field 602S, est. 2011 † | | | | | | Field 602C, est. 2012 ‡ | | | | | | Field 602S, est. 2011 ¶ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $K_2O$ rate, lb/a | | | | | | $K_2O$ rate, lb/a | | | | | | $K_2O$ rate, lb/a | | | | | |
| | 0 | 40 | 80 | 120 | 160 | mean | 0 | 40 | 80 | 120 | 160 | mean | 0 | 40 | 80 | 120 | 160 | mean |
| lb/a | -------------- 2014 Yield, T DM/a -------------- | | | | | | -------------- 2015 Yield, T DM/a -------------- | | | | | | -------------- 2016 Yield, T DM/a -------------- | | | | | |
| 0 | 3.61 | 8.61 | 10.05 | 9.64 | 10.21 | 8.42 | 1.87 | 5.77 | 9.28 | 9.14 | 7.76 | 6.76 | 2.48 | 10.35 | 10.30 | 9.88 | 10.11 | 8.62 |
| 30 | 2.39 | 9.36 | 10.70 | 10.46 | 9.58 | 8.49 | 1.70 | 6.59 | 8.64 | 8.87 | 8.83 | 6.93 | 2.34 | 9.90 | 10.61 | 10.99 | 10.79 | 8.93 |
| 60 | 2.80 | 7.57 | 11.03 | 11.72 | 10.61 | 8.75 | 1.91 | 6.08 | 9.37 | 9.50 | 10.99 | 7.57 | 2.33 | 9.33 | 11.32 | 11.12 | 11.22 | 9.06 |
| 90 | 3.45 | 9.80 | 10.16 | 12.08 | 10.57 | 9.21 | 1.64 | 4.85 | 9.92 | 11.57 | 11.14 | 7.82 | 2.48 | 10.61 | 10.78 | 11.71 | 10.97 | 9.31 |
| mean § | 3.06d | 8.83c | 10.48ab | 10.97a | 10.24b | | 1.78 c | 5.82 b | 9.30 a | 9.77 a | 9.68 a | | 2.41 c | 10.04 b | 10.75 a | 10.93 a | 10.77 a | |

† $P_2O_5$ rate $p = 0.13$. $K_2O$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.07$. CV = 13%.
‡ $P_2O_5$ rate $p = 0.16$. $K_2O$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.26$. CV = 23%.
¶ $P_2O_5$ rate $p = 0.29$. $K_20$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.75$. CV = 13%.
§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

Table 4. Soybean yield in 2014 after three consecutive years of P and K fertilizer applications (Field 602C) and in 2015 (Field 602S) and 2016 (Field 602C) after five consecutive years of P and K fertilizer applications .

| $P_2O_5$ rate | Field 602C, est. 2012 † | | | | | | Field 602S, est. 2011 ‡ | | | | | | Field 602C, est. 2012 ¶ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $K_2O$ rate, lb/a | | | | | | $K_2O$ rate, lb/a | | | | | | $K_2O$ rate, lb/a | | | | | |
| | 0 | 40 | 80 | 120 | 160 | mean | 0 | 40 | 80 | 120 | 160 | mean | 0 | 40 | 80 | 120 | 160 | mean |
| lb/a | --------------- 2014 Yield, bu/a --------------- | | | | | | --------------- 2015 Yield, bu/a --------------- | | | | | | --------------- 2016 Yield, bu/a --------------- | | | | | |
| 0 | 33 | 49 | 54 | 53 | 53 | 48 | 30 | 50 | 54 | 57 | 60 | 50 | 49 C | 69 B | 73 bA | 69 bB | 71 bB | 66 |
| 30 | 28 | 51 | 51 | 55 | 54 | 48 | 27 | 48 | 57 | 58 | 61 | 50 | 43 B | 70 A | 74 bA | 75 aA | 74 aA | 67 |
| 60 | 33 | 48 | 58 | 58 | 60 | 51 | 23 | 49 | 57 | 61 | 62 | 50 | 47 C | 67 B | 76 abA | 75 aA | 76 aA | 68 |
| 90 | 28 | 47 | 58 | 57 | 58 | 50 | 24 | 48 | 58 | 61 | 57 | 50 | 41 C | 68 B | 80 aA | 79 aA | 76 aA | 69 |
| mean § | 31 c | 49 b | 55 a | 56 a | 56 a | | 26 d | 49 c | 56 d | 59 a | 60 a | | 45 c | 69 b | 76 a | 75 a | 74 a | |

† $P_2O_5$ rate $p = 0.35$. $K_2O$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.75$. CV = 13%.

‡ $P_2O_5$ rate $p = 0.97$. $K_2O$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.14$. CV = 8%.

¶ $P_2O_5$ rate $p = 0.36$. $K_2O$ rate $p <0.01$. $P_2O_5$ rate x $K_20$ rate $p = 0.06$. CV = 7%.

§ Mean $K_2O$ values or values within a given $K_2O$ rate followed by the same lowercase letter or values within a given $P_2O_5$ rate followed by the same uppercase letter are not significantly different at the 0.10 probability level.

Table 5. Soil test P levels in spring 2015 after four (2011 to 2014) or three (2012 to 2014) consecutive fertilizer applications on Field 602S and 602C, respectively.

| $P_2O_5$ rate | Field 602S, est. 2011 † | | | | | | Field 602C, est. 2012 ‡ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $K_2O$ rate, lb/a | | | | | | $K_2O$ rate, lb/a | | | | | |
| | 0 | 40 | 80 | 120 | 160 | mean | 0 | 40 | 80 | 120 | 160 | mean |
| lb/a | --------------- Soil test P, ppm --------------- | | | | | | --------------- Soil test P, ppm --------------- | | | | | |
| 0 | 8 | 9 | 7 | 5 | 5 | 7 d § | 5 | 4 | 3 | 4 | 4 | 4 d |
| 30 | 18 | 11 | 11 | 8 | 7 | 11 c | 8 | 8 | 6 | 5 | 5 | 6 c |
| 60 | 25 | 17 | 12 | 13 | 13 | 16 b | 14 | 12 | 10 | 8 | 9 | 11 b |
| 90 | 30 | 26 | 22 | 21 | 21 | 24 a | 16 | 14 | 17 | 13 | 14 | 15 a |
| mean | 20 a | 16 b | 13 c | 12 c | 11 c | | 11 a | 9 ab | 9 abc | 7 c | 8 bc | |

† $P_2O_5$ rate $p < 0.01$. $K_2O$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.20$. CV = 24%.

‡ $P_2O_5$ rate $p < 0.01$. $K_2O$ rate $p = 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.76$. CV = 31%.

§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

Table 6. Soil test K levels in spring 2015 after four (2011 to 2014) or three (2012 to 2014) consecutive fertilizer applications on Field 602S and 602C, respectively.

| $P_2O_5$ rate | Field 602S, est. 2011 † | | | | | | Field 602C, est. 2012 ‡ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $K_2O$ rate, lb/a | | | | | | $K_2O$ rate, lb/a | | | | | |
| | 0 | 40 | 80 | 120 | 160 | mean | 0 | 40 | 80 | 120 | 160 | mean |
| lb/a | --------------- Soil test K, ppm --------------- | | | | | | --------------- Soil test K, ppm --------------- | | | | | |
| 0 | 68 | 73 | 81 | 89 | 102 | 82 a | 60 | 64 | 65 | 78 | 92 | 72 |
| 30 | 64 | 73 | 78 | 90 | 116 | 84 a | 56 | 59 | 69 | 80 | 90 | 71 |
| 60 | 62 | 69 | 77 | 90 | 107 | 81 a | 54 | 68 | 73 | 69 | 82 | 69 |
| 90 | 50 | 57 | 68 | 77 | 94 | 69 b | 56 | 57 | 67 | 78 | 85 | 69 |
| mean § | 61 e | 68 d | 76 c | 86 b | 105 a | | 56 e | 62 d | 68 c | 76 b | 87 a | |

† $P_2O_5$ rate $p < 0.01$. $K_2O$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p = 0.93$. CV = 11%.

‡ $P_2O_5$ rate $p = 0.21$. $K_2O$ rate $p < 0.01$. $P_2O_5$ rate x $K_2O$ rate $p < 0.01$. CV = 7%.

§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

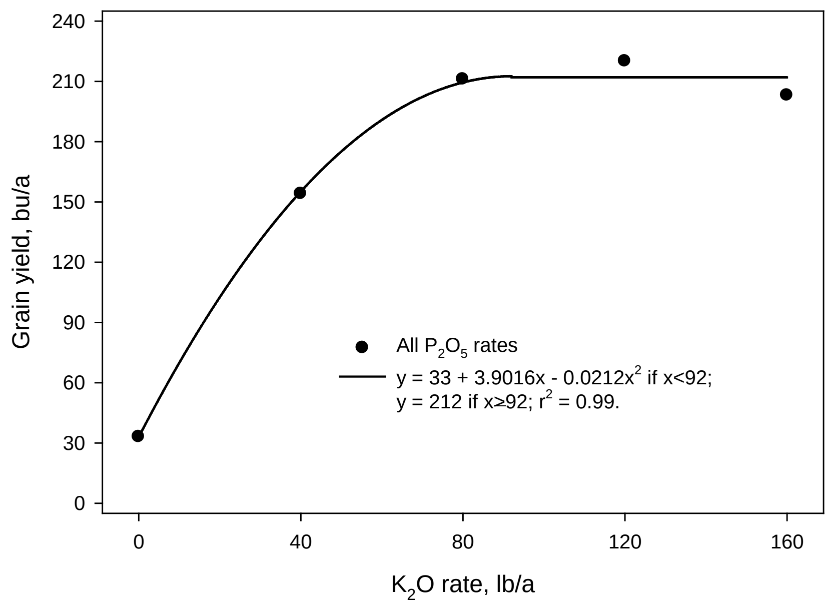


Figure 1. Relationship between $K_2O$ fertilizer rate and corn grain yield averaged across all $P_2O_5$ rates (0 to 90 lb/a) in 2014 (Field 602S).

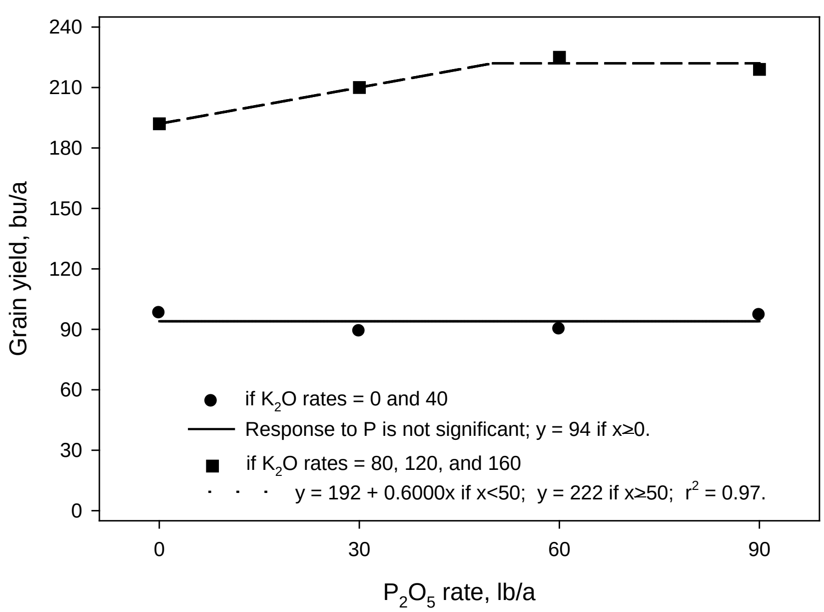


Figure 2. Relationship between $P_2O_5$ fertilizer rate and corn grain yield at two $K_2O$ rate groupings (0 and 40; 80 to 160 lb/a) in 2014 (Field 602S).

# ASSESSING THE QUALITY OF POLYMER-COATED UREA

Matt Ruark and Mack Naber [1/]

## Introduction

Polymer-coated urea (PCU) is a fertilizer product in which each urea prill is individually coated with a polymer (or plastic) coating. All PCUs are considered a slow or controlled release fertilizer, which is defined by the Association of American Plant Food Control Officials as a fertilizer that contains plant nutrients in a form that extends its availability significantly longer than a reference fertilizer (in this case urea) (Slater, 2014). The way PCU works is that urea dissolves inside the coating and slowly diffuses into the soil over time. The mechanism for the nitrogen-release from PCU includes three phases: (1) lag phase, (2) constant release phase, and (3) release decay phase (Shaviv et al., 2003). During the *lag phase* water is absorbed inside the coating through the pores of the polymer. Little, if any, N is released into the soil during this phase. During the *constant release phase* the water dissolves the urea and the dissolved nitrogen diffuses through the polymer into the soil. While urea in PCU readily dissolves in water, the nitrogen-release from PCU is controlled by the rate urea diffuses through the polymer coating. Diffusion is a process where the N moves from an area of high N concentration (inside the polymer coating) to an area of low N concentration (the soil environment). Nitrogen release increases as temperature increases as the coating slightly expands making the pores in the plastic bigger; N release decreases as temperatures get cooler. During the third phase, *release decay*, the release rate of N through the polymer coating slows after the urea is completely dissolved within the polymer. Unprotected urea rapidly dissolves with water and then converts (via the soil enzyme urease) to the ammonia/ammonium form. Through the microbial process of nitrification, ammonium is then converted to nitrate. While both nitrate and ammonium are plant available forms of N, they are subject to losses especially when plants are small. The advantage of PCU over unprotected urea is that it prevents large amounts of nitrate from existing in the soil early in the growing season, reducing the likelihood that it could be leached, denitrified, or volatilized. Use of PCU will have the most benefit (and is perhaps the most widely used) on sandy soils where nitrate leaching can be problematic. Use of PCU on sandy soils can lead to increases in NUE and decreases in groundwater nitrate and need for supplemental N later in the growing season (Bero et al., 2013; Maharjan et al., 2016; Wilson et al., 2010). PCU can also be beneficial on wet or poorly drained soils where denitrificaiton losses (conversion of nitrate to nitrous oxide [$N_2O$] or $N_2$ gas) can be substantial (e.g., Halvorson et al., 2011; Noellsch et al., 2009). The PCU can also reduce N loss through ammonia volatilization compared to non-coated urea when surface applied (e.g., Connell et al., 2011) compared to non-coated urea.

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PCU is more expensive than urea fertilizer although the difference in price will vary year to year. Thus, the advantage of using PCU over urea may not be economical every year. The benefits of PCU are only realized when there are environmental conditions causing substantial nitrogen loss. Deciding to use PCU means you are accepting an additional cost every year to mitigate the risk that can occur in any one year.

PCU is marketed under several trade names including, in alphabetical order, CoteN® (Haifa), DurationCR® (Agrium), ESN® (Agrium) and Polyon® (Harrell's), although new products may be available on the market at any time. Each product's polymer is company specific and proprietary, and different PCU products will have different release rates of N based on the molecular characteristics and thickness of the polymer. The thickness of the coating reduces the N concentration of the fertilizer product. For example, urea is 46% N by weight while ESN® is 44% N and Polyon® is 43% N. Some of these products are marketed for agricultural crops and some for horticultural crops, turf, or ornamentals. For the purposes of this publication, mention of specific products does not indicate endorsement.

Evaluating Quality of PCU

Damage to PCU's polymer coating can result in faster nitrogen-release rates and in its effectiveness as a controlled-release fertilizer. Once the polymer is cracked, water can easily enter and the release of N will be similar to uncoated urea. Damage can occur as a result of handling practices, blending or mixing the PCU with other fertilizers, or the method of application (e.g., Agrium's ESN Use and Handling FAQ, www.smartnitrogen.com). The most severe damage has been seen during handling of PCU, especially when transferring in equipment with scaly deposits (Beres et al., 2012). Transporting with a belt conveyer instead of a steel auger would further reduce damage (Beres et al., 2012). Asking for the PCU to be the last component mixed can reduce the time in contact with other fertilizers and reduce damage as well. Also, changing the way the fertilizer is applied can also reduce damage. For example, use of airboom spreaders to apply the PCU tends to increase polymer damage. However, as long as the PCU is not damaged prior loading into the airboom truck, the amount of damage with the airboom spreader is usually less than 15% of the prills (Rosen, unpublished). Spinner spreaders or drop spreaders will result in less damage than airboom spreaders. The bottom line is not to mix the PCU with other fertilizers and avoid any unnecessary handling prior to application.

Damaged to the polymer coating can change the release pattern of N during the growing season. Research conducted at the Sand Plain Research Farm in Becker, MN showed that damaged PCU (damaged via applicator) released 60% of its N after 8 days, while undamaged PCU only released 12% (Bierman et al., 2015). Since there is extra cost of the fertilizer N with the polymer coating, it is important to know that you are receiving PCU that is relatively undamaged and that your fertilizer application method is not damaging the product. A simple test, explained here, can be conducted to test the damage to the PCU. It is recommended that fertilizer dealers and co-op test PCU at different points in the handling process and before and after mixing and that farms and crop consultants test the PCU after mixing or after land application. Knowing if PCU is damaged and may release over a shorter period of time is important when interpreting mid- and late-season plant nitrogen levels especially if tissue results are low. Any damage that occurs to a prill of PCU is not visible to the naked eye and the only way to assess the quality is to quantify its release. The PCU N release test described here is a 24-hour water test that can be conducted with minimal effort.

The 24-Hour Water Test Procedure

The method is quite simple: weigh out PCU fertilizer, put it in water for 24-hours, and weigh the PCU again. The method outlined here is a modified version originally reported by Bierman et al., 2015. The test requires at least 1 ounce (28 grams) of the PCU, an accurate scale, at least three containers able to hold 3 ounces (~ 90 mL) of water, a few miscellaneous supplies, and a place to dry wet samples. The scale needs to be accurate enough to measure ounces to two decimal places (i.e., down to 0.01 ounce) or grams to a tenth of a gram (i.e., down to 0.1 gram), and be able to weigh the PCU and the container at the same time. There are several common household items that are the right size including coffee cups, mason jars, plastic cups or drink containers, or yogurt containers.

To begin, the PCU fertilizer samples need to be dried – a warm dry place with plenty of air circulation is good, but a low temperature (105° F) drying oven is even better. If premade drying dishes are not available, drying dishes can be made from a sheet of aluminum foil. It is also ideal if a sample of undamaged PCU is also tested, but if one is not available, the values reported here can be used for comparison. Each PCU sample should be tested in triplicate, so label the containers accordingly. Here we test two PCU fertilizers (unblended and blended) and the samples are labeled: Unblended-1, Unblended-2, Unblended-3, Blended-1, Blended-2, and Blended-3. Using at least three replications per sample is the best way to account for variation given that we are only using a small sample compared to the amount applied to the field. The unblended PCU used here is Environmentally Smart Nitrogen (ESN®) and was obtained directly from the manufacturer (Agrium, Inc.). The blended fertilizer is also ESN® and was collected from after being blended at a fertilizer dealer with ammonium sulfate and potassium chloride. The fertilizer was collected directly from the bulk truck as it was falling out of the augur and into a spreader. Also, the blended PCU was evaluated alone, meaning the ammonium sulfate was removed. This was a specialty blend as requested by a farmer.

Results and Interpretations

- Unblended (and relatively pure) PCU lost about 6% of its mass during the 24-hour water test (Table 1). This is consistent with other findings. Thus there is always a minor percentage of the product that can be immediately lost and the minimum purity that can be expected is 94%.
- Blended PCU lost 22% of its mass in 24 hours (Table 1), indicating that blending with sharply angled fertilizer products can damage PCU during mixing. For purposes of this study, we attempted to find the most aggressive handling of the PCU. This handling process is not likely a standard practice and it was conducted upon farmer request.

- It is clear that the purity of PCU can be compromised during handling, mixing, and application of the product. The 24-hour water test outlined is a simple and effective approach that can be conducted by the fertilizer dealer, a crop consultant, or the farmer to evaluate the damage to the product at each stage in the handling and application of the product

Table 1. Example of data calculations to determine % mass loss of PCU from water immersion test.

| **Source** | **Initial I** | **Post P** | **Loss L** | **Loss (%)** |
|---|---|---|---|---|
| formula | -- | -- | I-P | 100*(I-P)/(I) |
| | | weight in grams | | |
| Blended-1 | 10.1 | 7.3 | 2.8 | 27.6 |
| Blended-2 | 10.6 | 8.5 | 2.1 | 19.7 |
| Blended-3 | 10.0 | 8.3 | 1.7 | 17.1 |
| | | | **average loss (AVG)** | **21.5** |
| Unblended-1 | 10.1 | 9.3 | 0.9 | 7.8 |
| Unblended-2 | 10.1 | 9.6 | 0.5 | 5.0 |
| Unblended-3 | 10.1 | 9.6 | 0.5 | 5.2 |
| | | | **average loss (AVG)** | **6.0** |

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NUTRIENT MANAGEMENT – PANEL

Joe Baeten [1/], Sara Walling [2/], and Judy Derricks [3/]

SPACE PROVIDED FOR QUESTIONS OR NOTES

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[1/] Wisconsin Department of Natural Resources

[2/] Wisconsin Department of Agriculture, Trade & Consumer Protection.

[3/] U.S. Department of Agriculture, Natural Resource Conservation Service.

# NITROGEN CYCING ON WISCONSIN DAIRY FARMS

J. Mark Powell [1/]

Improving nitrogen (N) use on dairy farms provides both economic and environmental benefits. The goal is to have more N recycled on the farm (from crops to cows to manure used as fertilizer), which results in fewer N inputs purchased and brought onto the farm and less N lost to the environment. But because N cycles through the whole farm system, positive changes in one part of the N cycle might create negative tradeoffs in another part of the N cycle. Two emerging dairy industry trends are used to elaborate the complexity of N use and N loss from dairy production systems (1) feeding less protein to reduce both feed costs and emissions of ammonia and nitrous oxide (the most potent agricultural greenhouse gas) from the farm, and (2) feeding more corns silage and less alfalfa silage to feed more cows and reduce feed costs.

Nutrition trials coupled with in-barn, laboratory and field experiments revealed that feeding less crude protein (to approximately 16% of dietary dry matter intake) to lactating cows has no effect on milk production or quality but this practice reduces urinary N excretion and ammonia loss from dairy barns and soils. Although this strategy enhances profits through reduced feed costs, it appears to also decrease the crop-available N after manure application to soil, requiring more fertilizer N.

The whole-farm scale Integrated Farm System Model (IFSM) was used to evaluate how feeding more corn silage (CS) and less alfalfa silage (AS) may impact N use and N loss on a typical Wisconsin dairy farm. In the model, crop and animal production, and N use and N loss are simulated daily over 25 years of weather. The quantity and N content of milk, meat and manure are a function of the feeds consumed and herd characteristics. Nitrogen flows are tracked through the farm to predict N losses. IFSM simulations revealed that growing and feeding more CS and less AS to dairy cows reduces the land requirement for feed production by 27% (feeds more cows); maintains milk production per cow; increases herd N use efficiency from 20 to 25%; decreases manure N excretion per unit milk by 22%; increases nitrate and nitrous oxide loss from the farm; and requires additional fertilizer N to offset soil N immobilization after land application of manure from cows fed high levels of CS.

Alfalfa for silage (AS), corn for silage (CS), corn grain (CG), and soybeans (later made into soybean meal SBM) were enriched in the field with the stable isotope $^{15}N$ to track how much of each component's N is secreted in milk, excreted in manure, and after application to soil, recycled back into the feed supply. Relative more of the N contained in the concentrates CG and SBM was secreted as milk N (about 32%), than the N contained in the forages AS and CS (about 18%). Approximately 32, 24, 22, and 16% of the $^{15}N$

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[1/] USDA-Agricultural Research Service (ARS), US Dairy Forage Research Center (USDFRC), Madison WI (mark.powell@ars.usda.gov).

contained in CG, SBM, CS, and AS respectively was retained by the cows. The differences in $^{15}N$ recoveries and retention seem to warrant new investigations into how the concentrates, especially CG, may be fed differently (rather than their single daily offer in the TMR) to more effectively synchronize dietary N supply with cow N demands. This could maximize N secretions in milk and minimize N excretions in manure. There were distinct differences in how much of each diet component's manure N was recycled back into the feed supply. Approximately 38, 35, 33, and 30% of applied manure $^{15}N$ derived from SBM, CG, AS and CS was incorporated into corn for silage. Study results seem to bolster other findings that feeding more CS and CG require more fertilizer N and increase N loss per unit land area and milk produced. The long term environmental impacts associated with land use changes to grow different diet components will likely be more important than short-term impacts of dietary components on cow N use and manure N recycling through crops. A balance between corn, alfalfa and soybeans in dairy cropping system would be needed to not only enhance overall N use efficiency and reduce N loss, but also to capture many of the benefits of corn-legume rotations.

Further Reading

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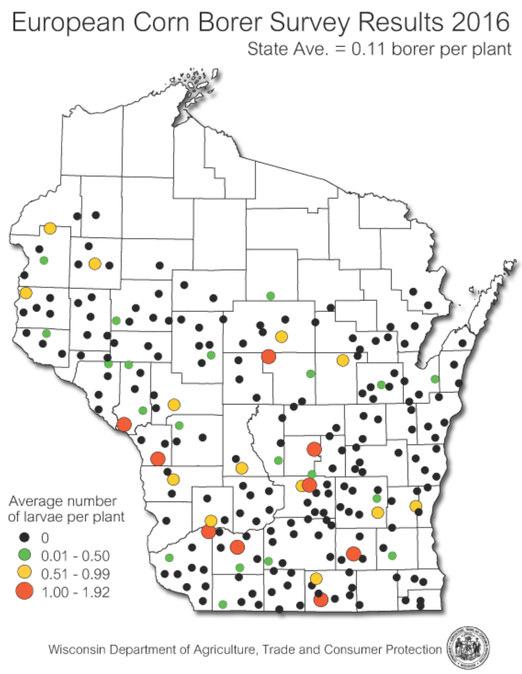
# WISCONSIN INSECT SURVEY RESULTS 2016 AND OUTLOOK FOR 2017

Krista L. Hamilton[1/]

## European Corn Borer

An increase in conventional corn acreage due to lower commodity prices apparently favored larval populations this fall. The 75th annual survey in September and October found a state average of 0.11 borer per plant, an increase from last year's historical low of 0.02 borer per plant. Minor population increases from 2015 were documented in seven of the nine crop districts, except in the east-central and northeast regions. Larval densities in the central area rose to 0.24 borer per plant, or 24 per 100 plants, the highest average recorded in that area since 2007. Although more sites had economic averages above 1.0 larva per plant than in recent years, and second-generation larvae were detected in 49 of the 229 fields (21%) surveyed compared to14% in 2015, the very low state average of 0.11 borer per plant indicates that Bt corn continues to suppress corn borer populations and reduce the pest status of this insect in Wisconsin.



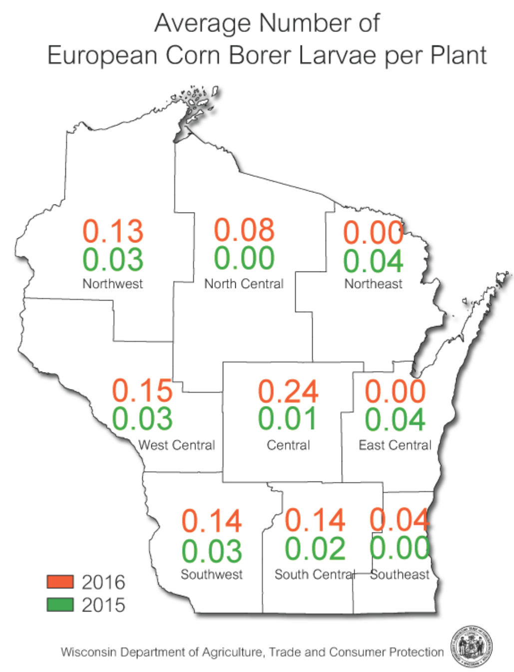




Table 2. European corn borer fall abundance survey results 2007-2016 (Average no. borers per plant).

| District | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 10-Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **NW** | 0.24 | 0.12 | 0.06 | 0.08 | 0.15 | 0.04 | 0.07 | 0.06 | 0.03 | 0.13 | 0.10 |
| **NC** | 0.35 | 0.18 | 0.10 | 0.02 | 0.07 | 0.01 | 0.02 | 0.04 | 0.00 | 0.08 | 0.09 |
| **NE** | 0.07 | 0.12 | 0.12 | 0.19 | 0.13 | 0.05 | 0.02 | 0.01 | 0.04 | 0.00 | 0.08 |
| **WC** | 0.52 | 0.04 | 0.10 | 0.08 | 0.12 | 0.09 | 0.06 | 0.12 | 0.03 | 0.15 | 0.13 |
| **C** | 0.42 | 0.11 | 0.06 | 0.06 | 0.05 | 0.01 | 0.01 | 0.00 | 0.01 | 0.24 | 0.10 |
| **EC** | 0.21 | 0.20 | 0.09 | 0.01 | 0.03 | 0.01 | 0.01 | 0.01 | 0.04 | 0.00 | 0.06 |
| **SW** | 0.28 | 0.05 | 0.06 | 0.12 | 0.03 | 0.03 | 0.06 | 0.00 | 0.03 | 0.14 | 0.08 |
| **SC** | 0.33 | 0.07 | 0.02 | 0.07 | 0.20 | 0.01 | 0.08 | 0.01 | 0.02 | 0.14 | 0.10 |
| **SE** | 0.12 | 0.04 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.04 | 0.02 |
| **State Ave.** | **0.31** | **0.09** | **0.06** | **0.07** | **0.09** | **0.03** | **0.04** | **0.03** | **0.02** | **0.11** | **0.09** |

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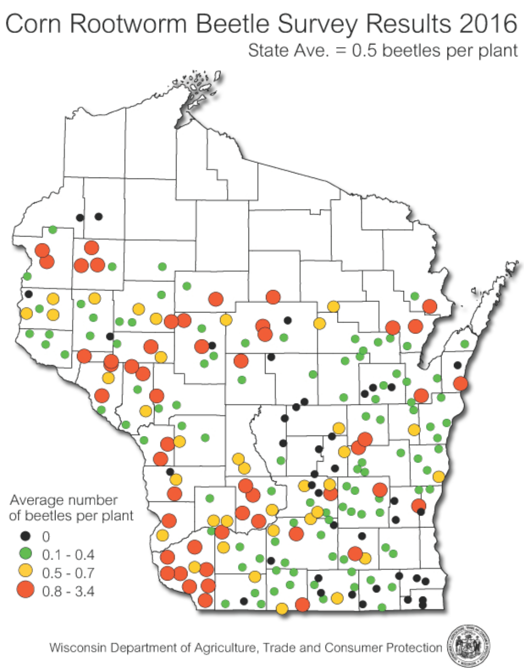
# Corn Rootworm

Review of annual beetle survey data shows that populations decreased from 2015 levels across southern, central and east-central Wisconsin, while beetle counts in the west-central and northern counties were markedly higher. Averages declined in five of the nine crop districts and increased in four. The largest decreases were found in the south-central and southeast districts where averages fell sharply from 0.8 to 0.4 beetles per plant and from 0.7 to 0.2 beetles per plant, respectively. By contrast, the survey found substantially higher averages in west-central and northern Wisconsin, particularly in the northeast where the district count more than tripled from 0.2 to 0.7 beetles per plant. Despite regional increases, the 2016 state average of 0.5 beetles per plant still represents a decrease from the 2015 average of 0.6 per plant.

Results of the survey suggest a greater threat of larval rootworm damage to non-Bt continuous corn in the northern and west-central counties next season, while beetle pressure may be lower across the southern, central and east-central areas.



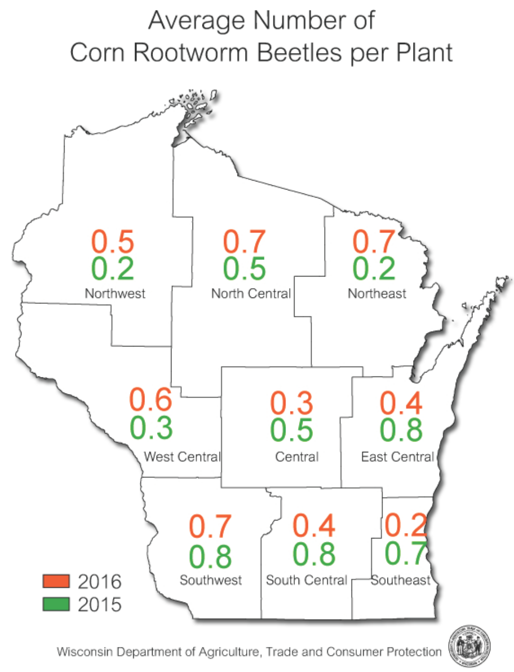




Table 1. Corn rootworm beetle survey results 2007-2016 (Average no. beetles per plant).

| District | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 10-Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **NW** | 0.4 | 0.5 | 0.4 | 0.3 | 0.1 | 0.5 | 0.7 | 0.5 | 0.2 | 0.5 | 0.4 |
| **NC** | 0.7 | 0.9 | 0.4 | 0.1 | 0.1 | 0.3 | 0.2 | 0.2 | 0.5 | 0.7 | 0.4 |
| **NE** | 0.5 | 0.6 | 0.6 | 0.1 | 0.3 | 0.6 | 0.2 | 0.1 | 0.2 | 0.7 | 0.4 |
| **WC** | 0.4 | 0.6 | 0.5 | 0.4 | 0.6 | 0.4 | 0.4 | 0.6 | 0.3 | 0.6 | 0.5 |
| **C** | 0.8 | 0.5 | 0.4 | 0.4 | 0.8 | 0.5 | 0.2 | 0.2 | 0.5 | 0.3 | 0.5 |
| **EC** | 1.4 | 1.0 | 0.6 | 0.3 | 0.5 | 0.4 | 0.3 | 0.3 | 0.8 | 0.4 | 0.6 |
| **SW** | 0.4 | 1.1 | 0.7 | 0.3 | 1.1 | 0.8 | 0.6 | 0.9 | 0.8 | 0.7 | 0.7 |
| **SC** | 2.2 | 1.5 | 1.1 | 0.3 | 1.4 | 0.9 | 0.5 | 0.3 | 0.8 | 0.4 | 0.9 |
| **SE** | 1.0 | 1.6 | 0.3 | 0.2 | 0.7 | 0.9 | 0.8 | 0.4 | 0.7 | 0.2 | 0.7 |
| **State Ave.** | **1.0** | **1.0** | **0.6** | **0.3** | **0.7** | **0.6** | **0.5** | **0.4** | **0.6** | **0.5** | **0.6** |

## Black Cutworm

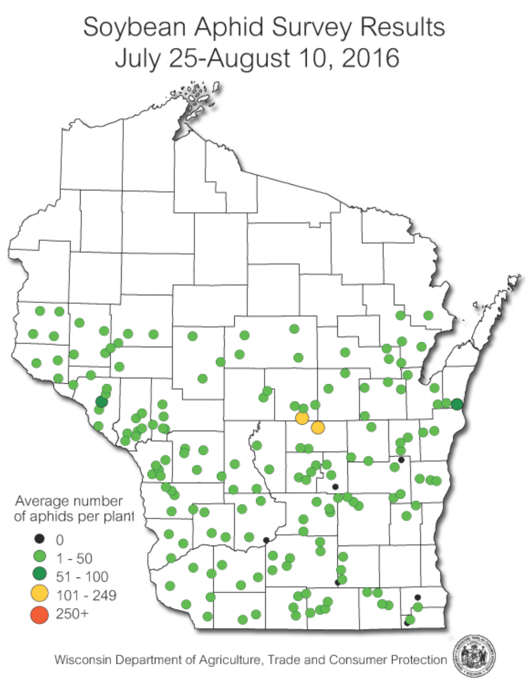
Migrants began arriving in the state by March 29 and an initial cutting date of May 20 was anticipated based on an April 17 biofix. The spring trapping survey registered 1,835 moths in 43 traps from March 15-June 1, with a peak from April 21-May 4. Light infestations developed in corn by early June as a result of the migration and favorable field conditions, but significant injury was not reported or observed.

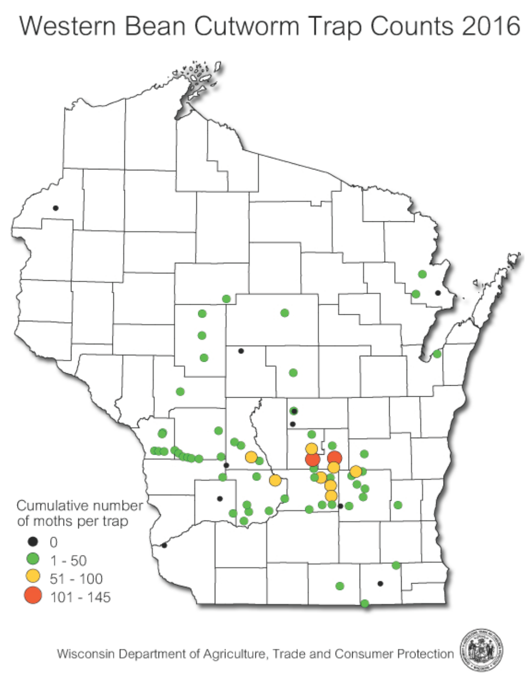
## Western Bean Cutworm

Moth counts increased moderately after a three-year collapse. The state cumulative capture of 1,530 moths in 75 traps (20 per trap) was a substantial increase from the 644 in 96 traps (seven per trap) moths collected last season, yet moderate in comparison to counts registered during the 2007-2012 surveys and the 12-year average of 23 moths per trap. The highest individual count for the nine-week monitoring period was 145 moths near Markesan in Green Lake County. Larvae were also more common than anticipated this season and infested approximately 9% of the 458 corn sites surveyed in August and September. Damage to both traited and non-traited corn hybrids was reported.

## Soybean Aphid

The annual survey found a statewide average count of eight soybean aphids per plant. This average compares to 35 aphids per plant last year and is only marginally higher than the record-low count of seven aphids per plant documented in 2012. One hundred and seventy soybean fields in the R2-R5 growth stages were sampled during a three-week period from July 25-August 15. Aphid densities were below 151 per plant in all fields, and the majority of sites had counts of fewer than 25 aphids per plant. No field sampled had an average exceeding the 250 aphid-per-plant treatment threshold. Results of the survey suggest that aphid populations remained low or moderate in most soybean fields this season and widespread treatment for aphid control was not required.



## Corn Earworm

A late-season migration yielded a cumulative total of 6,402 moths in 16 traps, with a well-defined peak from August 18-31. Almost one-third of the moths (31%) were captured at the Ripon monitoring site during the last week of August. Compared to 2015, the migration was larger and lengthier, with the heaviest flights concentrated in Columbia and Fond du Lac counties. Late sweet corn and other susceptible crops such as tomatoes and snap beans remained under a moderate to severe threat until mid-September.

## Japanese Beetle

Defoliation was observed in about 74% of the soybean fields examined in late July and August, indicating that Japanese beetle injury was more widespread than ever. Defoliation estimates were mostly below the 20-30% treatment threshold, but chemical intervention was justified in some instances. Once primarily a fruit and landscape pest, the Japanese beetle has become an increasingly serious threat to Wisconsin's agronomic crops that more soybean and corn growers now have to manage for the first time.

## Obliquebanded Leafroller

This generalist leafroller was common in Wisconsin soybean fields for the second year in a row. Larvae began emerging by early June and were prevalent in fields throughout July. Most of the larval population pupated by early August. Despite their abundance, the OBLR damage to soybeans observed in 2015 and 2016 was minor and not of economic importance.

# INSECTICIDAL SEED TREATMENT IN SOYBEAN

Kelley J. Tilmon [1/]

## Abstract

The use of insecticidal seed treatments containing neonicotinoids has become extremely widespread in field crops. Often these products are used as a default at planting, without specific reference to an insect pest problem requiring management. This talk summarizes a two-year, checkoff-funded multistate study aimed at understanding the average value and return on investment of neonicotinoid seed treatment in soybean in the North Central Region, including a comparison to the return on investment with the classic Integrated Pest Management approach of scouting and applying a foliar product at pest threshold. In summary, IPM provides both a greater probability of a positive return on investment, and a larger average return.

[1/] Associate Professor, Dept. of Entomology, 1680 Madison Ave., Ohio State Univ. Ohio Agricultural Research and Development Center, Wooster, OH 44691.

INSECT MANAGEMENT IN CONVENTIONAL CORN

Bryan Jensen[1/]

Recently, there has been interest in using conventional corn hybrids (non-GMO) to cut input costs because of low commodity prices. However, using conventional corn can also be considered part of an overall IPM plan that diversifies management tactics to increase profitability and avoid resistance.

Using corn hybrids without below ground traits can fit into an IPM program because beetle monitoring is completed prior to making seed purchases. However, you are substituting the convenience of prophylactic treatments (traited corn) for increased labor costs (field scouting). Also, in the absence of below ground traits, at-plant, preventive treatments are available for corn rootworm which are efficacious and have had a history of successful use. Furthermore, field scouting will provide the added value of supportive information that you can use to select field specific management practices that can be used to diversify corn rootworm treatment. Thereby reducing the reliance on a single tactic and delay resistance to Bt hybrids.

Conversely, using corn hybrids with above ground traits does not fit into an IPM approach. Seed purchases are made well in advance of the time period you should scout to determine if control is needed. Fortunately, the insects which are targeted by the above ground Bt traits have scouting procedures, economic thresholds and rescue treatment available if you forgo hybrids with the above-ground traits.

## Corn Rootworm

Below-ground traits are only necessary on continuous corn. Exceptions do exist in the southern and southeast part of Wisconsin where western corn rootworm adults have been known to lay eggs in soybean. However, not all first-year corn fields are affected and the chances of damage to first-year corn in the rest of the state is minimal. Furthermore, adult rootworm populations in continuous corn fields are variable. You should not assume all continuous corn will require control or that traited hybrids are the most economical.

Field Scouting for adult beetles will provide the information needed to make cost-effective management decisions. Several written (http://ipcm.wisc.edu/download/pubsPM/Corn-rootworm-card2015hx.pdf, http://ipcm.wisc.edu/download/pubsPM/UW-IPM-ScoutingManual-web.pdf ) and video (https://www.youtube.com/watch?v=hYQCJmKNFMo) resources are available to help learn the procedure.

Before switching from below-ground traits, an important consideration would be to check the grower's planter to see if it has insecticide boxes, is plumbed for liquid insecticides or has liquid fertilizer capability. Various aftermarket units are available but cost to retrofit a planter may be an important consideration. Some options may range from $500-$1000/row depending on number of units purchased or if other incentives (rebates) are offered. Others options may be less expensive but this cost does need to be addressed before a decision is made.

Using soil applied insecticides (granules or liquids) at planting is a good option to Bt CRW hybrids. However, care must be taken to choose an effective product. Read labels carefully.

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Some product labeling will provide restriction on rates, placement or dependability in high corn rootworm fields. Most products are restricted use and certification is required before you can buy or use these products. Calibration will also be important to ensure a lethal dose is metered out.

Use of the corn rootworm rate (1.25 mg a.i./seed) of the neonicotinoid seed treatments is also an option to consider. However, these commercially applied seed treatments are most appropriately used in low to moderate rootworm injury situations as per label instructions. These populations should be verified with field scouting data.

Above-ground Insect Pests

Deciding not to use corn hybrids with above-ground Bt traits can be a cost-effective decision because you have reliable scouting procedures, the availability of economic thresholds, as well as efficacious rescue treatments if/when needed. Furthermore, the insects controlled by the above ground traits, like corn rootworm populations, are variable making prophylactic use of the above ground traits questionable or even desirable.

The Field Crop Scouting Manual http://ipcm.wisc.edu/download/pubsPM/UW-IPM-ScoutingManual-web.pdf provides the information needed to scout for all Wisconsin insects such as European corn borer, black cutworm, true armyworm and stalk borer as well as economic thresholds. Insecticides labeled for control of these insects are listed in the UW Extension publication, Pest Management in Wisconsin Field Crops-2017.

The rationale for not using hybrids with the above-ground traits is like that of corn rootworm. That is, insect populations are variable making an economical payback inconsistent. For example, European corn borer populations were at a historical low in 2015. However, locally heavy populations were noted in 2016. Similarly, Western bean cutworm populations have been also low in recent years. Stalk borer tend to be an edge insect and not a problem throughout the field. Black cutworm and true armyworm are a different problem because they are migratory and populations vary greatly from year to year.

# RECOGNIZING AND PROTECTING INSECT POLLINATORS IN THE AGRICULTURAL LANDSCAPE

PJ Liesch[1] and Bryan Jensen[1]

**Basics of Pollinator Biology**:

- Pollinators include bees, but also various other insects (wasps, beetles, moths, flies, etc.) and other animals (hummingbirds, bats, small mammals); *any creature that visits a flower could be a pollinator to some extent!*
  -Of these creatures, bees are amongst our best and most important pollinators.

- The US is home to ~4,000 bee species; Wisconsin is home to ~400 bee species
  - Honey Bee (1 sp.) social, live as colony year round
  - Bumble Bees (~20 sp.) social, seasonal colonies
  - Wild Bees (~400 sp. in several families) solitary, biology varies for each type

- Bees pollinate ~80% of flowering plants (~250,000 flowering plants known)
  -Roughly 1 out of every 3 bites of food due to pollinators

- Bees have two main needs: food sources (i.e., flowers) and shelter (i.e., nesting habitat)
  - Other than cuckoo bees, all bees collect pollen and nectar to feed their young
    - Solitary bees use provisioning to stockpile food for their developing young
  - Three main types of nesting sites:
    A) Ground nesters [~70 % of bees]
    B) Hole Nesters (use preexisting tunnels in most cases) [~30 % of bees]
    C) Cavity nesters (bumble bees, feral honeybees) [<1% of bees]

**Identifying and Understanding Pollinators-Resources**

1) *Pollinators* [USFS webpage: http://www.fs.fed.us/wildflowers/pollinators/]
2) *Wisconsin Bee Identification Guide* [UWEX Handout; http://labs.russell.wisc.edu/insectid/files/2016/06/WI-BEE-IDENTIFICATION-GUIDE.pdf]
3) *Wisconsin Spring Bee Guide* [Online ID Guide; http://energy.wisc.edu/bee-guide/]
4) *The Bees in Your Backyard* [Book; 2016; Wilson & Carrill]
5) *Bee Basics: An Introduction to our Wild Bees* [USDA Publication; http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5306468.pdf]
6) *Bumble Bees of the Eastern US* [USDA Booklet; http://www.fs.fed.us/wildflowers/pollinators/documents/BumbleBeeGuideEast2011.pdf]

[1]University of Wisconsin-Madison Entomology Department

**Pollinator Conservation on and Around Farms**

1) Use a wide variety of plants that bloom from early spring into late fall
   -Diversity of flowers = diversity of pollinators by providing food [pollen and nectar]
   - Include host plants for specific species (i.e., specific butterflies)

2) "Go wild" (i.e., use native plants & allow weeds to grow in appropriate situations)
   - Native plants suited for local conditions
   - Hybrid flowers (esp. with "doubled" flowers) may have little/no pollen or nectar!!!
   - In urban areas, consider leaving lawn weeds (dandelions, clover, etc.) – food for pollinators

3) Eliminate pesticides whenever possible
   * See *Wisconsin Pollinator Protection Plan* for additional information
   A) Eliminate pesticides entirely
   B) Choose products or formulations that are less toxic to bees
   C) Use pesticide appropriately and apply in ways that will eliminate/minimize exposure to bees
      - i.e. apply when bees not actively foraging
      - i.e. Don't apply to or allow to drift to flowering plants

4) Create and maintain pollinator nesting habitat
   A) "Bare" patches of soil for ground-nesting bees; minimize tilling
   B) Leave dead/dying trees (if appropriate) for nesting habitat (Hole nesters)
   C) Leave vegetation standing when appropriate (some hole nesters like pithy stems)
   D) Provide nesting habitat ("bee boxes" & "bee hotels")

**Pollinator Conservation-Resources**

7) *Wisconsin Pollinator Protection Plan* [DATCP Publication; https://datcp.wi.gov/Pages/Programs_Services/PollinatorProtection.aspx]
8) *How Farmers can Help Pollinators* [USDA-NRCS webpage; www.nrcs.usda.gov/wps/portal/nrcs/main/national/plantsanimals/pollinate/farmers/]
9) *Supporting Native Bees: Our Essential Pollinators* [UWEX Factsheet; https://learningstore.uwex.edu/Supporting-Native-Bees-Our-Essential-Pollinators-P1629.aspx]
10) *Selecting Plants for Pollinators: Eastern Broadleaf Forest* [Pollinator Partnership Publication; http://pollinator.org/PDFs/Guides/EBFContinentalrx13FINAL.pdf; see also: www.pollinator.org]
11) *Enhancing Nest Sites For Native Bee Crop Pollinators* [USDA Agroforestry Note; http://www.plants.usda.gov/pollinators/Enhancing_Nest_Sites_For_Native_Bee_Crop_Pollinators.pdf]
12) *Conservation of Native and Domestic Pollinators in Managed Turfgrass* [UWEX Factsheet; https://learningstore.uwex.edu/Conservation-of-Native-and-Domestic-Pollinators-in-Managed-Turfgrass-Landscapes-P1812.aspx]

**Protecting Pollinators from Pesticides**

There are several practices a crop advisor or applicator can implement in an agricultural landscape, however, these practices may require site-specific decisions.

[1]University of Wisconsin-Madison Entomology Department

## IPM and Insecticide Use

The first practice to consider is to make sure the pesticide application is necessary. Eliminating prophylactic use is an important consideration when protecting pollinators. Use IPM practices, including scouting and economic thresholds to determine if the need is critical.

## Drift Control

Controlling pesticide drift onto honey bee colonies is crucial. Drift is often a reason for acute, if not catastrophic poisoning of honey bees. Although hives can be easy to spot, some may not be visible. Furthermore, knowing if hives are present prior to application can be useful information to have which may allow for alternative application timings. To help determine if hives may be present consult the Wisconsin **Driftwatch** map https://driftwatch.org/map . **Driftwatch** is an interactive mapping program which is operated by a non-profit company created by Purdue University. It allows commercial beekeepers (and specialty crop producers) to voluntarily register sensitive sites on a map. Applicators can use this information to determine if potential concerns exist prior to application. Registering is voluntary and not all beekeepers have uploaded bee yard locations, however, several hundred apiaries were register during 2016. **Driftwatch** allows applicators to zoom in on application sites using Google Imagery which allows for precise positioning of bee yards. Beekeepers who do upload bee yard locations are required to do so each year so map data stays current. Data Stewards, employed by the cooperating state's Department of Agriculture, approve or deny request for beekeepers and specialty crop producers who want to upload sensitive sites. This process helps verify the requests are from commercial bee keepers and producers, not homeowners. **Driftwatch** is free and viewable by the public. Membership is voluntary but provides operating funds for sustained operation and development of updates.

Other practices applicators can use to minimize drift are typical best drift management practices which include monitoring weather condition including wind speed and direction prior to spraying sensitive areas. Use appropriate nozzles and pressure settings that are designed to minimize drift yet are still appropriate for the target pest. Specific pollinator protection practices include avoid spraying near water sources. Pollinators often use various water sources (ditches, ponds, dew, etc.) for a source of drinking water. Avoid drift onto blooming plants which serve as nectar or pollen sources.

## Insecticide Selection

Choosing the appropriate insecticide is not always an easy decision when pollinator protection is a goal. To help with the decision process, The Environmental Protection Agency has implemented a Bee Advisory Box on labels. This icon was developed to draw attention to the potential harmful effects that certain pesticide will have on pollinators. It makes it clear that the labeled pesticide can kill bees as well as other pollinators. It also warns that drift, direct contact, etc. are issues and if there are specific restrictions applicators must follow.

According Wisconsin statues, beekeepers can request a 24 hr. advanced notice if pesticides labeled as "Highly Toxic to Bees", are to be applied 1½ miles of their bee yards. The person who owns or control the land where the applications is to be made is legally responsible for this notification. However, communication between the applicator and landowner is important.

Choosing a pesticide or pesticide formulation that is least toxic to bees is an important consideration. There are too many pesticides available today to list. Always check labels prior to application. A few hints are important. Insecticides are certainly the most toxic group of pesticides to pollinators, however, some fungicides may possibly be toxic to pollinators. Consult labels for more information.

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Pesticide formulations can have some effect on relative toxicity to pollinators, however, the active ingredient probably plays a bigger role in prevention. In general, wettable powders, dusts and microencapsulated insecticides have a greater potential for toxicity than the same active ingredient with a different formulation. The speed in which an insecticide kills also can play a role in pollinator toxicity. The worst possible combination might be a slow killing insecticide used in a formulation that is a wettable powder, microencapsulated or is a dust. The bees exposed to these compounds may live long enough to return to the hive and expose other adults and/or brood.

The science associated with pollinator health and with seeds treated with neonicotinoid insecticides is not completely understood. What is known, however, is that dusts from planting operations that drifted onto hives or nectar/pollen sources is an acute source of mortality. Sub-lethal effects from pollen and nectar is unclear at this point and certainly these results will be dependent on detection, landscape and foraging behavior.

Applications timing can have some influence on honey bee exposure to pesticides. Typically, honey bees are actively foraging until approximately 4-5 in the afternoon. Applying a short residual pesticide after bees are done foraging for the day may help. However, this serves as a useful guideline for honey bees but foraging may occur much later in the day. Also, it does not consider foraging behavior of other native pollinators.

Attractiveness of the crop can also have an impact on pesticide exposure to honey bees and other pollinators. Alfalfa and soybean can be considered a source of both pollen and nectar for honey bees. Corn only a pollen source and wheat is not a source of pollen or nectar. However, that only tell part of the story. Alfalfa is only a source of pollen and nectar when it is flowering. Most of the alfalfa in Wisconsin is cut well before flowering. Also, weeds in non-attractive crop must be considered. A list of weeds that serve as pollen and/or nectar sources common to Wisconsin cropping systems include: dandelion, milkweed, white clovers, asters, bindweed, mustards, ragweed, sow thistle and wild buckwheat. Also, important in attractiveness to crops and or weeds is nectar and pollen competition from other plants. Although a crop may be listed as an attractive nectar source another non-crop plant may be more attractive to pollinators and they may not visit that crop plant.

**References**

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# WILL YOU CRY (1F) OVER WESTERN BEAN CUTWORM?

Kelley J. Tilmon [1/]

## Abstract

Western bean cutworm, a native pest originally found in the western US, has become an increasingly common pest of corn in the North Central Region as its range spreads eastward. The Bt toxin Cry1F has been used to help manage this pest. However, there is increasing evidence that this toxin is no longer effective against western bean cutworm in many parts of its range. This talk summarizes the identification, biology, and damage from this pest, and discusses management including Bt and alternate management approaches. Scouting and insecticide are effective against western bean cutworm, but careful monitoring is necessary to get timing right.

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GRAIN ORIGINATION CHALLENGES IN THE TODAY'S ENVIRONMENT

Scott Hansen[1/]

**Can effective Grain Origination be taught?**

**Can it be developed into a system – with every team member speaking in one voice?**

**Can you get your grain origination program more efficient?**

**Build your loyal tribe of farmers. What creates loyalty with your farmers? A consistent professional message goes a long way.**

► Learn how to build credibility with the farmer and take part in meaningful conversations without feeling intimidated.

► Experienced grain originators learn to use modern communication methods to strengthen the customer relationship and aid in directing the marketing team.

► Originate bushels with a focus on accomplishing high volume without giving up margins. Lead everyday conversations into action through the delivery of a simple, consistent message. Come away with specific tools and ideas for enriching all your farmer communications and improved customer service.

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# PROACTIVE MAINTENANCE FOR THE GRAIN INDUSTRY

Edward LaPreze, CMRT [1/]

Proactive maintenance programs need to become a culture. What are the different types of maintenance? How can we move from a reactive program to a proactive program? What tools are available for a proactive maintenance program? Using tools like Infrared, Vibration Analysis, and Precision Alignment will provide early warning of a failure. This early warning will enable repairs to be accomplished in a planned time instead of reacting to a breakdown. Most commonly, reactive breakdowns are during our busiest times.

[1/] Pepper Maintenance, Minier, Illinois.

# EPA AIR EMISSION REGULATIONS FOR GRAIN ELEVATORS

Jennifer Hamill, Lisa Ashenbrenner Hunt, and Renee Lesjak Basheli [1/]

Abstract

Environmental matters for any small business including grain elevators can be complex. Fortunately, the Department of Natural Resources' (DNR) Small Business Environmental Assistance Program (SBEAP) is here to help. SBEAP offers free, non-regulatory assistance to small businesses to help owners understand their state and federal environmental responsibilities. The program provides "plain language" resources, answers compliance questions and directs businesses to other appropriate assistance providers and relevant DNR staff.

SBEAP will be presenting on typical permit options for grain elevators. SBEAP will cover in depth how to calculate emissions, typical thresholds to be exempt from permitting, permitting options and examples of processes that may require a permit. Then SBEAP will discuss how to maintain compliance with environmental regulations. DNR even has a program on auditing your facility to determine if you need a permit to limit your liability. Finally, SBEAP is looking for input on tools or resources that would help the agribusiness industry with environmental regulations.

SBEAP assists with business start-up, permitting, compliance, understanding state & federal environmental regulations, property transactions, and sustainable practices. If you have any questions regarding environmental requirements for grain elevators or other environmental regulation questions in Wisconsin, contact the Small Business Environmental Assistance Program toll free at 855-889-3021, email us at DNRSmallBusiness@wisconsin.gov or visit our website at http://dnr.wi.gov/topic/smallbusiness/.

[1/] Small Business Environmental Assistance Program, Wis. Department of Natural Resources.

# UNDERSTANDING SPRAY TANK CONTAMINATION: REDUCING YOUR RISK

Daniel Heider [1/]

Although it happened many years ago, I remember my first experience with spray tank contamination as if it happened this past season. The year was 1991 and nearly constant rains had us moving from site to site in search of "dry" ground to drive on. Rigs buried in mud and partial loads left in tanks overnight were the norm. The rig was a Spray Coupe with a massive 40 foot boom. The culprit was a plant growth regulator based herbicide presumed to have been completely cleaned out prior to switching to soybeans. The proof that it was not completely cleaned out showed up 4-5 days later when the headlands and first pass were obviously injured – injured enough to be noticed in a windshield survey at 50 mph!

Fast forward to 2016. The equipment is larger. Pesticide labels now provide very specific cleanout procedures. And yet as I drive this state traveling between research trials, it seems that herbicide injury is just as prevalent as ever. Although spray drift can be blamed for some of the incidents, tank contamination with its classic appearance of straight lines and inverted-V shaped symptoms appears to be responsible for many of the cases. Applicator understanding of pesticide chemistry, formulation and herbicide injury symptoms is critical for proper sprayer cleanout and avoidance of these costly mistakes.

**Understanding Tank Contamination**

How a pesticide is formulated can play a role in determining its potential for tank contamination. Although it would seem that there are many pesticide formulations on the market, they can be subdivided into three general classes:

1) Petroleum based – includes emulsifiable concentrates (EC) and ester formulations. These formulations generally bloom into a cloudy emulsion when added to the tank and may form sticky residues on tanks and lines.
2) Water based – includes salt formulations such as glyphosate and amines. These formulations generally form a clear, true solution when added to the tank and are comparatively easy to clean out.
3) Clay based – includes wettable powders (WP), water dispersible granules (WDG), dry flowables (DF), flowables (F) and suspension concentrates (SC). In most cases the pesticide remains on very small clay particles which are dispersed in the spray tank during agitation and application. This clay has been known to settle out and accumulate in strainers, lines and other low spots in the plumbing. Physical removal of the clay is often necessary to achieve full cleanout.

Acknowledging the pesticide formulation will provide insight into the cleanout process, long before you check the label for the exact procedure for the products you are spraying.

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[1/] Distinguished Senior Outreach Specialist, IPM Program, Univ. of Wisconsin-Madison, 1575 Linden Dr., Madison, WI 53706.

Herbicide mode of action, i.e. the chemistry of the pesticide being applied will play the greatest role in tank contamination. Group 2 products, especially sulfonyl ureas tend to cause some of the most significant problems. In addition, products which produce very noticeable injury symptoms at relatively low rates should be addressed with equally aggressive cleanout procedures. Some examples include contact herbicides (like PPO inhibitors applied POST) or products like plant growth regulators (dicamba, 2,4-d) and the bleaching symptoms of HPPD Inhibitors. The following chart addresses issues to watch out for within the herbicide mode of action categories:

| Group | Site of Action | Comments |
|---|---|---|
| 1 | ACCase Inhibitors | Most group 1 herbicides are EC formulations potentially leaving oily residues. Greatest concern is contamination onto corn and other grass crops. |
| 2 | ALS Inhibitors | Sulfonyl ureas can be very difficult to effectively clean out. Raising the pH improves solubility and is essential to attaining proper cleanout. |
| 9 | EPSP Synthase Inhbitors | Glyphosate is water soluble and relatively easy to clean. Greatest concern is tendency for glyphosate to soak loose residues from previous applications. |
| 4 | Plant Growth Regulators | Minute residues of PGR's can leave visual symptoms on broadleaf crops. Amine formulations are easier to clean than ester formulations. |
| 19 | Auxin Transport | Includes the active ingredient diflufenzopyr which is a component of Status. Minute residues can leave very visual symptoms. |
| 5,6,7 | Photosynthesis Inhibitors | Generally EC and clay based formulations. Greatest concern is residues post-emergence to susceptible crops. |
| 10 | Glutamine Synthesis Inhibitors | Glufosinate is primarily a contact herbicide. Lack of cleanout may leave quick visual injury symptoms on susceptible crops. |
| 13,27 | Pigment Inhibitors | HPPD Inhibitors are mostly formulated as clay based. Be sure to check strainers, etc. Small residues can leave very visual bleaching symptoms |
| 14 | PPO Inhibitors | Residues rarely cause issues with soil applied applications. Post-emergence can cause stunting and necrotic spots so careful cleaning is necessary. |
| 22 | Photosystem 1 Electron Div. | Gramoxone is water soluble. Although achieving cleanout is relatively easy, minor residues will cause noticeable injury symptoms. |
| 3 | Seedling Root Growth Inhibitors | Several formulations. Although rarely problematic as tank contaminants, oil based EC formulations may hold residues of other tank mix partners. |
| 8,15 | Seedling Shoot Growth Inhibitors | Several formulations. Although rarely problematic as tank contaminants, oil based EC formulations may hold residues of other tank mix partners. |

# SPRAY RIG TECHNOLOGY AND FEATURES

Tim Reid [1/], Kent Syth [2/], and Pete Jordan [3/]

SPACE PROVIDED FOR QUESTIONS OR NOTES

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# MOST COMMON VIOLATIONS OF COMMERCIAL PESTICIDE APPLICATORS

Mark McCloskey [1/]

(1) Obtaining and maintaining individual certification and license.

(2) Use of a pesticide that results in significant drift or overspray.

(3) Incomplete application records.

(4) Use of a pesticide in a manner inconsistent with the pesticide label.

(5) Use of atrazine in atrazine prohibition areas

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# COMMODITY FUTURES OUTLOOK

Brenda Boetel [1/]

SPACE PROVIDED FOR QUESTIONS OR NOTES

[1/] Univ. of Wisconsin-River Falls.

# POLICY UPDATE ON NEONICOTINOIDS, PYRETHROIDS, AND ATRAZINE

Paul Mitchell [1/]

SPACE PROVIDED FOR QUESTIONS OR NOTES

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# TOOLS AND TECHNOLOGY FOR PRACTITIONERS: FIVE BIG AG TRENDS

John Shutske [1/]

**Outline:**

It's a time of exponential change in our society and in the industries that heat and light our homes, transport us, entertain us, and feed our families. This is also true in agriculture and closely allied industries! What does exponential change and growth really mean? First, linear growth means adding a fixed amount of "something" every time period. Like a year. If I invest $10,000 in the stock market and it grows only by a fixed, linear rate of $1,000 a year, after 25 years, I will have $34,000. Not bad. But, if I invest that same $10,000 and grow the balance by 10% per year, compounding last year's gain on top of this year's, I will have $98,497 after 25 years. Compound interest is an example of exponential growth that we're all familiar with.

Technology and SPECIFICALLY, computing power, has been growing in this exponential way since the 1950s. But, computing power doesn't grow by single digits as is the case with investing money in a savings account. "Moore's Law," named after an early computer pioneer, tells us that computing power doubles approximately every 12 to 18 months. That means the annual growth rate is close to 100%! We will talk about what this means for all of us in the conference session.

Nearly all of us at the Wisconsin Agribusiness Classic carry in our pockets a computer that has more power than all of the computers that NASA used to send Neil Armstrong to the moon in 1969. It's called a smartphone. Computer performance is often measured in units called "FLOPS" which is FLoating-point Operations Per Second. To show how quickly things have advanced, in 1961, an early high-speed computer would have theoretically cost $8.3 trillion to perform one "gigaFLOPS," or <u>one billion calculations per second</u>. In 2013, the Sony PlayStation 4 videogame console (actually a computer) performed calculations that allowed users to play graphics-rich games (like Call of Duty) at a cost of 22 cents per one gigaFLOPS. And, today, a modern $500 laptop computer has that cost down to 8 cents! That's the power of exponential growth. Looking at things another way, my Apple 6 IPhone has a graphics processing unit that would have cost $637 trillion in 1961 to have the same computing speed and power.

In this session, we will talk about four major future trends brought about by these technology capabilities. I will also talk about a 5th major trend that we see at places like university ag colleges and a trend that will continue to shape agriculture in Wisconsin, and across the globe. To learn about the fifth one, you will need to attend the session. These are:

**Number 1. Big Data (and, not so big data)**

- Driven by new data collection devices, platforms, and systems
    - Drones and UAVs (yes, they are super cool, but they largely now serve as data collection devices)
    - Sensors
    - Internet of Things

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- Also enabled by super-cheap data storage technologies (including cloud).
- If we are not able to figure out high speed mobile access and "broadband" coverage, some areas of our state are going to be left behind.
- Questions about data security, ownership, effect on land and other asset values.

**Number 2. Artificial Intelligence**

- Think SIRI, Alexa, and J.A.R.V.I.S. (see Iron Man).
- Healthcare and other bio-applications.
- Watson-style computers (now the size of five pizza boxes) comb EVERY one of the 700,000+ cancer-related journal articles published each year – the average cancer doc only has time to read 200. Computers (and AI) are suggesting new treatments for complex cases that docs cannot find an answer to or that might take months.
- The <u>same potential</u> capabilities exist in agriculture (in the future) – with a dire warning.

**Number 3. Autonomous Vehicles – Cars, Semis, Tractors & Other Robotic/UAV Applications**

- Google, Tesla, several U.S. and international companies are leading the way.
- This technology will be here before you know it – safety is the concern (now), but will ultimately be the major selling point.
- Will also see applications in truck transportation systems.
- Biggest delay will not be the technology – it will be regulation and insurers.
- Autonomous tractors – the talk of the 2016 Farm Progress Show.

**Number 4. Sharing and Collaborative Economy Business Models**

- For those who travel, think AirBNB, Uber, and VRBO.
- Doubling utilization of a $500,000 machine that's only used 5-7% of time might make sense.
- Also includes crowdfunding, freelance workers (sites like UpWork)
- What about a car/tractor/manufacturing machine "parts" center that shares a 3-D parts printer?
- Enabled by technology, apps

**Number 5. Changes in Agriculture's Future Leadership and Workforce**

- Show up to learn more!

**Some other things that did not make it into this list (just not enough time!):**

- 5G wireless (5G is not just 1G better!)
- 3D printing (even of specialized foods and medicines? – yuck)
- Virtual and augmented reality
- Changing consumer demands – information and "the story"
- Big-time concerns about science literacy, risk perception
- Population trends and demographics in parts of Wisconsin (and, some of the causes)
- How do we go "high- tech" without losing the high-touch connectedness, community, and personal touch we see in Wisconsin agriculture?
- How do we capture the cool-factor to engage the generations who will follow us?

# On-Farm Traffic Optimization for Increased Efficiency

Brian D. Luck[1]

## Introduction

Management of vehicle fleets is a complex task. Interactions between a harvesting machine, transport vehicles, and a storage site provides the opportunity for introduction of inefficiencies in the harvest process. These inefficiencies translate to an increased cost of harvest. at best. and possibly a reduction in feed quality. Even when ignoring uncontrollable aspects of machinery, such as break-downs, there still exists idle time during the harvest process that can be minimized to improve harvest efficiency. In 2015 the entire forage harvest process on a commercial dairy was recorded using low-cost GPS data loggers. Controller Area Network (CAN) data were also collected on machines that had the data available. Machine working states were defined based on the GPS and CAN data to determine the time each machine spent doing a certain task. Idle time was defined for the harvesting equipment during alfalfa and corn harvest for silage production.

The equipment involved in this harvest operation was two self-propelled forage harvesters (SPFH), 10 straight trucks and 2 tractor-trailers. During the 2015 growing season, data were collected on these machines for 1600 acres of alfalfa (*Medicago sativa*) and over 2000 acres of corn (*Zea mays*). Machine working states for the SPFH were defined by the rules shown in Table 1 and working states for the transport vehicles are shown in Table 2.

The working states and the relationship between the vehicles provided sufficient information to determine the working time and idle time within a field (Fig. 1). Times when the SPFH was working are highlighted in green, travel time is highlighted in blue, idle time are marked as red, and metal detection (delay time) is highlighted as yellow within the figure. Most idle locations marked in the image are less than one minute-long while a “break” idle time (lunch during the working day) lasted over 75 minutes.

Table 1. Machine working state definitions for a self-propelled forage harvester equipped with a controller area network.

| State | Identification |
|---|---|
| Working | Feedroll Speed > 0, Cutterhead Speed >0, Vehicle Speed > 0 |
| Travelling | Feedroll Speed = 0, Cutterhead Speed =0, Vehicle Speed > 0 |
| Idle | Vehicle Speed = 0, but not due to Delayed or NP event |
| Delayed | Metal Detection = 1 |
| Non-Productive | Any known idle times not related to Idle or Delayed |

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Table 2. Machine working state definitions for transport vehicles based on GPS data and SPFH working state.

| State | Identification |
|---|---|
| Working | SPFH is working, Vehicle Speed > 0, Closest Truck to SPFH |
| Travelling | Vehicle Speed > 0, Not the Closest Truck to SPFH |
| Unloading | Within Geofence at Unloading Zone |
| Idle | Vehicle Speed = 0, Not Working/Travelling/Unloading/NP |
| Non-Productive | Any known idle times not related to Idle or Delayed |

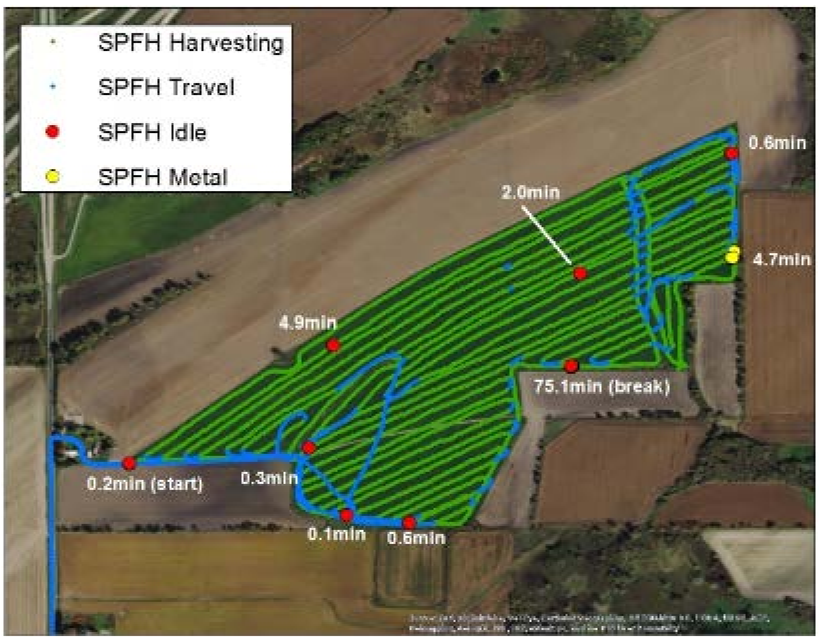


Figure 1. Alfalfa haylage field harvest during 2015. Idle locations and times are highlighted in red during the harvest operation.

Tables 3 and 4 show the harvest efficiency of this operation during haylage harvest and corn silage harvest in 2015. In general, corn silage production was much more efficient than haylage production owing to reductions in travel time, elimination of delay time due to metal detection, and decreased idle time. The harvester was working 54.0% of the operating time during haylage production while during corn silage production it was working 80.1% of the time. Idle time was reduced during corn silage production, by 3%, due to every transport vehicle being in service. Haylage production had a reduced transport vehicle fleet due to the other operation required on the farm like planting other crops.

Table 3. Harvest efficiency for haylage production at a commercial dairy in 2015.

| | Minimum | Average | Maximum | Std. deviation |
|---|---|---|---|---|
| Operation | 2.3 h | 7.7 h | 10.6 h | 2.8 h |
| Harvest | 40.0% | 54.0% | 68.9% | 9.6% |
| Travel | 21.7% | 29.1% | 40.6% | 7.1% |
| Delay | 0.4% | 1.5% | 4.1% | 1.4% |
| Idle | 6.1% | 15.0% | 22.6% | 4.9% |

Table 4. Harvest efficiency for corn silage production at a commercial dairy in 2015.

| | Minimum | Average | Maximum | Std. deviation |
|---|---|---|---|---|
| Operation | 8.2 h | 11.9 h | 12.8 h | 2.2 h |
| Harvest | 65.5% | 80.1% | 84.9% | 7.3% |
| Travel | 4.2% | 8.2% | 15.6% | 4.1% |
| Delay | 0.0% | 0.0% | 0.0% | 0.0% |
| Idle | 5.5% | 12.2% | 21.9% | 5.4% |

Minimization of idle time in the forage harvest process helps optimize harvest efficiency. Utilizing sufficient transport vehicles will reduce the time the SPFH is idle. Reductions in non-productive travel time will also produce gains in harvest efficiency.