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Damon Smith, Dept. of Plant Pathology, Univ. of Wisconsin-Madison
{For Leadership & Commitment to Educational Excellence}

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AGRICULTURAL ADVOCACY

Greg Peterson [1/]

The topic of agricultural advocacy has become increasingly important over the last few decades. The number of people involved in production agriculture continues to shrink and the percentage of the population who grew up on a farm becomes lower each year. As part of the millennial generation, my brothers and I have grown up surrounded by many who know nothing of what farming is and who farmers are. We have spent much of our lives attempting to address misconceptions and defy stereotypes of what it means to be a modern-day farmer. Only recently did our idea to start making music videos on YouTube take what we'd tried to accomplish with the people around us to the masses.

Over the last 5 years, my brothers and I have stumbled upon a communication platform that gives us a wider reach than anyone could have predicted. Our YouTube videos have been seen over 50 million times in over 200 countries. Our daily Facebook post interaction frequently eclipses 500,000 people. Many of these people do not come from agricultural backgrounds. Teachers have been able to use our videos in schools around the world, even in urban areas. The humor and relatable content found in our videos is what drives our success and the popular songs we parody are the bridge we use to drive people from urban areas to our channel.

Ten years ago, much of what we are able to do on social media today was not possible. Smart phones have given us the ability to capture what we are doing on the farm and broadcast it to thousands of people at the click of a button, all from the seat of a tractor or wireless internet in our homes. At no time in history has such a powerful communication tool made reaching large groups of people so accessible. Unfortunately, this surge in communication has led to a frustrating amount of misinformation being shared as well. Simple google searches of modern day agricultural technology result in overt negativity toward farmers and the agricultural industry. My brothers and I have realized over the years that not only should we be showing what farming looks like and what farmers do in our videos, we need to be prepared to answer the tough, controversial questions that people have about the technology farmers use.

After watching our videos, people often have questions about farming practices. There is a sense of trust and credibility that is built after watching our family have fun together. This trust and credibility allows us to answer these questions with honesty and candor. It opens up a valuable opportunity to share with millions of people why farmers use the technology they

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do. Without that trust, many will reject information about tools such as GMOs, pesticides, preventative animal medicine, and feed additives before they are even explained. We believe building trust is as big a part of advocacy as presenting the information.

As we enter into the future of agriculture and advocating for what we do, we must remember that trust, transparency, and vulnerability is essential to telling our story. The need to advocate has never been clearer and will continue to increase. Each and every person in the industry needs to be prepared to share answers to hard questions. Social media and new technology allow us to do this in ways not possible in the past. Although the battle to educate may never end, we must not give up the conversation.

EFFECT OF STRIP-TILLAGE, FERTILIZER PLACEMENT, CROP ROW SPACING, AND IN-FURROW FUNGICIDE ON SOYBEAN SEED YIELD

Derek J. Potratz, John M. Gaska, Spyridon Mourtzinis, Francisco J. Arriaga, Joseph G. Lauer, and Shawn P. Conley [1/]

Cold, wet, compacted soils can have negative implications on soybean production. Alleviation of these issues is of importance for earlier planting and improved seed yield. Strip-tillage adoption in corn has increased as a sustainable means to improve soil conditions and improve yield; however, the response of soybean to strip-tillage has been less consistent. This study aims to determine the yield response and best management practices for strip-tilled soybean production. Strip-tillage can be loosely defined as any tillage that only loosens the soil and removes or incorporates residue in a narrow (10- to 20-cm) band set to a 5- to 20-cm depth ahead of planting. Planting follows the strip-tilling and the seed furrow is formed in the middle of these strips while the area between the crop rows remains undisturbed. The most popular strip-tillage implements incorporate four individual procedures into a single pass: 1) residue removal, 2) residue sizing, 3) narrow tillage with a knife or coulter, and 4) twin opposing coulters to form an elevated berm. This can be performed in spring or fall and combined with deep banded fertilizer in each row. Experiments were conducted in Wisconsin using both field scale and small plot equipment. In soybean, combinations of strip-tillage, no-tillage, deep banded, and surface applied fertilizer, and 15- and 30-inch row spacing were compared. Physical plant and soil measurements were taken throughout the growing season. Results from the first 2 years of the study conclude that in small plot experiments, 15-inch row spacing significantly out-yielded 30-inch row spacing by 23%. In addition, strip-tillage significantly out-yielded no-tillage in 30-inch row spacing by 17%. Results from this study will provide best management decisions for strip-tilled soybean in Wisconsin and applicable to the upper Midwest. The potential for soybean seed yield improvement and environmental stewardship make strip-tillage an appealing option for soybean production.

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WHAT IS THE DEAL WITH TILLAGE?

Francisco J. Arriaga [1/]

There are advantages and disadvantages to tillage. Advantages include smooth seedbed preparation, weed control with reduced risk of herbicide resistance, and break-up of compacted soil. Destruction of soil aggregates, creation of plow pans, and increased production costs are often referred as disadvantages. There is increased interest in no-tillage and its use is increasing. However, some form of tillage is still widely used by most farmers. Are there benefits to both approaches? Certain soils and crop rotations might be more conducive to one approach versus the other. Soils with high soil organic matter contents, high amounts of aggregation, and in flat fields can be quite productive when tillage is used. However, this increased crop productivity is often at the expense of organic matter and soil health. Other practices, such as crop rotations, manure application and cover crop use, might help offset declines in organic matter and soil health brought by tillage. A combination of approaches are most likely to provide benefits for a wide range of soils and conditions. In this presentation, we will explore the advantages and disadvantages of tillage practices on soil health, organic matter, and productivity.

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TOP 10 LESSONS FROM BRAGGER FAMILY DAIRY

Joe Bragger and Amber Radatz [1/]

In 2002, Bragger Family Dairy became the first Discovery Farms Core Farm through monitoring efforts on two streams located on the farm. The dairy is located in Buffalo County, Wisconsin, which is known for its steep sloped, hilled landscape. Because of the sensitive landscape, the dairy used conservation practices and management strategies to minimize soil loss. The monitoring locations were chosen to compare cropped acres to perennial grassland and woodland. Monitoring took place for 7 years. Sites were referred to as the north site (corn and alfalfa rotation next to the stream) and the south site (pasture and woodland with cropped acres further from the stream). UW Discovery Farms learned valuable lessons from the study on Bragger Family Dairy, here are the top 10:

1. **Agricultural and non-agricultural areas performed similarly while the ground was frozen and after crop canopy was established.**

   When the soil was frozen, soil and nutrient losses at the two sites were comparable. Runoff at this time of year was driven by snowmelt. This relationship shows that the farming system, including manure management, did not have a significant impact on the stream while the soil was frozen or when snow was melting.

2. **Soil and phosphorus were mostly transported in flow during and following storm events, even though most water in the streams comes from springs.**

   Stormflow accounted for less than 25% of the total water flow from the north and south sites, but more than 80% of the soil and total phosphorus losses at each site. Storms have the biggest impact on water quality when the soil is not covered by a fully developed crop canopy.

3. **May and June were the only months of the year when average monthly P and N loss was higher at the north site compared to the south site.**

   This was driven by two particular storm events in June 2002 and June 2004 which delivered significant proportions of the soil (55% of total) and total phosphorus (44% of total) lost during the entire study period.

[1/] Bragger Family Dairy and Univ. of Wisconsin Discovery Farms Program.

4. **Large storms have a major impact, and it matters what month they occur in.**

   The two June storms (2002 and 2004) delivered more soil loss than 125 other storm events combined during the entire study period. The large storm events (1 to 2.5 inches of rain per hour) were more impactful in the agricultural watershed due to limited crop canopy in the early June time period. A storm in August 2007 had similar intensity to the June storms but was not even in the top 20 storms for soil loss at the sites. Fully grown crops intercepted rainfall and protected the soil surface, thus preventing runoff.

5. **Making sure banks are stabilized and protected from large flow events pays dividends.**

   Since the monitors at this farm were in the stream, it's reasonable to think that some of the losses could be coming from the fields and some within the stream. During the large August storm, losses would have likely been much higher if the banks were not stabilized and properly maintained. It's not just fields or banks to protect, but instead placing a network of practices together to build a resilient farming system.

6. **In Western Wisconsin, grade stabilization structures are a worthwhile conservation practice to protect streams and fields**.

   Mid-way through the study, a grade stabilization structure was installed at the headwaters of the stream in the agricultural watershed to slow water from the wooded areas upstream of the cropland. The structure reduced average sediment concentrations in the stream by 73%. This practice is a valuable addition in the Driftless landscape to slow water and prevent erosion.

7. **Consistent nutrient stewardship practices can decrease nitrogen concentrations in streams.**

   Most of the nitrogen measured in the stream at Bragger Family Dairy was delivered during baseflow and was in the nitrate form due to the carbonate bedrock that underlays the Buffalo County landscape and springs that feed the perennial streams. There was a downward trend in baseflow concentrations of nitrate at the agricultural watershed site during the study period, and concentrations were nearly identical to those at the non-agricultural watershed (which stayed consistent) by the end of the study. The Braggers are committed to the right rate, time, placement and source of nitrogen, and it is making a water quality difference.

8. **Listen to your wife when she says don't spread manure today, it's going to rain.**

   Manure and fertilizer were applied in the monitored areas dozens of times, but only two of the 2,557 monitored days indicated an impact from an application. Manure was applied immediately before a runoff event in October 2005, which increased phosphorus and nitrogen loss. However, it did not impact annual loss significantly and there were no effects on the trout population in the stream. And Joe Bragger's wife told him not to spread manure that day.

9. **Streams were always below the phosphorus criteria for Wisconsin.**

   Both streams were always below the numeric phosphorus criteria for Wisconsin–an indicator that both were of good quality–and neither was impaired, regardless of land use.

10. **Agricultural management and water quality complement each other at Bragger Family Dairy as a result of thoughtful use of conservation practices and nutrient management.**

For more information on these lessons learned visit https://bit.ly/2mson8R to read the full project report. Formal printed copies of the report are available upon request, email Erica.olson@ces.uwex.edu.

TILE DRAINAGE PRINCIPLES

John Panuska [1/]

ABSTRACT

In order to be agriculturally productive tile drain systems are often installed in areas with low permeability soils or high water tables, to lower the water table depth. Some benefits of tile drainage include providing an aerobic root zone for crop growth, improved field trafficability and creating conditions where soils can warm more quickly in the spring. Tile systems also pose environmental risks such as the increased potential for loss of soluble nutrients (nitrate and phosphorus) along with pesticides and pathogens. In addition, soil macro-pores such as shrinkage cracks and earth worm holes can deliver low solids content injected manure directly into tile lines. Keeping injected manure solids content greater than 5%, tilling prior to injection to break up macro-pores or avoiding tiled areas can reduce the risk of manure loss through tiles. Tile systems are gravity-flow systems and in order to function properly must have a free-flowing outlet. In cases where field elevation and grades don't allow for a gravity flow, a pump lift station will be required, which will increase installation and maintenance cost. A relationship exists between depth and spacing of tile laterals. For uniform permeability soils deeper drains can have wider spacing (within reason). Tile system design performance is specified by the drainage coefficient (Dc), which is equal to the depth in inches of water removed from a field in 24 hours. Typical Dc values range from 0.5 to 1.0 inch per day. A higher Dc equals a higher system flow rate, larger pipes and higher cost. Field- and crop-specific conditions will dictate the appropriate design Dc to use.

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UPDATE ON BAYER SEED TREATMENT PORTFOLIO FOR 2019

Nick Tinsley[1]

The wetter-than-usual conditions experienced by many soybean growers in the northern Midwest posed a number of challenges this fall. Some of these challenges, such as reduced seed quality and germination issues associated with fungal infections, are worthy of seed producers' attention going into 2019. A brief review of this issue as well as how seed treatments can play a role in mitigating losses will be presented.

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Soybean Flowering Fallacy

LINDSAY CHAMBERLAIN, JIM SPECHT AND SHAWN P. CONLEY

In a bean pod…

- There is an old rule-of-thumb that soybean does not flower until after the summer solstice — the longest day of the year occurring on June 21st in the Northern Hemisphere — yet many of us have seen soybean flower much earlier.
- Early planted soybean experience shorter days before June 21st, so floral induction and the subsequent appearance of flowers may occur ahead of the summer solstice.
- Soybean management decisions depend on proper identification of reproductive stage R1 (1st flower), which means relying on scouting to observe flowers, not calendar date.

Soybean is a 'short-day' plant.

Nearly all plant species depend on seasonal change in day/night length as a cue for initiating flowering so that it occurs at a seasonally optimum time. In both natural and cultivated systems, this ensures successful pollination, seed fill, and dispersal/harvest. In crop species, breeders can genetically develop cultivars that have specific adaptation to latitudinal zones of north-south variance in day/night photoperiod. This is a major reason that different soybean maturity groups are grown at different latitudes (Mourtzinis and Conley, 2017).

There are two main types of plant species photoperiod dependency, known as 'long-day' and 'short-day'. These historically assigned names are misleading; we now know plants actually measure the length of the night, not the day. For both types, there is a critical night length that varies between species and among wild ecotypes or crop cultivars adapted to different latitudes. For most short-day plants (like soybean), exposure to a few successive nights longer than the critical length will induce flowering. Long-day plants require the successive nights to be shorter than the critical night length to flower (Taiz et al., 2015; Figure 1).

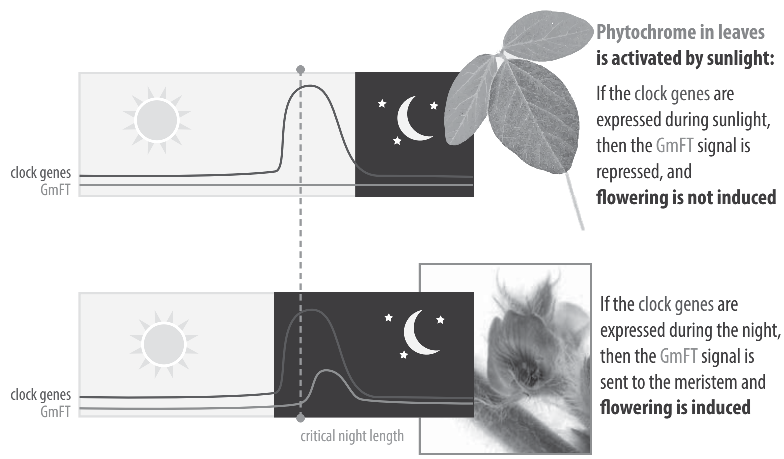
There are two cyclic processes at play in the mechanism of photoperiod sensitivity: 1) the solar 24-hour cycle of day and night, and 2) a within-plant circadian rhythm. This circadian rhythm also keeps time, but because it does not precisely do so, it must be entrained to keep 'plant time' close to 24-hour solar time.

A protein found in plant leaves called phytochrome is responsible for photoperiod detection. This protein is converted into an active form by sunlight and returns to an inactive form in the dark. Expression of certain genes in the plant are controlled by circadian rhythm, increasing expression at specific time intervals. When expression of these 'clock' genes occurs in the daylight, a signal that induces flowering (GmFT) is repressed, so flowering does not occur (Taiz et al., 2015; Cao et al., 2016). This model is consistent with the mechanism that controls flowering in rice, which is a model short-day plant. These mechanisms in soybean are less well understood than in rice, in part because there are multiple, redundant genes in soybean, which may allow some soybean cultivars to have reduced photoperiod sensitivity (Cao et al., 2016). The molecular mechanisms that control soybean photoperiod sensitivity and flowering induction are areas of ongoing research. The exact mechanism of perceiving night length and floral induction is complex, but the main idea is that longer nights, which is perceived by the leaves, induce flowering in soybean (Figure 1).

Nights are long before the solstice, too!

Research on this subject has shown that in soybean, the unifoliate leaves are able to perceive night length. If the night is long enough, those leaves will transmit a signal to leaf axil vegetative meristems that induces them to become floral meristems (Wilkerson et al., 1989). If soybean are planted early enough, flower induction can occur before the summer solstice when nights are long (Bastidas

Figure 1. Nights longer than the critical length (dashed line) induce flowering in 'short-day' plants like soybean. *This is a schematic representation of the process and not intended to show actual measurements.*



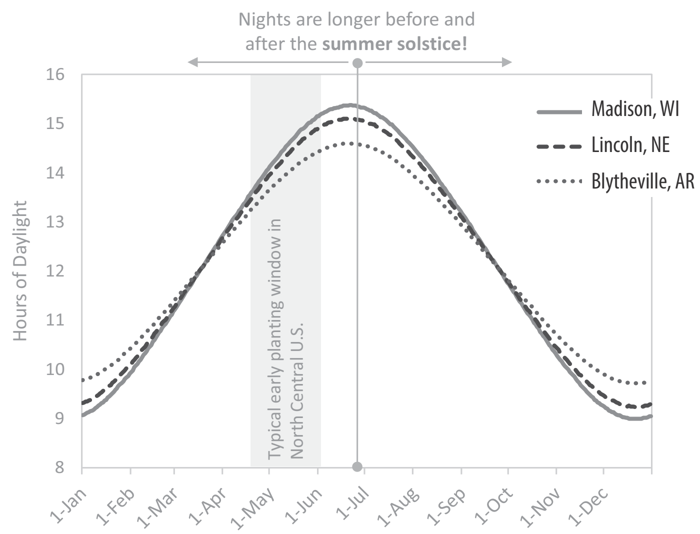


Figure 2. Hours of daylight at three U.S. locations throughout a year. The highlighted box indicates a typical planting window for the North Central U.S., which occurs before the the summer solstice.

et al., 2008). Typical planting dates in the North Central U.S. occur well before the shortest-night of the year (e.g., solstice), generally providing unifoliate leaves opportunity to perceive long nights as soon as they emerge (Figure 2).

Floral Induction, does that mean R1?

Induction of flowering occurs long before your eyes can observe flowers on the plant. This refers to the very first chemical signals in the plant that cause the meristematic tissue to begin forming a flower instead of a branch in each leaf axil. In soybean, those signals are photoperiod dependent, requiring long nights. Flower **evocation** refers to the growth of that differentiated tissue to result in a visible flower. The speed of that growth is temperature dependent, much like growth of vegetative tissue. In general, higher temperatures result in faster growth. The first reproductive growth stage (R1) is only noted after the human eye can see flowers (Fehr and Caviness, 1977). Therefore, both **induction** and **evocation** are required to reach R1, meaning that photoperiod and temperature will impact the timing of R1. Perception of an inductive night length is needed to initiate flowering, but temperature increases can speed up flower evocation. A very warm late spring could lead to hastened R1 timing, which was observed in the Midwest in 2018.

Maturity group is a reflection of photoperiod sensitivity.

Night length changes over the course of the year, but the magnitude of this change is latitude dependent. Higher latitudes experience a longer period of sunlight on the longest day, and therefore a shorter night. Soybean grown at higher latitudes are able to flower under these shorter nights because maturity groups adapted for these locations have reduced photoperiod sensitivity (Cao et al., 2016).

For example, Madison, WI (latitude 43.0°) experiences a night length about 15 minutes shorter on June 21st than Lincoln, NE (latitude 40.8°) and about 45 minutes shorter than Blytheville, AR (latitude 35.9°) (Figure 2). Soybean maturity groups II and III are best suited to southern Wisconsin and Nebraska, respectively, and are less photoperiod sensitive than the maturity group IV or V soybean typically grown in Arkansas (Mourtzinis and Conley, 2017).

Why does early flowering matter?

In future growing seasons, increasing frequency of extreme warm and cool temperature fluctuations during the floral evocation period can result in increased variability of R1 timing after V1. Since early planted soybeans are able to perceive long nights before the solstice, we cannot count on June 21st as the typical R1 date in the North Central U.S. The best way to identify the timing of R1 is to regularly scout soybean. Crop models like SoySim predict growth stages by using planting date, maturity group, photoperiod, and temperature data, plus projection of coming temperatures. Predictors like this can be useful management tools but should be validated in the field. Identifying R1 is important for effective weed and disease management. Several common post-emergent herbicides are not labeled for use in soybean after R1. The legal application window for these products refers to the growth stage present in the field, regardless of the calendar date. For disease management, earlier white mold risk comes with early flowering soybean. Sporecaster, a white mold predictor app, can aid in white mold management but only with accurate information about the presence of flowers. Relying on the calendar for R1 determination increases your risk for missing the window for an effective fungicide application.

The advances in agricultural production in the last century have allowed increased food production on less acres, and this pattern needs to continue in order to feed a growing global population. New technologies and modern crop management strategies (like planting earlier) along with extreme weather patterns becomng more frequent, will challenge us to be wary of old rules-of-thumb that may not hold up to farming in the 21st century and beyond.

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ESTIMATING THE CONTRIBUTION OF THE SOIL MICROBIAL COMMUNTIY TO THE CROP ROTATION EFFECT

Marian L. Bolton[1,2], Madison Shay-Cox[3], Shawn P. Conley[2],
Garret Suen[3], and Jean-Michel Ané[2,3]

Crop rotation has many benefits including, increased yield, decreased disease pressure, and decreased soil nutrient depletion. While the benefits of crop rotation are well established, the underlying drivers behind these benefits remain unclear. The soil microbial community plays an essential role in plant health by fostering soil nutrient cycling, availability and uptake. Plants and microbes are known to communicate with each other in the soil and plants can alter their microbial community based on the composition of their root exudates. Due to this, the soil microbial community could be significantly altered based on crop type planted and may play a key role in the crop rotation effect. The goal of this study was to determine the contribution of the microbial community to the corn soy crop rotation effect in south central Wisconsin. We measured the bacterial and fungal community composition and structure under continuous corn, continuous soybean, annual corn-soybean and a five-year corn-soybean monocropping rotation systems. Soil sampling occurred in the at planting, mid-season (approximately R1), and at harvest by collecting and pooling 5 soil cores (0-15 cm) from the middle rows of each plot. Extracted soil DNA was subjected to Illumina MiSeq amplicon sequencing for the bacterial V3-V4 region of the 16S rRNA and fungal ITS2 region 18S rRNA. Sequence data were processed using the Mothur (version 1.40.5) standard operation protocol and R statistical software (version1.0.143) was used to analyze and visualize the data. Additionally, we estimated the carbon utilization diversity of the soil microbial community based on crop rotation scheme at planting, mid-season and harvest using Biolog EcoPlates plates. Preliminary results from the 2016 planting time-point show significant differences in beta diversity between bacterial communities of continuous corn, continuous soybean and annual rotations (PERMANOVA, $p<0.05$). Bacterial and fungal sequencing data from the additional 2016, 2017 and 2018 time points are in process.

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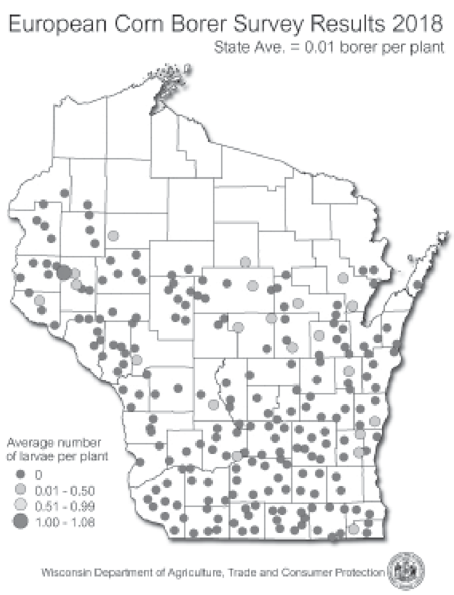
A REVIEW OF DATCP'S INSECT SURVEY RESULTS FROM 2018

Krista L. Hamilton[1/]

European Corn Borer

Larval counts in September and October were the lowest in 77 years of annual surveys. The 2018 state average European corn borer (ECB) population decreased to 0.01 borer per plant or one larva per 100 plants, falling below the previous record of 0.02 borer per plant set in 2015. Seven of the state's nine agricultural districts showed averages less than or equal to 2017 levels, while negligible increases were noted in the west-central and northeast areas. Larvae were found in only 10% of the fields, with infestation rates below 36% at all but one Dunn County site which averaged 108%. The exceptionally low ECB pressure documented by the fall survey should provide reassurance to growers who opted to plant non-trait corn seed, though conventional acreage will continue to require a higher level of scouting and management to address local variability in seasonal ECB abundance.



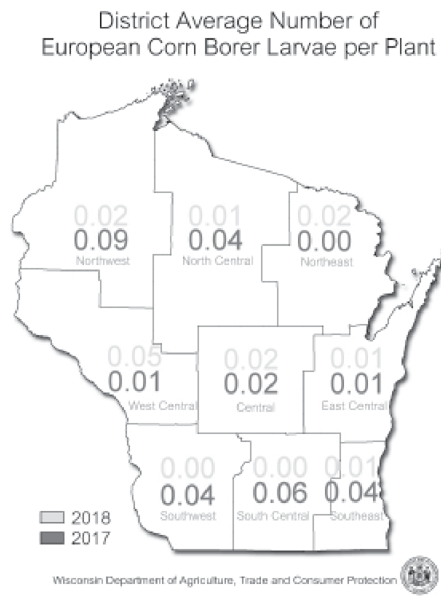


Table 1. European corn borer fall survey results 2009-2018 (Average no. borers per plant).

District	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	10-Yr
NW	0.06	0.08	0.15	0.04	0.07	0.06	0.03	0.13	0.09	0.02	0.07
NC	0.10	0.02	0.07	0.01	0.02	0.04	0.00	0.08	0.04	0.01	0.04
NE	0.12	0.19	0.13	0.05	0.02	0.01	0.04	0.00	0.00	0.02	0.06
WC	0.10	0.08	0.12	0.09	0.06	0.12	0.03	0.15	0.01	0.05	0.08
C	0.06	0.06	0.05	0.01	0.01	0.00	0.01	0.24	0.02	0.02	0.05
EC	0.09	0.01	0.03	0.01	0.01	0.01	0.04	0.00	0.01	0.01	0.02
SW	0.06	0.12	0.03	0.03	0.06	0.00	0.03	0.14	0.04	0.00	0.05
SC	0.02	0.07	0.20	0.01	0.08	0.01	0.02	0.14	0.06	0.00	0.06
SE	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.04	0.04	0.01	0.01
WI Ave.	**0.06**	**0.07**	**0.09**	**0.03**	**0.04**	**0.03**	**0.02**	**0.11**	**0.03**	**0.02**	**0.05**

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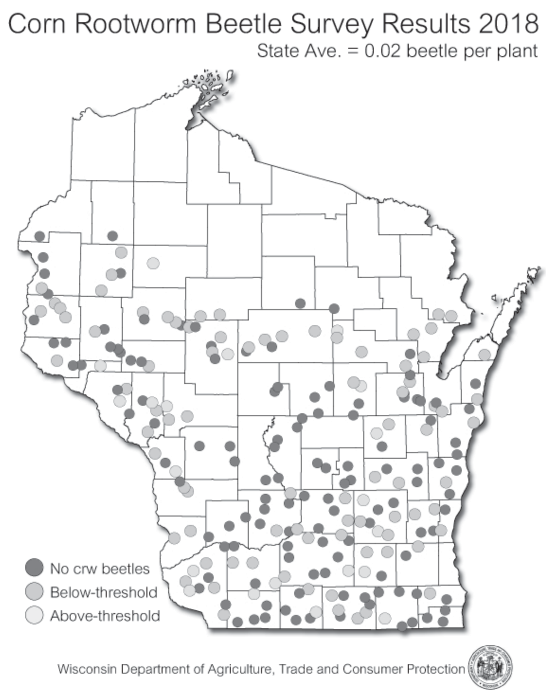
Corn Rootworm

Beetle populations were historically low again in 2018. The state average count of 0.2 beetle per plant was equivalent to the 2017 average, while numbers in all nine crop reporting districts remained at or below 0.4 beetle per plant for the second year in a row. The only district-level increases in 2018 occurred in the west-central and northeast areas, where the averages rose from 0.2 beetle per plant in 2017 to 0.3 per plant and from 0.2 to 0.4 per plant, respectively. A minor decrease was recorded in the central district. Above-threshold counts of 0.75 or more beetles per plant were found in 21 of 229 (yellow circles) fields surveyed, low to moderate counts of 0.1-0.7 per plant were found in 81 fields (green circles), and no beetles were observed at 127 (gray circles) of the survey sites.



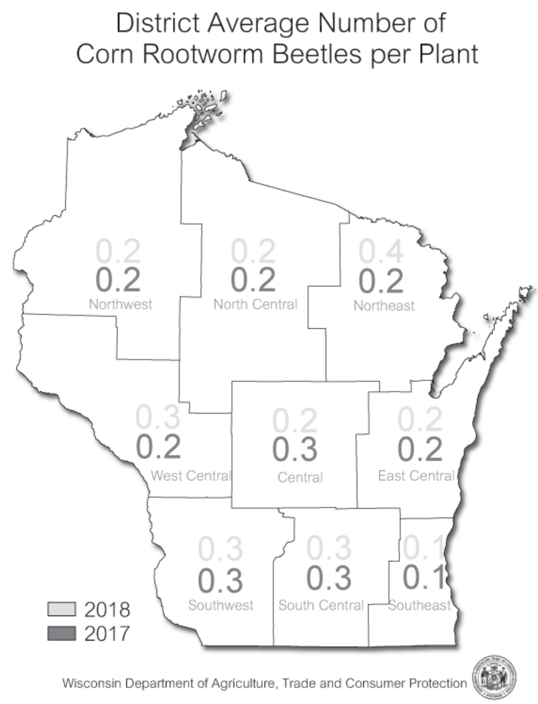


Table 2. Corn rootworm beetle survey results 2008-2017 (Average no. beetles per plant).

District	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	10-Yr
NW	0.4	0.3	0.1	0.5	0.7	0.5	0.2	0.5	0.2	0.2	0.4
NC	0.4	0.1	0.1	0.3	0.2	0.2	0.5	0.7	0.2	0.2	0.3
NE	0.6	0.1	0.3	0.6	0.2	0.1	0.2	0.7	0.2	0.4	0.3
WC	0.5	0.4	0.6	0.4	0.4	0.6	0.3	0.6	0.2	0.3	0.4
C	0.4	0.4	0.8	0.5	0.2	0.2	0.5	0.3	0.3	0.2	0.4
EC	0.6	0.3	0.5	0.4	0.3	0.3	0.8	0.4	0.2	0.2	0.4
SW	0.7	0.3	1.1	0.8	0.6	0.9	0.8	0.7	0.3	0.3	0.7
SC	1.1	0.3	1.4	0.9	0.5	0.3	0.8	0.4	0.3	0.3	0.6
SE	0.3	0.2	0.7	0.9	0.8	0.4	0.7	0.2	0.1	0.1	0.4
WI Ave.	**0.6**	**0.3**	**0.7**	**0.6**	**0.5**	**0.4**	**0.6**	**0.5**	**0.2**	**0.2**	**0.4**

True Armyworm

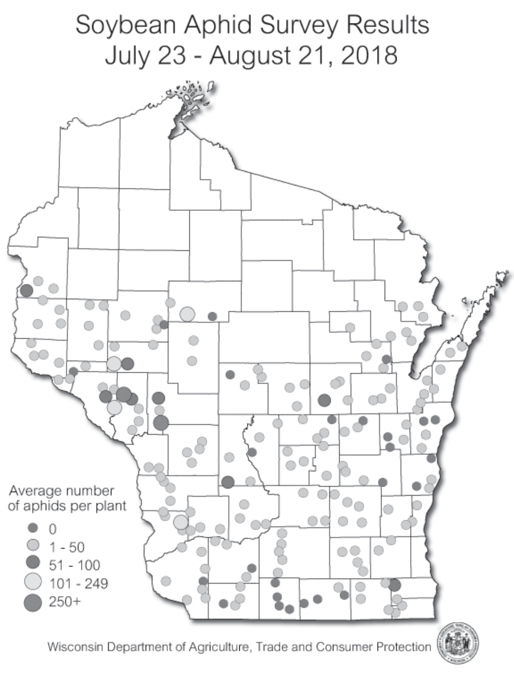
Conditions favored mid-season armyworm populations and outbreaks developed in July in scattered areas of the state. Reports of severe infestations in barley, corn, oats, peas, and wheat were received from several counties, including Clark, Columbia, Eau Claire, Marquette, La Crosse, Rusk, Taylor and Vernon, with a few accounts of masses of caterpillars migrating across roadways. The armyworm outbreak subsided by late July due to pupation of second-generation larvae and insecticide treatment of many acres of cropland.

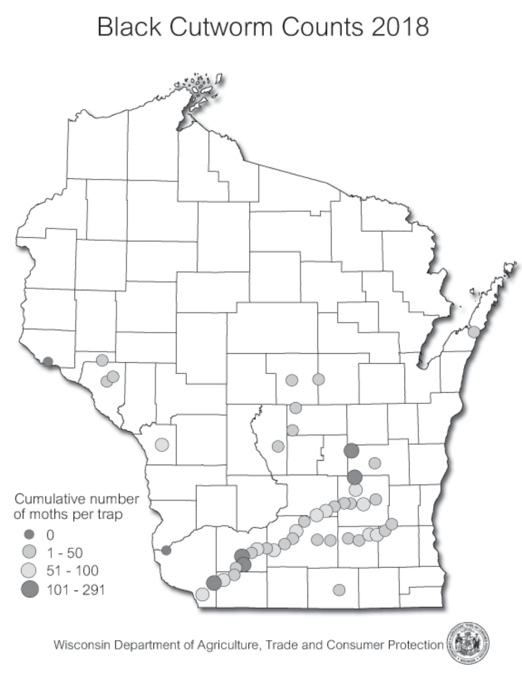
Corn Earworm

The DATCP network of 14 pheromone traps captured a cumulative total of 7,905 moths, with the majority arriving during the six-week period from August 2-September 12. More than one-quarter of the migrants (2,269) were collected at the Beaver Dam (Dodge County) location. Three other sites in Dane, Dodge and Fond du Lac counties also reported high cumulative counts of 500 or more moths. This year's total count was nearly three times larger than that of 2017 when 2,760 moths were captured in 15 traps. Corn earworm flights ended about September 26.

Soybean Aphid

Aphid populations reached the 250 aphid-per-plant treatment threshold in scattered fields during the first two weeks of August, but densities on a statewide scale were mostly low this season. The annual survey conducted from July 23-August 21 found a statewide average count of 14 aphids per plant. This was an increase from six aphids per plant last year and eight aphids per plant in 2016, still far below the threshold. One hundred and eighty-nine soybean fields in the R2-R6 growth stages were surveyed, with aphids counted on 40 plants per field. Only two sites, one each in Jackson and Trempealeau counties, contained above-threshold populations of 260 and 290 aphids per plant. Densities were below 100 aphids per plant in 96% of fields, and the majority of those sites (86%) had average counts of less than 25 per plant.





Results of the survey suggest that while aphid pressure was slightly higher in 2018 than in the previous two years, most sampled soybean fields did not meet treatment guidelines during the survey timeframe. In addition, no cases of pyrethroid insecticide failure were reported or confirmed in the state.

Black Cutworm

Larval feeding injury was encountered in unexpectedly few cornfields surveyed in spring of 2018, despite planting delays and large moth flights throughout May. The cumulative total count for the April 12-June 13 survey period was 2,217 moths in 47 traps, with an individual high of 291 moths near Waupun in Dodge County. In 2017, the survey captured 3,228 moths in 45 traps. Although this year's trap counts indicated a large and threatening spring moth migration, economic damage to emerging corn was not as common as anticipated.

Japanese Beetle

This insect was a leading pest of concern to Wisconsin soybeans again in 2018, second only to the soybean aphid. Surveys in July and August found defoliation in 72% of fields. In 2017, a banner year for Japanese beetle in Wisconsin, 87% of surveyed sites had some degree of feeding. Sweep net sampling during the August aphid survey yielded average counts ranging from 0-21 beetles per 100 sweeps in the state's nine crop districts. Areas with the highest numbers were the southeast (21 per 100 sweeps), south-central (17 per 100 sweeps) and west-central (13 per 100 sweeps) districts (see Table 3). The state average was 8.4 beetles per 100 sweeps. The prevalence of Japanese beetles documented by the survey signals that this invasive pest continues to pose a significant threat to the state's soybean crop.

Table 3. Soybean pest survey results 2018 (Average no. insects per 100 sweeps).

District	**Bean leaf beetle**	**Japanese beetle**	**Northern CRW**	**Southern CRW**	**Western CRW**	**Green Cloverworm**	**Grass-hopper**	**Stink Bug**
NW	0.0	3.9	0.0	0.0	0.0	0.0	0.4	0.0
NC	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4
NE	0.2	0.2	0.0	0.0	0.0	0.0	2.0	0.1
WC	0.0	13.2	0.0	0.0	0.0	0.4	1.4	0.3
C	0.0	3.6	0.0	0.0	0.0	0.1	1.3	0.2
EC	0.0	0.0	0.1	0.0	0.0	0.0	0.7	0.1
SW	0.1	7.7	0.9	0.1	0.1	0.6	1.4	0.2
SC	0.1	16.6	1.0	0.2	0.0	0.3	0.8	0.2
SE	0.4	20.6	0.4	0.1	0.0	2.9	1.5	0.2
WI Ave.	**0.1**	**8.4**	**0.3**	**0.1**	**0.0**	**0.5**	**1.2**	**0.2**

Soybean Gall Midge

An emerging pest of Midwestern soybeans, the soybean gall midge (SGM) was not found in Wisconsin this year. Populations were confirmed in 12 western Iowa counties, as well as in Nebraska and South Dakota. Larvae of the SGM, a member of the Hessian fly family (Cecidomyiidae), feed internally at the base of soybean stems and cause stem discoloration. Infested plants snap off near the ground and the orange or white maggots can be found feeding inside. Much remains unknown about this insect, including the exact species and whether it is a direct or a secondary soybean pest. Consultants and soybean growers are encouraged to become familiar with SGM for 2019.

"DISSECTING" TRUE ARMYWORM MANAGEMENT

Bryan Jensen[1]

True armyworms are an occasional pest in Wisconsin's corn and wheat production systems. Typically, field damage is superficial and spotty in nature. During the summer of 2018, we had few, if any, reports of damage from the spring (migrating) generation. However, there were several significant, if not severe, damage from the summer generation throughout the state.

Armyworm larvae have a tan head w/numerous vein-like lines in the compound eyes. Body color and intensity can be very diverse, but alternating light to darker color lines are usually noticeable. Typically, the "belly" is lighter colored than the rest of the body. Larvae are nocturnal feeders and often rest in the corn whorl or on the soil surface in wheat during the day. Larvae may grow up to 1.5 inches long. The adult moth has a wingspan of 1.5 inches and few identifying characteristics.

Adult moths migrate to Wisconsin on spring weather events. Once they arrive, they are usually attracted to grasses to lay eggs. Larvae emerge one week to 10 days after eggs are laid and will feed for approximately 3 to 4 weeks. Fully developed larvae will pupate for approximately 2 weeks before emerging as adults.

Armyworm prefer to feed on grass plants including corn and small grains. The presence of grassy weeds (including cover crops) and corn no-tilled into alfalfa may attract adults to lay eggs. If these hosts are unavailable, broadleaf weeds and other crop plants, including vegetables and soybeans may serve as hosts. Armyworm larvae may also migrate short distances from one host to another. In this situation damage is usually highest along field margins.

Larvae will begin feeding at the leaf margin, often leaving a ragged edge. If holes are chewed in a leave, they too will have a ragged appearance.

Because armyworms migrate to Wisconsin timing of arrival and intensity of the flight is difficult to forecast. Routine monitoring of attractive fields (corn planted into not-till alfalfa, lodged wheat, grassy weeds and/or rye cover crop) is suggested. Damage from the summer generation if more difficult to predict and requires an extensive monitoring of corn and other susceptible crops.

The economic threshold for armyworms varies according to the crop. However, one commonality is that armyworm are best controlled when under 1-inch long. In wheat, and other small grains, the long-established economic threshold is a field average of three armyworms per square foot. Armyworms are nocturnal feeders so look for larvae on the soil

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surface and under surface residue. Furthermore, armyworms can switch from leaf feeding to head clipping prior to harvest. Seedling corn can be very resilient. In a recent article published by Kelly Tilmon and Andy Michel (Ohio State University), they suggested rescue treatments may be needed if stand infestation is greater than 50% and larvae are not yet mature. In late vegetative/early reproductive corn, the threshold is one armyworm on 75% of the plants or two armyworms on 25% of the plants. Again, armyworms are best controlled if under 1-inch long.

There are several foliar broadcast insecticide options available to control armyworm larvae. Insecticide classes include carbamates, organophosphates, synthetic pyrethroids, diamides and microbials (Bacillus thuringiensis and spinosads). However, read label direction before deciding. Pay close attention to the Preharvest Interval especially in small grains.

There are several corn Bt hybrids with proteins that provide control of European corn borer. However, these proteins do not all offer adequate control of armyworm, especially when larval pressure is high. Of those proteins, the trait packages with the Vip3A protein can provide control of true armyworm.

AN OVERVIEW OF NEONICOTINOID IN INSECTICIDE CONTAMINANTS IN CENTRAL WISCONSIN'S SURFCE AND GROUNDWATER SYSTEMS

Ben Bradford and Russell Groves [1/]

Introduction

Neonicotinoids are a popular and widely-used class of insecticides whose water-soluble nature and 20-year usage history has led to questions about their potential to accumulate in the environment and harm local ecosystems [1–6]. When first registered in the United States in 1995, these compounds promised increased efficacy, long-lasting systemic activity, lower application rates, low vertebrate toxicity, and reduced environmental persistence, all of which contributed to the rapid adoption and widespread use of this class of insecticides, which now account for over 25% of the entire global pesticide market [7]. Over 6.7 million pounds of neonicotinoid insecticides are now applied annually on 140 different crops in the United States, with the three most popular compounds, imidacloprid (IMD), clothianidin (CLO), and thiamethoxam (TMX) making up over 90% of agricultural usage nationally [7,8].

Most neonicotinoids are registered for application as seed treatments, foliar sprays, and in-furrow soil drenches, with seed treatments and soil applications constituting 60% of agricultural neonicotinoid usage [7]. Seed and soil application methods are of particular environmental concern because uptake rates of applied active ingredients have been reported as 2-5% in cotton, eggplant, potato, and rice, and up to 20% in maize, meaning that in excess of 80% of applied active ingredients remain in field soils potentially resulting in off-site movement and environmental contamination [9]. Emerging concern about neonicotinoid contamination has motivated the development of ecosystem- and regional-scale water quality surveys [5,10–14]. Conservation groups have also raised calls for neonicotinoids to be banned or phased out due to the substantial ecological risks their continued use may pose [15,16].

To assess the extent of contamination we perform a structured, multi-year study of neonicotinoid contamination in high-capacity irrigation wells distributed throughout the Central Sands and Lower Wisconsin River Valley agroecosystems in Wisconsin. Irrigation wells provide both a broad spatial sampling scale (landscape to state), can be sampled repeatedly during growing seasons, and draw groundwater from deeper than the static test wells sampled by Wis. Dept. of Agriculture, Trade, and Consumer Protection (WDATCP), potentially revealing the extent to which contaminants have permeated the underlying aquifers. In addition to our high-capacity well observations, we also present the results of neonicotinoid monitoring in shallow groundwater test wells and private potable wells conducted by the WDATCP from 2011 through 2017 in the same geographic area.

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Environmental detections of neonicotinoid contaminants in Wisconsin

Monitoring well detections (WDATCP). From 2011 through 2017, 28 of the 53 monitoring well sites managed and tested by the WDATCP tested positive for at least one neonicotinoid, with five wells testing positive for two neonicotinoids, and 14 wells testing positive for IMD, CLO, and TMX during this seven-year period. Of the 527 total samples collected from monitoring wells, 150 (28%) tested positive for TMX, 162 (31%) tested positive for IMD, and 194 (37%) testing positive for CLO. Mean TMX detection was 0.90 µg/L, with a maximum detection of 3.89 µg/L recorded in Adams Co. in 2015. Mean IMD detection was 0.61 µg/L, with a maximum of 4.54 µg/L recorded in Waushara Co. in 2014. Mean CLO detection was 0.503 µg/L, with a maximum of 2.30 µg/L recorded in Dane Co. in 2017. In 2016 and 2017, WDATCP also tested all monitoring well samples for the three less common neonicotinoids acetamiprid, dinotefuran, and thiacloprid. No monitoring well samples were positive for these three compounds at concentrations above the detection limit of 0.05 µg/L.

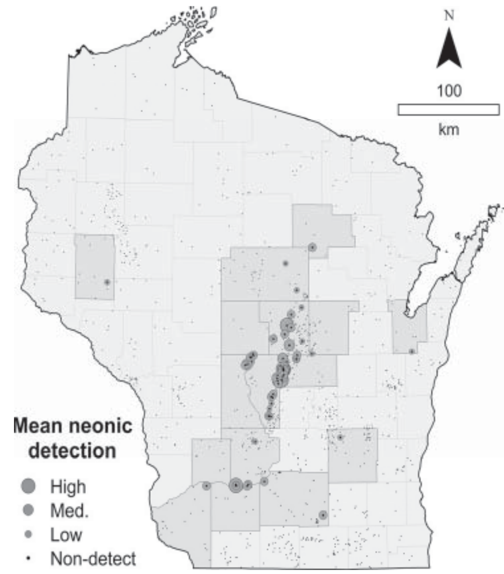

Figure 1. Positive neonicotinoid detections in shallow groundwater monitoring wells (data courtesy WDATCP).

Private potable well detections (WDATCP). Neonicotinoid compounds were detected with significantly less frequency among private potable well samples as these private wells are distributed throughout the state, whereas monitoring wells have been specifically established to monitor agricultural chemical intrusion into aquifers in areas where past contamination has been detected or where the risk of such contamination was considered elevated. During the 2011-2017 period, WDATCP collected and tested 1313 samples from 1120 individual private potable wells; 51 wells tested positive for at least one neonicotinoid compound, with 27 wells positive for one, 13 wells positive for two, and 11 wells positive for all three major neonicotinoids. TMX was detected in 59 samples (4%), with a mean of 0.52 µg/L and a maximum of 1.43 µg/L, recorded in Sauk Co. in 2011. IMD was detected in 40 samples (3%), with a mean of 0.47 µg/L and a maximum of 1.59 µg/L recorded in Waushara Co. in 2013. CLO was detected in 37 samples (3%), with a mean detection of 0.49 µg/L and a maximum of 3.88 µg/L recorded in Waushara Co. in 2013. All samples collected from private potable wells in 2016 and 2017 were also tested for the less common neonicotinoids acetamiprid, dinotefuran, and thiacloprid. One sample, from Juneau Co. in 2017, tested positive for dinotefuran at 0.15 µg/L.

High-capacity irrigation well detections (Groves Lab). The frequency of neonicotinoid detections in shallow groundwater specifically in the Central Sands and LWRV agroecosystems suggested that further study of this area was warranted. A significant fraction of irrigated potato and processing vegetable production in Wisconsin occurs in the Central Sands and LWRV and neonicotinoid insecticides are frequently employed as crop protectants by local growers. In addition, the hydrology of these regions is characterized by sandy, fast-draining soils, and shallow, unconfined aquifers that have been identified as at an elevated risk of contamination according to the Wisconsin Groundwater Contamination Model. To assess the extent of contamination we perform a structured, multi-year study of neonicotinoid contamination in high-capacity irrigation wells distributed throughout the Central Sands and Lower Wisconsin River Valley agroecosystems in Wisconsin. Irrigation wells provide both a broad spatial sampling scale (landscape to state), can be sampled repeatedly during growing seasons, and draw groundwater from deeper than the static test wells sampled by WDATCP, potentially revealing the extent to which contaminants have permeated the underlying aquifers. Results of these investigations are summarized in the table below.

Table 1. Thiamethoxam detections in high-capacity irrigation well water, 2013-2015.

Year	Timing	Months	High-capacity wells			Samples			TMX Detections (ppb)			
			n	Positive	% Pos.	n	Pos.*	% Pos.	Max	Mean	±	SD
2013	Late	Aug/Sep	48	39	81%	48	39	81%	1.56	0.28	±	0.28
2014	Mid	Jun/Jul	53	34	64%	53	25	47%	1.06	0.25	±	0.26
	Late	Aug/Sep	26	19	73%	26	19	73%	1.21	0.28	±	0.29
		Year Total	53	35	66%	79	53	67%	1.21	0.26	±	0.27
2015	Early	May	40	27	68%	55	34	62%	0.89	0.32	±	0.27
	Mid	Jun/Jul	52	35	67%	83	54	65%	1.69	0.32	±	0.38
	Late	Aug-Oct	40	25	63%	52	33	63%	0.77	0.21	±	0.17
		Year Total	56	40	71%	190	121	64%	1.69	0.29	±	0.30
		Grand total	**91**	**71**	**78%**	**317**	**213**	**67%**	**1.69**	**0.28**	**±**	**0.29**

Surface water detections. In Wisconsin's Central Sands, most surface water systems are largely groundwater-fed, so frequent detections of neonicotinoid contaminants in groundwater in these areas likely translates into detectable levels in surface water systems. In 2016, we began collecting surface water grab samples from a larger number of sites in the Central Sands including five river systems in the Wisconsin River watershed (three more than in our 2015 investigations), and three river systems in the Fox River watershed (one more than in 2015). These sites and watersheds in particular have been selected because they occur within a gradient of agricultural intensity. Percentage of land devoted to agriculture within each watershed varies from nearly 100% (Fourmile and Tenmile) to 40% (Big and Little Roche-a-Cri) within the Wisconsin River watershed, and from 37%-24% in the Fox River watershed. These two regions then provide a high-agriculture and low-agriculture condition for making comparisons in neonicotinoid detection levels. The sites in the Wisconsin River watershed were sampled four times (Dec 2016, Mar, Jun, Jul 2017), while the Fox River sites were samples once (Jul 2017). Water samples were assayed for the presence of both imidacloprid and thiamethoxam, two common neonicotinoids. Samples testing positive for > 0.05 µg/L of a compound were considered positive detections for that compound. See results summarized below in Table 2.

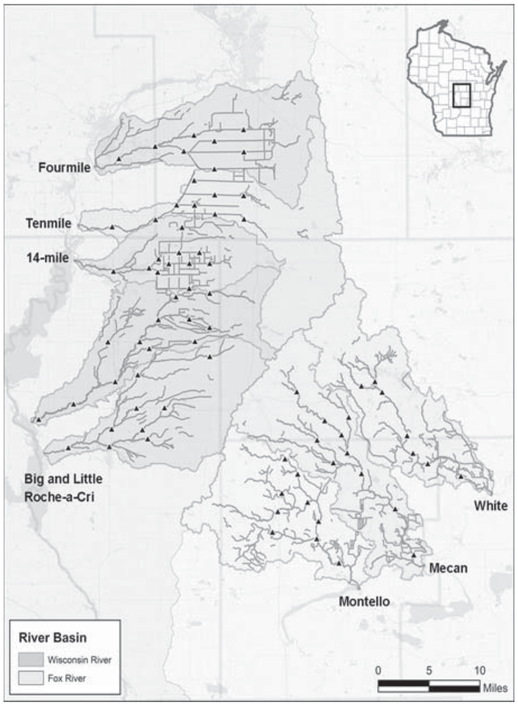

Figure 2. Surface water sample locations.

Table 2. Neonicotinoid detections in surface water, 2016-2017.

River system	Ag intensity	Imidacloprid (µg/L)					Thiamethoxam (µg/L)				
		n	dets	% det	mean	max	n	det	% det	mean	max
Wisconsin	39%	187	35	19%	0.029	0.213	187	95	51%	0.217	4.110
Fourmile	49%	32	0	0%	0.009	0.042	32	13	41%	0.054	0.337
Tenmile	50%	36	9	25%	0.036	0.213	36	20	56%	0.275	2.851
Fourteenmile	34%	35	9	26%	0.041	0.192	35	26	74%	0.528	4.110
Big Roche-a-Cri	29%	48	6	13%	0.025	0.135	48	31	65%	0.200	1.432
Little Roche-a-Cri	28%	36	11	31%	0.034	0.193	36	5	14%	0.022	0.216
Fox	23%	26	10	38%	0.047	0.081	26	4	15%	0.039	0.061
White	19%	7	3	43%	0.045	0.059	7	0	0%	0.036	0.047
Mecan	23%	10	5	50%	0.051	0.070	10	2	20%	0.038	0.055
Montello	27%	9	2	22%	0.045	0.081	9	2	22%	0.040	0.061

Conclusions

The frequency of thiamethoxam detections in both shallow and deep wells throughout the study region underscores the need for growers to be judicious in the use of these chemicals when operating in areas at elevated risk of groundwater contamination. In combination, frequent neonicotinoid detections in shallow field-edge monitoring wells, deeper high-capacity irrigation wells, and private potable wells highlight the potential risk of agricultural contaminants to appear throughout an entire aquifer underlying an intensive agroecosystem. Neonicotinoids are popular and effective insecticides whose usage will likely continue to expand, absent new regulatory action or the commercialization of next-generation insecticides. Their usage is not currently considered a human health hazard, but it is becoming increasingly clear that neonicotinoids are easily mobilized into the environment after field applications [6,17]. Evidence is also mounting that even very low environmental concentrations of neonicotinoids are harmful to aquatic and terrestrial invertebrates and damage local ecosystems [18]. Clearly, alternative cultural or chemical pest control strategies must be implemented to reduce neonicotinoid-related environmental impacts [19]. We hope that additional studies on groundwater contamination are pursued in other at-risk areas to expand our understanding of water quality issues related to intensive agriculture.

This summary draws heavily from Bradford, Huseth, and Groves, 2018 [20], available: https://doi.org/10.1371/journal.pone.0201753.

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NITROGEN FIXATION IN A LANDRACE OF MAIZE IS SUPPORTED BY A MUCILAGE-ASSOCIATED DIAZOTROPHIC MICROBIOTA

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Plants are associated with a complex microbiota that contributes to nutrient acquisition, plant growth, and plant defense. Nitrogen-fixing microbial associations are well characterized in legumes but are largely absent from cereals, including maize. We studied an indigenous landrace of maize grown in nitrogen depleted soils in the Sierra Mixe region of Oaxaca, Mexico. This landrace is characterized by extensive development of aerial roots that secrete a carbohydrate-rich mucilage. Analysis of the mucilage microbiota indicated that it was enriched in taxa for which many known species are diazotrophic; was enriched for homologs of genes encoding nitrogenase subunits; and harbored active nitrogenase activity as assessed by acetylene reduction and $^{15}N_2$ incorporation assays. Field experiments in Sierra MIxe using ^{15}N natural abundance or ^{15}N-enrichment assessments over 5 years indicated that atmospheric nitrogen fixation contributed 30 to 82% of the nitrogen nutrition of Sierra MIxe maize.

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NUTRIENT FORM AND FATE THROUGH MANURE PROCESSING

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

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

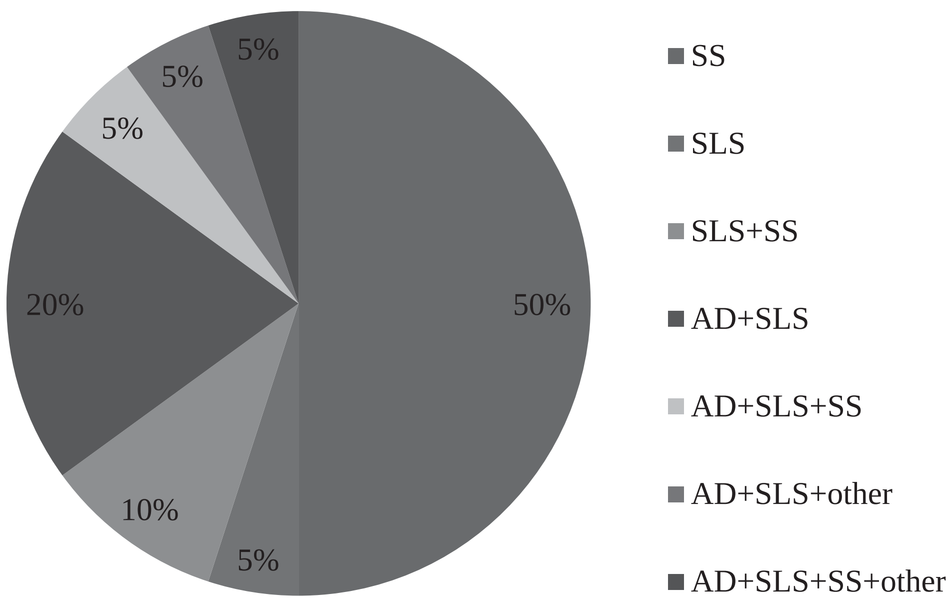

Figure 1. Processing technologies at permitted Wisconsin facilities surveyed (Aguirre-Villegas and Larson, 2017)

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

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HOW TO BUILD SOIL ORGANIC MATTER

Matt Ruark [1/]

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

Soil Management – Adding Carbon

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

Soil Management – Protecting Carbon

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

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

Soil Properties

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

Time and Expectations

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

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EFFECTS OF SEED TREATMENTS ON THE BIOLOGY OF SOYBEAN CYST NEMATODE

Gregory L. Tylka[1/]

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

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

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

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

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

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

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

Gregory L. Tylka[1/]

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

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

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

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

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

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

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

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

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

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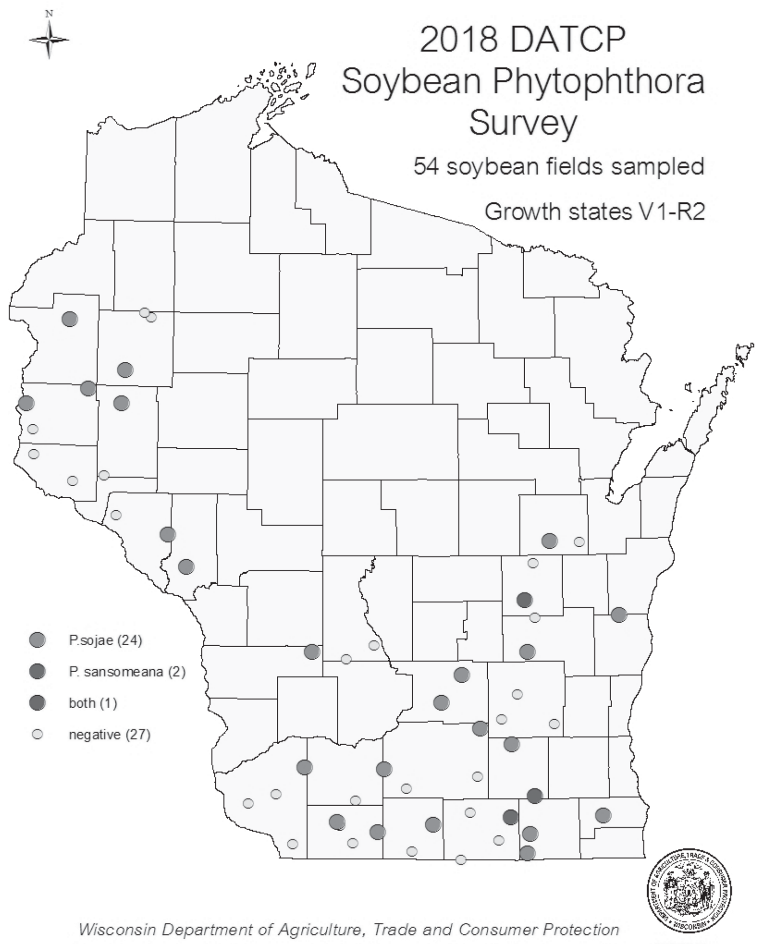
2018 WISCONSIN CROP DISEASE SURVEY

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

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

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

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



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

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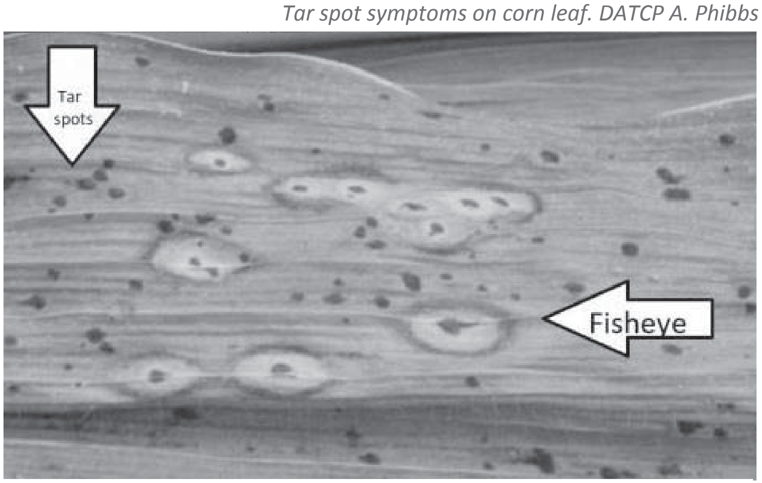
Tar spot of corn – Wisconsin and other Midwest states experienced a major outbreak of this disease in 2018. In Wisconsin, tar spot was first detected in Green and Iowa Counties in 2016. Appearing at low levels at the end of the season, tar spot was considered of no economic significance in 2016 and 2017.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

Tar spot symptoms on corn leaf. DATCP A. Phibbs



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

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

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

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

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

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

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

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

INTEGRATED APPROACHES TO WHITE MOLD MANAGEMENT

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

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

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

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

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

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

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

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WATERHEMP MANAGEMENT IN ESTABLISHED ALFALFA

Mark Renz[1/]

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

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

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

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

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

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

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

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KERNEL PROCESSING SCORE: DETERMINATION WITH SILAGESNAP[1]

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

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

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

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

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

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

FORAGE HARVEST LOGISTICS MODELING UPDATE

Brian D. Luck[1]

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

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

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KEYS TO ALFALFA ESTABLISHMENT IN HIGH YIELDING SILAGE CORN

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

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

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

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

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

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

THE ANATOMY OF GRAIN DUST EXPLOSION AND HOW TO AVOID IT

Bruce McLelland [1/]

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

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UNDERSTANDING THE GROWTH STAGES FOR CORN, SOYBEAN, AND WHEAT

Lindsay Chamberlain [1/]

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

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

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WISCONSIN POTATO AND VEGETABLE WEED MANAGEMENT UPDATE

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

Potato and vegetable weed management in the 2018 season was challenged yet again by variable and extreme weather events, the spread of new and often herbicide-resistant weeds and regulatory headwinds. Despite these hurdles, the future looks relatively bright if we're willing to take an innovate and integrated approach to weed management.

Extreme and variable weather events not only made it challenging to apply weed management measures but also increased injury risk. Early-season heavy rains made it difficult in many areas to time pre-emergent herbicides, which put a lot of pressure on the limited post-emergent tools for the majority of season-long weed control. The rapid switch in temperatures from a cool season start to blazing-hot during crop emergence increased the risk for injury from herbicides. For example, soil temperatures Memorial Day weekend were well over 100 F in the Central Sands. Weather challenges at the end of the season remain fresh in our memory, with many potatoes, carrots and other long-season crops suffering frost damage in ground frozen before they could be harvested. Such potato fields should be carefully scouted for volunteers early in the 2019 season.

At a national level, dicamba remains in the news. The initial registrations of three new dicamba products that could be used over-the-top of resistant soybean and cotton were scheduled to expire near the end of 2018. With many concerns over alleged off-target dicamba movement noted again across the country during the 2018 growing season, new 2-year registrations were recently announced by the US EPA that include additional restrictions beyond those introduced last year. However, the details of these new restrictions and implications for dicamba use remain ambiguous as commercial labels are pending at the time of this writing.

Also on the regulatory front, the herbicides linuron and diquat remain in the US EPA pesticide registration review, a process that occurs with all pesticides at least every 15 years. At this time, EPA's registration review schedule now forecasts an interim decision for both herbicides by the end of June 2019.

Nationally, the interest in dicamba is primarily to overcome widespread weeds that have become resistant to glyphosate herbicide. Even worse, this year the first case of resistance to six herbicide sites of action in a single plant was documented in a Missouri waterhemp population. In Wisconsin, we were relatively immune to the widespread herbicide resistance observed among weeds in states to the south of us, but that's changed quickly and is no longer true. UW-Madison agronomy colleagues have tracked the spread of waterhemp in the state and have now found this troublesome weed in 61 counties. In fact, the 11 counties where it hasn't yet been documented are in the farthest northern tier of the state where agriculture is less common and therefore less scouted for such pests. In 2018, there were 28 counties with confirmed glyphosate-resistant waterhemp, up from just 12 counties in 2015.

With these challenges in mind our research program in this area focuses on integration and innovation. Our research portfolio has included about two dozen specialty crops in the past few years such that we can provide solutions throughout the crop rotation and state. Despite the lack

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of new herbicide active ingredients in agriculture in general, we continue to have success "recycling" products developed for major agronomic crops such as corn and soybean for registration in specialty crops. For example, in potato we continue to work four potential herbicide active ingredients toward registration, with two new products in the final stretch with new commercial labels likely in the very near future. Few new herbicides are in development for any crop, so it's time to really think outside the box for new yet practical solutions. In this area, we're working with natural plant growth regulators to make the crop emerge faster and form a canopy sooner, enhancing competition with weeds. In crops like carrot, we've had early success when combining these growth regulators with competitive varieties and optimized planting timing and spacings, with yields greater than the conventional system and reduced reliance on herbicides. We're also interested in how these natural plant growth regulators affect weeds, both in germination and seed production.

In a broader sense, our program continues to develop other programs at the request of the agricultural community, such as the Water Stewards Program, where we now turn our focus from water quantity to quality. This year, we're also putting together a Specialty Crop Task Force to work with growers, processors and others to identify potential new agricultural crops and resulting products that could add value in a time when most commodities are challenged by low prices and increasing production costs. We look forward to continued potato and vegetable community leadership and involvement in these and other programs designed to benefit our diverse Wisconsin agriculture.

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

VARIABLE RATE IRRIGATION FOR VEGETABLE PRODUCTION

Yi Wang [1]

Water is an invaluable resource for the Wisconsin vegetable industry. In recent years, agricultural irrigation has been linked to reduced ground and surface water levels in the Central Sands region, where the majority of the Wisconsin vegetable production is located. Therefore, new technologies and strategies that can improve the irrigation efficiency of vegetable cropping systems have become a top priority for the industry. About 99% of Wisconsin vegetable growers are using center pivot irrigation systems, and Variable Rate Irrigation (VRI) has been adopted by some pioneers in recent years.

The VRI technology applies water at variable rates rather than one uniform rate along the length of the center pivot. There are two steps to apply VRI: firstly, based on electrical conductivity (EC) or elevation mapping, the field is divided into different management zones; secondly, the system applies specific amount of water on different management zones by controlling the moving speed of the pivot or turning on and off individual nozzles. VRI can apply water at differing rates to different crops or cultivars, varying soil types, high runoff areas or low areas prone to getting wet and saturated, and environmentally sensitive areas within the field. The overarching goal of VRI is to avoid over- and under-irrigation so no water is wasted and no water stress occurs, while crop yield and quality are maintained or increased. Currently the main hurdle of wide adoption of VRI is the upfront cost, ranging between $5,000 and $50,000 per pivot, and the potential of VRI to improve farm water conservation as well as profitability.

In 2018, our group evaluated production of potatoes or green beans under VRI on three commercial fields. Each field had 10 to 20 feet elevation difference between the highest (driest) and lowest (wettest) areas. Field 1 grew potatoes and had nozzle control VRI; field 2 also grew potatoes and had speed control VRI; field 3 grew green beans, had nozzle control VRI but was irrigated with flat rate of water all through the season. Our data showed that:

- On field 1: About 0.2 million gallons of water per acre was saved by VRI, and there was a significant improvement of potato yield and quality in the driest area/average area compared to the wettest area;

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- On field 2: About 0.15 million gallons of water per acre was saved by VRI. There was no significant difference of potato yield over the field, but those in the driest area and the average area showed better quality than those from the wettest area;

- On field 3: No green bean yield difference was observed between the average area and the wettest area. Yield in the driest area was 27% lower ($p<0.05$) than yield in the average area, and 28% lower ($p<0.05$) than the wettest area.

So far our data have suggested that:

- A big benefit of using VRI is to improve vegetable crop yield, quality, therefore to improve the profitability in the high runoff (or the driest) area of a field, which is more vulnerable to under-irrigation;

- VRI can save irrigation water in the low area of a field that tends to be wet or saturated. However even under VRI, managing yield and quality in the low area is still challenging, since crops tend to have more rotting and defect issues.

FUNGICIDES AS INADVERTENT DRIVERS OF INSECTICIDE RESISTANCE

Justin Clements and Russell Groves [1/]

Abstract

The Colorado potato beetle (CPB), *Leptinotarsa decemlineata* (Say), is an agricultural pest of solanaceous crops which has developed insecticide resistance at an alarming rate. Up to this point, little consideration has been given to unintended, or inadvertent effects that non-insecticide xenobiotics may have on insecticide susceptibility in *L. decemlineata*. Fungicides, such as chlorothalonil and boscalid, are often used to control fungal pathogens in potato fields and are applied at regular intervals when *L. decemlineata* populations are present in the crop. In order to determine whether fungicide use may be associated with elevated levels of insecticide resistance in *L. decemlineata*, we examined phenotypic responses in *L. decemlineata* to the fungicides chlorothalonil and boscalid. Using enzymatic and transcript abundance investigations, we also examined modes of molecular detoxification in response to both insecticide (imidacloprid) and fungicide (boscalid and chlorothalonil) application to more specifically determine if fungicides and insecticides induce similar metabolic detoxification mechanisms. Both chlorothalonil and boscalid exposure induced a phenotypic, enzymatic and transcript response in *L. decemlineata* which correlates with known mechanisms of insecticide resistance [Clements, 2018].

Objectives

1) Determine whether field relevant rates of fungicides can have a selection pressure on Colorado potato beetles.
2) Characterize the genetic mechanisms that are activated in response to both fungicide and insecticide exposure and determine whether fungicides can activate similar detoxification mechanisms as insecticides.
3) Determine whether fungicide and insecticide susceptibility vary between different geographic populations of *L. decemlineata* and whether genes which are up-regulated after fungicide exposure in imidacloprid susceptible populations are constitutively up-regulated in either population.

Background

The Colorado potato beetle (CPB), *Leptinotarsa decemlineata* (Say), is a key agricultural pest causing significant crop loss and direct damage to commercial potatoes (*Solanum tuberosum*), tomatoes (*S. lypcopersicum*), eggplants (*S. melongena*) and peppers (*S. annuum*) [Hare 1990]. The global impact of *L. decemlineata* direct damage to crops is far ranging,

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and these beetles have significant pest status throughout the world, inclusive of over 16 million km2 [Alyokhin, 2008; Hare, 1990]. According to the United Nations Food and Agricultural Organization, the United States (US) produced 19.8 million tons of potatoes in 2013, and it is the leading vegetable crop in the country [FAOSTAT, 2014]. The impact of *L. decemlineata* on individual state agricultural markets is also significant, especially in Wisconsin, where potato production accounts for more than $310 M annually [Kashian, 2014]. To keep this vital crop safe from these pests, we estimate farmers in Wisconsin annually expend $10 M for pesticide inputs (based upon producer surveys) [Huseth, 2014]. The history of insecticidal inputs for control of *L. decemlineata* is a story retold in many potato production areas of the country, where many classes of insecticides have been effective for short periods of time before the beetles become resistant. Recent estimates suggest that populations of beetles have now become resistant to more than 52 insecticides [Alyokhin, 2008] over most of the potato production regions of the US, with the notable exception of far western production areas (Idaho, Washington, and Oregon) where susceptibility remains elevated. In 1995, the registration and introduction of a new insecticide class (Group 4A, neonicotinoid insecticides) resulted in the use of active ingredients which include, imidacloprid, thiamethoxam, clothianadin, and dinotefuran [Alyokhin, 2008; IRAC, 2016]. Since their initial introduction in the mid-1990s, *L. decemlineata* populations have steadily developed resistance to this class, but it remains the principal insecticidal tool used for potato protection [Alyokhin, 2008; Clements, 2016; Huseth, 2013; Mota-Sanchez, 2006]. Multiple studies have attempted to uncover the mechanisms by which this insect rapidly develops resistance [Alyokhin, 2006; Clements, 2016; Mota-Sanchez 2006], but no study to date has fully elucidated the answer.

In addition to heavy and repeated insecticide application, many other environmental factors may lead to, or assist in, the development of insecticide resistance. One notable factor may be cross-resistance between insecticides and fungicides that facilitates rapid evolutionary change. Cross-resistance refers to a situation whereby an insect develops tolerance to a usually toxic, insecticidal substance as a result of exposure to a different, sub-lethal substance that may be less toxic. This can be the product of nonspecific enzymes which attack functional groups rather than the specific molecules [Yu, 2015]. While cross-resistance has historically been examined between multiple insecticides [Alyokhin, 2006; Mota-Sanchez, 2006], few studies have explored the potential cross-resistance between insecticides and fungicides, which are frequently co-applied to potato crops. A comparison between fungicide and insecticide application in different geographic regions (USDA National Agricultural Statistics Service (NASS)) [USDA, 2016] has shown that in Eastern (ME) and Midwestern (MI, WI, MN, and ND) potato production regions, it is common to have 5 to 7 foliar applications of fungicides in a single season, while in the Northwestern region (Washington, Idaho, and Colorado), far fewer foliar applications are required. During seasons with high disease potential, Eastern and Midwestern crops receive 10 to 12 applications of fungicides [Guenthner, 1999; Stevens, 1994]. While there is a clear trend in increased applications of fungicides in Midwest and Eastern regions, the overall amount of neonicotinoid insecticide applications remains relatively constant across the US. At different times during the growing season, measured levels of resistance within populations of *L. decemlineata* varies widely. More specifically, past research in both Michigan [Szendrei, 2012] and Wisconsin [Clements, 2016] has revealed markedly higher levels of resistance in the 2nd generation of *L. decemlineata* (e.g., July to September) when compared to the 1st generation present during May and June. Mancozeb®, a dithiocarbamate, is regularly used as a broad-spectrum protectant for control of the late blight pathogen

Phytophthora infestans (deBary) in potato fields, with applications beginning around the first week of July and continuing throughout the entire growing season. We further hypothesize that the marked increase in insecticide resistance observed in 2nd generation *L. decemlineata* may be partially explained by frequent reapplication of fungicides during this specific portion of the growing season.

We hypothesize that cross-resistance in beetles induce a detoxification response to one chemical pressure (fungicide) that could promote development of more rapid resistance to another chemical stressor (insecticide). If such cross-resistance does occur between select fungicides and insecticides in potato crop culture, the genes activated could lead to considerable insecticide resistance in geographic areas where disease pressure is consistently elevated compared to arid regions where disease pressure is lower, and measured levels of insecticide resistance concomitantly remains low.

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COMPONENTS OF A VARIABLE-RATE NITROGEN RECOMMENDATION

Brian Arnall [1/]

What follows is a summary of an article published in American Society of Agronomy's Crops and Soils magazine. For the full article visit https://dl.sciencesocieties.org/publications/cns/articles/49/6/24.

Variable-rate nitrogen management (VRN) is a fairly hot topic right now. The outcome of VRN promises improved efficiencies, economics, yields, and environmental sustainability. As the scientific community learns more about the crop's response to fertilizer nitrogen and the soil's ability to provide nitrogen, the complexity of providing VRN recommendations, which both maximize profitability and minimize environmental risk, becomes more evident.

The components of nitrogen fertilizer recommendations are the same whether it is for a field flat rate or a variable-rate map. The basis for all N recommendations can be traced back to the Stanford equation (Stanford, 1973). At first glance, the Stanford equation is very basic and fairly elegant with only three variables in the equation.

$$N_{Fert} = (N_{Crop} - N_{Soil}) / e_{\mathrm{fert}}$$

Historically, this was accomplished on a field level through yield goal estimates and soil test nitrate values. The generalized conversions such as 1.2 lb N/bu of corn and 2.0 lb N/bu of winter wheat took account for N_{Crop} and e_{fert} to simplify the process.

N_{Crop}

The basis for N_{Crop} is grain yield × grain N concentration. As grain N is fairly consistent, the goal of VRN methods is to identify grain yield. This is achieved through yield monitor data, remote sensing and crop models.

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N_{Soil}

The N provided by, or in some cases removed by, the soil is dynamic and often weather dependent. Kindred et al. (2014) documented the amount of N supplied by the soil varied spatially by 107, 67, and 54 lb/ac across three studies. Much of the soil N concentration is controlled by organic matter (OM). For every 1% OM in the top 6 inches of the soil profile, there is approximately 1,000 lb N/ac.

e_{fert}

Historically, the efficiency at which N fertilizer is utilized was integrated into N recommendations and not provided as an input option, e.g., the general conversion factor for corn of 1.2 lb N/bu. Nitrogen concentration in corn grain ranges from 1.23 to 1.46% with an average of 1.31% (Heckman et al., 2003) or 0.73 lb N/bu. Therefore, the 1.2-lb value is assuming a 60% fertilizer use efficiency. More recently, recommendations have been to incorporate application method or timing factors in attempt to account for efficiencies.

Summary

While a VRN strategy that works across all regions, landscapes, and cropping systems has yet to be developed, the process of nitrogen management has greatly improved and is evolving almost daily. Those methods that are capable of determining the three inputs of the Stanford equation while incorporating regional specificity will capture the greatest level of accuracy and precision. Ferguson et al. (2002) suggested that improved recommendation algorithms may often need to be combined with methods (such as remote sensing) to detect crop N status at early, critical growth stages followed by carefully timed, spatially adjusted supplemental fertilization to achieve optimum N use efficiency. As information and data are gathered and incorporated and data-processing systems improve in both capacity and speed, the likelihood of significantly increasing nitrogen use efficiency for the benefit of the society and industry improves. The goal of all practitioners is to improve upon the efficiencies and economics of the system, and this should be kept in mind as new techniques and methods are evaluated. This improvement can be as small as a few percentages

NUE AND POTENTIAL ENVIRONMENTAL OUTCOMES ASSOCIATED WITH N APPLICATION TIMING FOR CORN

Carrie A.M. Laboski [1/]

Interest in improving nitrogen (N) use efficiency of corn production to increase farm profitability and reduce the deleterious effects of N on water quality has resulted in a greater focus on N application timing. A Midwestern study conducted in Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, North Dakota, and Wisconsin from 2014 to 2016 was designed to evaluate the profitability, potential N loss, and N use efficiency associated with at plant and split N application timing. In each year, two sites were selected in each state representing a high and medium/low productivity soil. Missouri had three sites in 2016. Selected sites had no manure history in at least the three previous growing seasons. The previous crop was soybean at 43 sites, corn at 5 sites, and sunflower at 1 site. The tillage system was either reduced tillage or no-till. All sites followed a standardized research protocol with regard to N treatments as well as soil and plant sampling. Nitrogen was applied at either planting or in a split application (40 lb N/a at plant plus sidedress), with N applications ranging from 0 to 280 lb N/a in 40 lb N/a increments. The economic optimum N rate (EONR) was calculated for each N application timing at each site.

At the EONR, 18 lb/a more N remained in the three-foot soil profile after corn harvest with split applications (55 lb N/a) compared to at plant (37 lb N/a); however, there was no difference in N uptake in the above-ground biomass at physiological maturity. These data suggest that some N will always be lost when producing corn; it's just a matter of when it will be lost – early or late in the season. When N applications were no more than 25 lb/a over the EONR, the amount of N remaining in the soil after harvest was similar to when N was under applied by 50 lb N/a or more. These data suggest that profitable N application rates do not necessarily lead to greater potential for N loss to the environment. We found split applications tended to be more profitable on sandy soils and more poorly drained soils in years with excess precipitation. On poorly drained, but tiled soils, there was a greater return on investment (ROI) when N was applied at planting. In other situations, split applications did not always have a greater ROI.

For each site and N application timing, N use efficiency (NUE) was calculated at a given N rate as the yield increase over the zero N plot divided by the N application rate. NUE was calculated in this manner to take into consideration the yield obtained

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from N supplied by the soil. At the EONR, NUE was highly variable, ranging from as little as 0.27 bu/a per pound of N to as much as 0.93 bu/a per pound of N. NUEs under as 0.27 bu/a per pound of N were typically, but not exclusively, associated with sites that were non- or minimally responsive to N (EONRs from 0 to 40 lb N/a). NUEs greater than 0.93 bu/a per lb of N were always associated with under application of N relative to the most profitable rate for a site and N application timing; while NUEs under 0.93 bu/a per lb of N were associated with both very large under and over application of N (more than 100 lb N/a over or under the EONR). These data suggest that NUE is not a suitable measure for determining the adequacy of an N rate with respect to profitability or potential N loss.

HERBICIDE APPLICATIONS: FINDING A BALANCE
BETWEEN DRIFT CONTROL AND EFFICACY

Thomas R. Butts[1]

The effectiveness of a herbicide application relies on two factors, (i) maximizing the biological effect, and (ii) minimizing environmental contamination through off-target spray movement. These two factors are often in competition with one another, like being on opposite sides of a seesaw. As a result, herbicide applications have become more challenging and reductions in weed control have been observed due to the current emphasis on reducing spray drift through more restrictive herbicide labels and increasing spray droplet size.

The identification of optimum droplet sizes (i.e., maintain a high level of weed control while simultaneously mitigating spray particle drift) would assist applicators with more effectively applying herbicides. To accomplish this goal, field research using pulse-width modulation (PWM) sprayers was conducted across six site-years in Mississippi, Nebraska, and North Dakota. The objective was to evaluate the influence of droplet size (150 µm to 900 µm) and carrier volume [47 L ha^{-1} (5 GPA), 94 L ha^{-1} (10 GPA), 140 L ha^{-1} (15 GPA), and 187 L ha^{-1} (20 GPA)] on the efficacy of several commonly used herbicides. Herbicides evaluated included glufosinate (Liberty®), dicamba (Clarity®), 2,4-D choline plus glyphosate pre-mixture (Enlist Duo®), dicamba plus glyphosate tank-mixture (Clarity® plus Roundup WeatherMax®), lactofen (Cobra®), and acifluorfen (Ultra Blazer®). Applications were made when weeds were ≥15 cm (≥6 in) and weed species evaluated included common lambsquarters (*Chenopodium album*), horseweed (*Erigeron canadensis*), kochia (*Bassia scoparia*), and Palmer amaranth (*Amaranthus palmeri*). Models were established to predict a droplet size which maximized weed control, and a droplet size which maintained 90% of the maximum weed control, but would also reduce particle drift.

Liberty®:

Liberty® was applied at 0.45 kg a.i. ha^{-1} (22 fl. oz. per acre) in 5 and 20 GPA. From this research, a 310 µm (Medium) droplet size across carrier volumes is recommended for Liberty® applications across pooled site-years; however, if particle drift concerns exist, Liberty® droplet size can be increased to 605 µm (Extremely Coarse) and 90% of the maximum weed control can still be achieved. Generally, across droplet sizes, 5 GPA out-performed 20 GPA to maximize weed control. This is likely due to the fact that no water-conditioning adjuvants such as AMS were used, and more concentrated droplets overcame hard water antagonism better than less concentrated droplets. If no water-conditioning adjuvants are used in conjunction with Liberty® herbicide, a lower carrier volume should be used, but applicators should keep in mind that greater weed control is often observed with the combination of water-conditioning adjuvants and increased carrier volume.

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Clarity®:

Clarity® was applied at 0.28 kg a.e. ha^{-1} (8 fl. oz. per acre) in 5 and 20 GPA. A 900 µm (Ultra Coarse) droplet size with a 20 GPA carrier volume is recommended for dicamba applications because this combination provided at least 90% of the maximum weed control with the least particle drift potential across pooled site-years.

Enlist Duo®:

Enlist Duo® was applied at 0.79 kg ae ha^{-1} 2,4-D choline plus 0.84 kg ae ha^{-1} glyphosate (3.5 pints per acre formulated product) with a carrier volume of 10 GPA. Across Mississippi and North Dakota sites, a 900 µm (Ultra Coarse) droplet size was recommended, while across Nebraska sites, a droplet size of 565 to 690 µm (Extremely Coarse) was typically needed to maintain 90% of the maximum weed control. These differences in optimum droplet sizes were likely due to differences in weed species, specifically their leaf structure. In Mississippi and North Dakota, the weed species evaluated were Palmer amaranth and common lambsquarters, respectively, which have rather flat, horizontal leaf surfaces. Conversely, in Nebraska, the primary weed species' evaluated were kochia and horseweed which have a much smaller, narrower leaf structure. Numerous other factors such as application weather conditions, geographic location, time of day, and herbicide resistance evolution, may have also played a significant role in final herbicidal efficacy.

Clarity® plus Roundup WeatherMax®:

Clarity® and Roundup WeatherMax® were applied at 0.28 kg ae ha^{-1} dicamba (8 fl. oz. per acre) plus 0.87 kg ae ha^{-1} glyphosate (22 fl. oz. per acre), respectively, with a carrier volume of 10 GPA. Across a broad geographic setting and diverse weed spectrum, tank-mixture applications of Clarity® and Roundup WeatherMax® should use a 620 µm (Extremely Coarse) droplet size when applying with a carrier volume of 10 GPA. Similar to Enlist Duo®, the tank-mixture of Roundup WeatherMax® plus Clarity® required a smaller than expected droplet size to maximize weed control; therefore, greater carrier volumes (above 10 GPA) should be considered to increase coverage and maintain weed control with larger droplet sizes.

Ultra Blazer®:

Ultra Blazer® was applied at 0.42 kg ai ha^{-1} (24 fl. oz. per acre) plus 1% v/v crop oil concentrate (COC) with a carrier volume of 15 GPA. Ultra Blazer® maximized weed control with a 300 µm (Medium) droplet. In fact, the 300 µm droplet size was the only treatment different from the nontreated control. This indicates Ultra Blazer® is very droplet size sensitive and requires a smaller droplet size to maximize weed control even with a carrier volume of 15 GPA.

Cobra®:

Cobra® was applied at 0.22 kg ai ha^{-1} (12.5 fl. oz. per acre) plus 1% v/v crop oil concentrate (COC) with a carrier volume of 15 GPA. Droplet size did not impact weed control from Cobra®, and across a range of droplet sizes, weeds were controlled better than with Ultra Blazer®. This research highlights that even within herbicide sites-of-action (PPO-Inhibitors), optimum droplet sizes can vary. For Cobra®, carrier volume affects weed control to a greater extent than droplet size; therefore, it is recommended to use at least 15 GPA with greater droplet sizes to maintain high levels of weed control while reducing drift potential.

Overall, droplet size impacts weed control differently across herbicides and carrier volumes. This data illustrates even with systemic herbicides, such as growth regulators, there is a critical droplet size and if the spray droplet size increases, weed control is reduced. Alternative drift reduction practices other than increasing spray droplet size must be identified and implemented to avoid reductions in weed control in the future. To optimize spray applications using droplet size, applications should be tailored for site-specific weed management approaches to more effectively account for variables such as herbicide, weed species, weather conditions, and geographic location. Additionally, it is always important to read and follow label instructions. In these studies, there were a few situations where the label restrictions were not followed for research purposes. It is recommended that applications ALWAYS meet label requirements.

For more information regarding optimum herbicide droplet sizes for weed control, please scan the QR codes below (Figures 1 and 2).

Figure 1. Spray droplet size and carrier volume effect on dicamba and glufosinate efficacy.

Pest Management Science article.

Figure 2. Precise spray droplet sizes for optimizing herbicide applications.

Univ. of Nebraska-Lincoln CropWatch article.

WISCONSIN WATERHEMP AND DICAMBA RESEARCH AND STAKEHOLDER SURVEYS

Rodrigo Werle [1/]

Waterhemp and giant ragweed, respectively, are currently ranked by stakeholders as the most troublesome weed species in corn and soybean production in Wisconsin (Zimbric et al., 2018; Werle and Oliveira, 2018). Due to widespread occurrence of resistance to glyphosate, PPO- and ALS-inhibitors in waterhemp populations across the state accompanied by the shortage of effective POST-emergence herbicide options in conventional and RR2Yield soybean systems, the use of effective PRE-emergence herbicide programs becomes imperative and the adoption of novel herbicide tolerance traits, such as Xtend (dicamba tolerance) or Liberty Link (glufosinate tolerance), appealing for providing additional effective POST-emergence weed control options.

In the fall of 2018, we invited Wisconsin stakeholders to submit waterhemp seed samples from their farms along with the last 5-year crop (e.g., rotation, tillage, manure application) and weed management program records. More than 80 populations were received and will be screened for herbicide resistance in the greenhouse in 2019. From a preliminary analysis of the 5-year management records we have learned that adoption of PRE-emergence herbicides in these farms was low (<30%) 5 years ago (2014) but increased over time (>60% in 2018). Thus, the presence of waterhemp has and will continue to lead to major changes in herbicide programs in these operations and beyond.

From our research evaluating waterhemp control with 29 different PRE-emergence herbicides conducted in 2018 at Lancaster Ag Research Station we were able to demonstrate that simply adding a PRE-emergence herbicide is not enough (Smith et al., 2018); an effective PRE-emergence herbicide program applied at the appropriate label rate is imperative for good early-season waterhemp control in soybeans. From this study we have learned that other than group 2 (ALS-inhibitors) sprayed alone, PRE-emergence herbicides from group 5, 14 and 15 applied at full label rates provided adequate reduction in waterhemp density at 25 days after treatment but a subsequent application POST-emergence would be necessary for complete control in most treatments. Pre-mixes (PRE-emergence herbicides with more than one active ingredient) containing adequate rates of individual active ingredients provided satisfactory waterhemp control.

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In terms of Xtend adoption in Wisconsin, from our recent survey we have learned that it was low in 2017 and 2018 (<25% of total acres represented in the survey); however, likely to increase substantially in 2019 (~50% of total acres represented in the survey; primarily due to challenges associated with waterhemp control POST in soybeans during the 2017 and 2018 growing seasons). Farmers adopting the Xtend technology in 2019 and beyond must be mindful and follow the label when spraying dicamba in soybeans. This season we conducted research trials investigating off-target dicamba movement under large-scale field conditions and in low-tunnels. According to results, proper application and environmental conditions are crucial to minimize off-target particle movement. Results from the low-tunnel trials indicate that tank-mix products containing ammonium salt can increase dicamba volatilization. In conclusion, weed management is becoming more complex and will continue to challenge farmers to modify their management strategies.

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PALMER AMARANTH: ANOTHER PIGWEED SPECIES TO CONSIDER

Aaron Hager [1/]

Background

Amaranthus species are among the most troublesome weed species in agronomic production systems because of their innate ability to cause crop yield loss and their propensity to develop resistance to various herbicide site-of-action families. Several *Amaranthus* species are regarded as weedy pests across the Great Plains region, including the monoecious (male and female flowers on the same plant) species redroot pigweed (*A. retroflexus*), smooth pigweed (*A. hybridus*), Powell amaranth (*A. powellii*), tumble pigweed (*A. albus*), prostrate pigweed (*A. blitoides*), and spiny amaranth (*A. spinosus*), and the dioecious (separate male and female plants) species common waterhemp (*A. rudis*) and Palmer amaranth (*A. palmeri*). Among these species, smooth pigweed, redroot pigweed, Powell amaranth, Palmer amaranth, and the waterhemps are most common in Illinois corn and soybean fields. Historically, Palmer amaranth's range was limited in Illinois but the species appears to be expanding its range in the state.

Palmer amaranth is perhaps the most "aggressive" *Amaranthus* species with respect to growth rate and competitive ability. The growth rate and competitive ability of this species exceed that of other *Amaranthus* species. Horak and Loughin (2000) conducted a two-year field experiment to compare several growth parameters of Palmer amaranth, waterhemp, and redroot pigweed. Their research demonstrated that Palmer amaranth had the highest values for plant volume, dry weight, and leaf area of all species, as well as the largest rate of height increase. Klingaman and Oliver (1994) reported soybean seed yield was reduced between 17 and 68 percent from Palmer amaranth interference at densities between 0.33 and 10 plants per meter of crop row. Yield losses in corn from Palmer amaranth interference also have been reported (Massinga et al., 2001).

Resistance to herbicides

Biotypes of Palmer amaranth from across the United States have developed resistance to herbicides from0 various herbicide families, including dinitroanilines, triazines, glyphosate, and HPPD-, PPO- and ALS inhibitors.

Identification of Palmer amaranth

Accurate identification of weedy *Amaranthus* species during early vegetative stages can difficult because many exhibit similar morphological characteristics (i.e., they look very much alike). Additional difficulty in *Amaranthus* species identification arises due to hybridization between certain dioecious and monoecious species. During the 1990s, waterhemp provided an excellent example of how difficult it can be to differentiate among the various *Amaranthus* species, especially when plants are small. The following descriptions are provided to aid the reader in the identification of Palmer amaranth. Refer to Table 1 for a generalized summary of identification characteristics for several *Amaranthus* species.

While many people tend to identify weeds based on "how the plant looks", more accurate identification can be achieved by examining parts of the flowers. Historically, taxonomic separation of *Amaranthus* species has been based on differences in floral characteristics, but new methods utilizing molecular biology techniques also are being employed. Instead of delving into molecular biology, the following discussion will be restricted to separating the *Amaranthus* species based on floral characteristics. Definitions of the terms that will be used in the discussion, beginning with the outer parts of a flower and working inward to the seed, follow.

Inflorescence - flowers collectively. While many people associate the term flower with the colorful plants growing around the home, this term herein refers to the reproductive structures of the plant. Male flowers produce pollen, while female flowers produce seed.

Bract - a modified leaf associated with flowers. A bract differs from foliage leaves in shape, color, size, texture, or some other feature.

Tepal - leaf-like scales that encircle the outer flower parts. Some people refer to these structures as *sepals* when describing *Amaranthus* species flowers. If the inflorescence of a mature pigweed plant is brushed against the palm of the hand, the tan-colored structures that fall into the hand are tepals.

Utricle - a membranous bladder-like sac enclosing an ovary or fruit (seed). The utricle is contained with the tepals, and the seed is enclosed by the utricle.

Seed - small, hard, black, and often glossy. Seeds give rise to the next generation of plants.

Identification of immature Palmer amaranth plants
The cotyledon leaves of Palmer amaranth are relatively long compared with other *Amaranthus* species (Figure 1). Similar to the other weedy *Amaranthus* species in Illinois, the true leaves (those produced after the cotyledon leaves) of Palmer amaranth have a small notch in the tip (Figure 2).

Figure 1. Cotyledons of Palmer amaranth.

Figure 2. Notch in leaf tip of Palmer amaranth.

The stems and leaves have no to very few hairs, which causes these plant parts to feel smooth to the touch. Leaves are alternate on the stem and are generally lance-shaped or egg-shaped and frequently with prominent white veins on the underside. As plants become older, they often assume a poinsettia-like appearance and occasionally have a V-shaped chevron on the leaves (Figure 3). Leaves are attached to the stem by petioles; petioles at the base of the stem usually are as long or longer than the leaf blade.

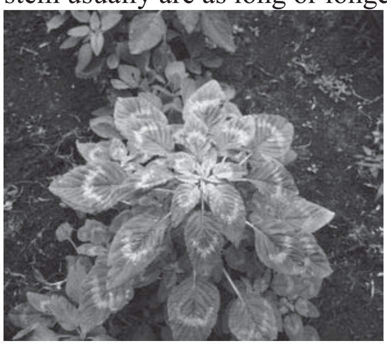

Figure 3. White chevron on the leaves of Palmer amaranth.

Identification of mature Palmer amaranth plants

Palmer amaranth plants are either male or female; male plants produce pollen while female plants produce seed. The terminal inflorescence of male and female plants (Figure 4) is generally unbranched and very long. Female Palmer amaranth plants have a long terminal inflorescence (10 to 24 inches) with flowers containing 5 spatulate-shaped tepals.

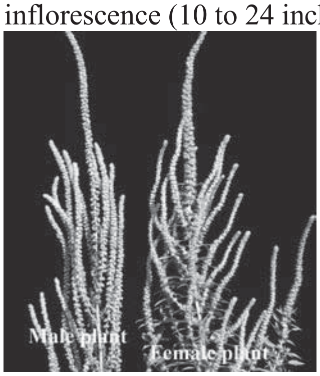

Figure 4. Male and female inflorescences of Palmer amaranth.

The tepals are about twice the length of the seed, and the seed capsule (utricle) breaks into 2 regular sections when fractured. Grabbing the inflorescence of a mature female Palmer amaranth plant with a bare hand is **not** recommended as the bracts are very stiff and sharp. The terminal inflorescence of male Palmer amaranth plants is much softer to the touch. Palmer amaranth is an aggressively growing plant that often reaches 6 to 8 feet in height (Figure 5).

Figure 5. Mature Palmer amaranth plants.

Management considerations

The ability of Palmer amaranth to aggressively compete with crop plants warrants careful attention to its integrated management in corn and soybean. The occurrence of herbicide-resistant biotypes of Palmer amaranth increases the difficulty in managing this species due to the loss of several previously effective herbicide options. Thus, weed control practitioners should not rely exclusively on this herbicide family to manage Palmer amaranth.

There are some several soil-applied and post-emergence herbicide programs that can provide good control of Palmer amaranth, but each type of application timing has some basic considerations that can influence the degree of success achieved. The most consistent management programs for corn and soybean involve an integrated approach that utilizes soil-applied herbicides, post-emergence herbicides, and mechanical cultivation.

Considerations with soil-applied programs

Numerous soil-applied herbicides possess good activity on Palmer amaranth and other small-seeded species. Time of application can have a significant impact on the successfulness of soil-applied herbicides for Palmer amaranth control. A common practice in no-till systems is to apply the herbicide several weeks prior to planting in order to receive sufficient precipitation to incorporate the herbicide. Keep in mind, however, that the earlier a herbicide is applied, the earlier within the growing season that the level of weed control begins to decline. Palmer amaranth, similar to waterhemp, is capable of emerging later into the growing season than many other summer annual weed species. Application of soil-residual herbicides closer to the time of corn or soybean planting may enhance Palmer amaranth control later into the growing season compared with applications made several weeks prior to planting.

Herbicide families that demonstrate control or suppression of Palmer amaranth include the triazines (atrazine, simizine, metribuzin), dinitroanilines (trifluralin, pendimethalin), chloroacetamides (metolachlor, acetochlor, dimethenamid, alachlor), and protox inhibitors (flumioxazin, sulfentrazone).

Considerations with post-emergence herbicides
There are several postemergence herbicides that are very effective on Palmer amaranth. The factors governing the effectiveness of postemergence herbicides are critically important when dealing with Palmer amaranth. Herbicide application rate and timing, spray additives and volumes all influence how well postemergence herbicides perform.

Often, producers like to wait as long as possible to apply postemergence herbicides, especially those herbicides that lack significant soil residual activity. Because Palmer amaranth can germinate and emerge over an extended period of time, there typically exists a wide range of plant sizes by the time postemergence herbicides are applied. This can present problems with spray interception by smaller plants under the protective canopy of larger plants. Adjustments in spray volume and pressure can help to overcome some of the problem with coverage. Spray volumes of 15 to 20 gallons per acre with application pressures of 40 to 60 pounds per square inch generally provide a very uniform coverage of the target vegetation.

Postemergence herbicides that demonstrate control or suppression of Palmer amaranth include growth regulators (dicamba, 2,4-D), diphenylethers (acifluorfen, lactofen, fomesafen), glufosinate, and glyphosate.

<u>Literature Cited</u>

Horak, M.J., and T.M. Loughin. 2000. Growth analysis of four *Amaranthus* species. Weed Sci. 48:347-355.

Klingaman, T.E., and L.R. Oliver. 1994. Palmer amaranth (*Amaranthus palmeri*) interference in soybeans (*Glycine max*). Weed Sci. 42:523-527.

Massinga, R.A., R.S. Currie, M.J. Horak, and J. Boyer Jr. 2001. Interference of Palmer amaranth in corn. Weed Sci. 49:202-208.

Table 1. Identification characteristics of several *Amaranthus* species common to Illinois.

Species	Hairs	Leaves	Flowers	Flowering Structures
Redroot	Small, fine	Rounded	Monoecious	Highly branched, compact
Smooth	Small, fine	Rounded	Monoecious	Highly branched, less compact than redroot
Powell amaranth	Small, fine	Tapered and slightly pinched at end	Monoecious	Branched, but less than redroot or smooth, 4 to 8 inches long
Spiny amaranth	None	"V" chevron, spines at nodes	Monoecious	Male flowers at top, female flowers in axils
Tumble	Small, fine	Egg-shaped, wavy edges, olive green color	Monoecious	No distinct flowering structure, flowers at nodes
Prostrate	Few to none	Spatulate	Monoecious	No distinct flowering structure, flowers at nodes
Palmer amaranth	Few to none	Poinsettia-like, "V" chevron	Dioecious	Non-branched, 1 to 2 feet long
Waterhemp	None	Lanceolate	Dioecious	At top of plant and tips of branches

THE INS AND OUTS OF PULSE-WIDTH MODULATION SPRAYERS

Thomas R. Butts[1]

Pesticide applications are complex processes with many variables potentially impacting the biological outcome of the application. Additionally, greater regulatory demands have increased the need for more precise application methods.

Pulse-width modulation (PWM) sprayers provide an opportunity to increase precision through variable rate flow control by pulsing electronically actuated solenoid valves at each nozzle. The solenoid valves are pulsed a designated amount of times per second (standard = 10). The percentage of time each valve is open (duty cycle) determines the flow rate.

Benefits of PWM sprayers include: (i) individual nozzle control, (ii) overlap and turn compensation to reduce herbicide overapplication, (iii) quick flow rate response times, (iv) minimal influence on droplet size, and (v) providing more application flexibility in terms of sprayer speed and maintaining proper output.

Although there are numerous potential benefits of the technology, little research had been previously conducted to characterize sprays and droplet dynamics from these systems, especially with current nozzle technologies. Therefore, multiple research projects were conducted to investigate the influence of PWM on droplet size, droplet velocity, nozzle tip pressure, and spray pattern. The research projects identified that to fully reap the benefits of PWM sprayers, some best use practices must be implemented.

1. **Air inclusion (AI) nozzles should not be used on pulsing systems.** AI nozzles (i.e. AIXR, AITTJ60, TDXL, ULD, etc.) cause pattern deformities, droplet size variation, and nozzle tip pressure fluctuations when pulsed. Additionally, spray solution can be forced out of the AI ports, negating their drift reduction benefits. AI nozzles simply do not provide the same consistency and precision in spray pattern and droplet size as non-air inclusion-type nozzles (i.e. XR, DR, 3D, Guardian, etc.).

2. **Operate PWM sprayers at or above a 40 percent duty cycle.** Lower duty cycles cause spray pattern and droplet size irregularities. Proper nozzle selection (specifically, orifice size) paired with appropriate sprayer speeds is critical to achieving this best use practice and optimizing a PWM sprayer application.

3. **Operate PWM sprayers at or above 40 PSI.** Solenoid valves contain an internal restriction that causes a pressure loss even when operated at a 100 percent duty cycle. As nozzle orifice size increases, the reduction in pressure across the solenoid valve increases. Nozzles with 04 orifice sizes result in a pressure loss of 2–3 PSI, but when a nozzle with 08 orifice size is equipped and operated, the pressure drop across the solenoid

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valve is approximately 10 to 12 PSI. This pressure loss can affect nozzle performance by reducing pressure at the nozzle below manufacturer's recommended minimum pressures, especially if operated with system pressures less than 40 PSI.

Through these practices, applicators can increase the efficiency of PWM pesticide applications and reduce potential environmental contamination. For example, when spraying a field border, applicators with a PWM system could reduce sprayer speed to more effectively manage drift potential and still maintain the proper application rate without changing nozzles. Site-specific management strategies could also be implemented as droplet size is relatively unaffected by PWM sprayers (no pressure-based changes required to maintain flow rates). Therefore, applicators could choose a nozzle and pressure combination to achieve a specific droplet size that would reduce drift potential while simultaneously maximizing pest control in their unique environment.

For more information regarding PWM sprayers and their operation, please scan the QR codes below (Figures 1, 2, and 3).

Figure 1. Pulse-width modulation (PWM) sprayers: What, why, and how?

G2302 Univ. of Nebraska-Lincoln Extension NebGuide.

Figure 2. Droplet size and nozzle tip pressure from a pulse-width modulation sprayer.

Biosystems Engineering article.

Scan me

Figure 3. How to better utilize pulse-width modulation sprayers.

Video – Univ. of Nebraska-Lincoln.

ECONOMIC DEVELOPMENT TOOLS TO SUPPORT BUSINESS

Brian Doudna [1/]

The State of Wisconsin, financial institutions and local communities have a variety of tools that can be used to assist with business needs, ranging from labor training to construction of a rail spur. This session will provide a summary of the commonly used tools and provide a guide on how to reach out to determine eligibility on a future project.

[1/] Wis. Economic Development Association.

AGRICULTURAL POLICY UPDATE

Paul D. Mitchell [1/]

This presentation will provide a first look at the major policy changes in the newly passed Farm Bill. The presentation will focus mostly on commodity support programs such as ARC, PLC and crop insurance, as well as conservation programs (CRP and EQIP). The goal will be to help farmers, crop consultants, and other agricultural professionals become aware of the available options under the new Farm Bill, what to expect in terms of income support, and recommendations of how to evaluate and use these options.

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INDUSTRIAL HEMP RESEARCH PILOT PROGRAM

Jennifer Heaton-Amrhein [1/]

- Wisconsin has a very broad industrial hemp law that encourages participation and innovation. No limits on the number of licenses or acreage provides great opportunities for farmers, citizens, and businesses of any size, in any location in Wisconsin, to participate in and grow a new industry.

- Looking back: Getting an emergency rule in place in 90 days was very challenging, and by necessity, very narrow in scope.

- Looking forward: DATCP has been gathering information over the past year about what works and what needs improvement for the permanent rule, which must be in place by July 1, 2020. The authorizing statute is very broad, so the permanent rule will likely clarify some areas and also cover more topics than the emergency rule does.

- In 2018, the industrial hemp research pilot program licensed 245 hemp growers and 99 hemp processors. 185 hemp growers and 82 hemp processors also had an annual registration.

- In 2018, about 1850 field acres and about 22.6 greenhouse acres were planted.

- In 2018, DATCP collected and analyzed 295 samples. All but 21 passed. Most of the failures were still below 1.0%.

- Law enforcement and local governments mostly sat on the sidelines in 2018 and watched this program unfold. Growing, processing, and retailing hemp in a highly responsible manner is key, because they can be the biggest allies or the largest roadblocks (i.e., ordinances, raids, etc.). Law enforcement and local governments are now paying attention.

- The 2018 Farm Bill redefines hemp, removes industrial hemp from the Schedule 1 controlled substances list by including it as an agricultural commodity, makes the national banking system available to hemp growers and processors, and allows for other benefits of a crop such as marketing, research and crop insurance.

[1/] Policy Analyst, AgChem Mgmt. & Plant Industry Bureaus/Div. of Agric. Resource Mgmt., Wis. Dept. of Agriculture, Trade and Consumer Protection.

- Wisconsin will need to amend our definition of hemp in statute and rule to match new federal law. This would make it clear that extracts and cannabinoids are both included in the definition of hemp and that the 0.3% also includes and applies to cannabinoids and other extracts. The Legislature may also consider other changes to the industrial hemp law.

- Under the Farm Bill, DATCP must write and submit an industrial hemp regulatory plan to USDA. Our current program covers most of the requirements to be submitted as part of the plan, therefore, it only will need some refinement or clarification of policy, not drastic changes.

- Hemp cannot be used in commercial animal feed currently because it is not an official, defined feed ingredient with the Association of American Feed Control Officials CO). The 2018 Farm Bill will have no effect on this.