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WinField
{For Exemplary Industry Professionalism}

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{For Leadership & Commitment to Educational Excellence}

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Dennis Frame, Retired from Discovery Farms
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2013 – 2014
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Lisa Chou
Thomas Larson
Jordan DeLong
Caleb Riedeman

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[1/] INTL FCStone.

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SOIL MANAGEMENT PRACTICES FOR REDUCING RISK

Francisco J. Arriaga [1/]

Farmers are faced with uncertainty and risk every growing season. Changes and differences in weather patterns are typically the main driver for this risk, but other factors such as commodity prices and pest pressure can also be contributing factors. Although every farm activity will have a certain inherent level of risk associated with it, some of this risk can be reduced and its impact lessened with certain management practices. This presentation will provide some recommendations to help lower risk for a crop production operation by looking at soil management, but these recommendations are not comprehensive by any means. It is advised to also pay close attention to agronomic, weed, insect, and other pest management guidelines to further improve risk management of a farming operation using an integrated approach.

The first step for managing soil to reduce production risks is to understand the soils you are working with. However, this can be a difficult task since soil can vary from one field to the next and even within a field. Homogenous soil and field conditions are simpler to manage than heterogeneous conditions. One of the largest factors affecting soil variability is slope. Position on a landscape can determine and affect to some degree the characteristics of a given soil profile. Exploring soil profiles in different positions on a slope typically reveals that there are zones of soil loss and accumulation (Fig. 1). Soil at a higher elevation has greater energy potential and thus is more prone to erosion, while areas with lower elevation are often areas where eroded soil accumulates. As soil erodes from higher elevation areas, subsoil layers are brought closer to the surface and often can be exposed.

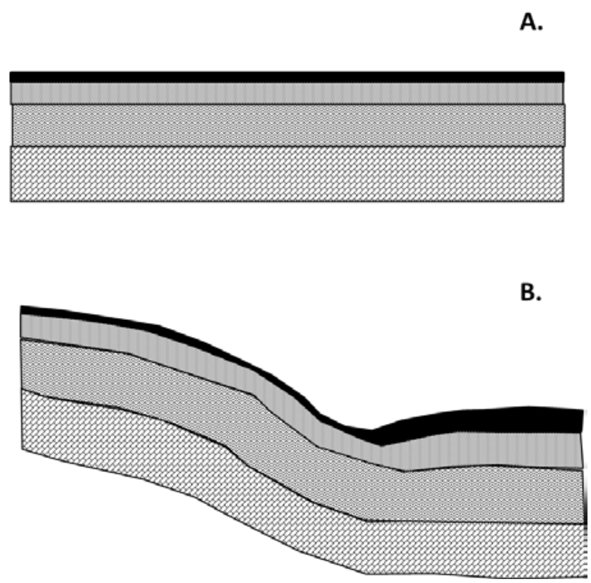

Figure 1. The soil profile of a field with relatively flat slope (A) typically is more uniform than the soil profile of a sloping landscape (B). Note that erosional processes can later the relative soil horizon thickness and depth to underlying soil layers, creating variability within a field.

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Overall, this process creates shallower soil conditions in upslope positions in the landscape and thicker soil layers downslope, but often eroded soil is transported into streams where they can cause siltation and contamination issues. An example of this problem is the hypoxic zone in the Gulf of Mexico due to nitrogen delivery from the Mississippi River Basin and sediment dredging required to keep this stream open to commercial navigation (Fig. 2).

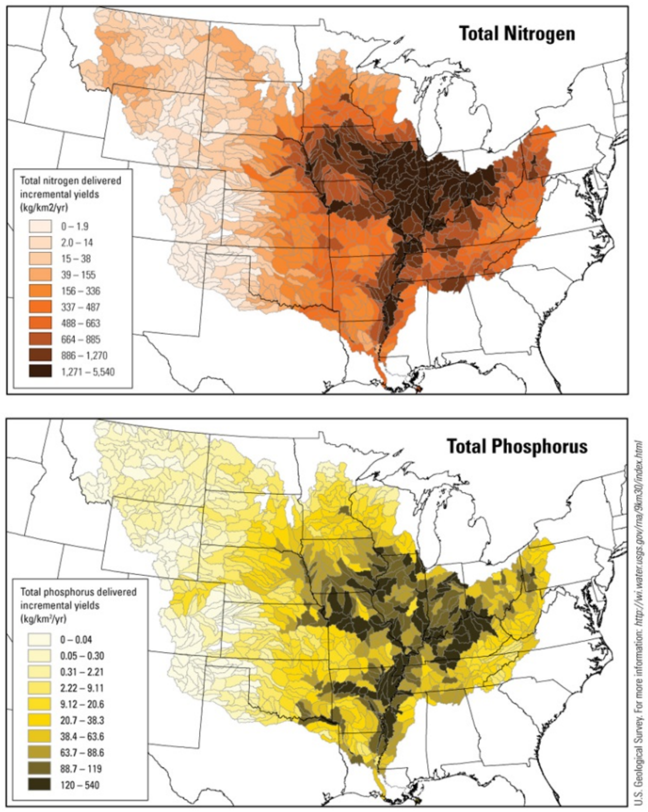

Figure 2. Nitrogen and phosphorus contribution from states within the Mississippi River Basin (Source: USGS; http://wi.water.usgs.gov/rna/9km30/). Nutrients lost from fields need to be replaced with fertilizer addition to maintain fertility levels.

As mentioned above, the erosional process can create areas with shallower soils with exposed subsoil layers and areas where this soil is deposited within a field. This process creates short- and long-term issues that increase the risk of a crop production operation. Changes in soil fertility and soil pH that can affect productivity are common in recently eroded areas. In this scenario, fertilizer and lime might be needed to replace lost nutrients and correct pH issues. Recent estimates for 2013 of the fertilizer replacement value for an average ton of soil lost due to erosion in Wisconsin are $8.80 per acre to replace nitrogen, phosphorus, and potassium.

Long-term problems are more difficult to correct, such as a decrease in the available rooting depth in the soil profile. Research conducted in South Dakota aimed to reduce the spatial variability caused by erosion on a landscape by moving topsoil from areas of accumulation to eroded areas (upper slope) as a remediation technique (Papiernik et al., 2013). Results from this 6-year study showed that replacing topsoil to eroded areas of a field improved overall soil chemical, physical, and microbiological properties with subsequent corn yield increases of between 20 to 60%. However, yields from areas within the field (i.e., toeslope) from which topsoil was removed decreased by 20 to 40%. These results highlight the importance of minimizing the degradation of soil given that remediation efforts can be tradeoff and costly.

The capacity of an eroded soil to store plant available water is diminished due to a reduction in rooting depth, loss of organic matter, and an exposure of subsoil soil layers that commonly have a larger clay content (Fig. 3; Arriaga and Lowery, 2003a). Results from a long-term study conducted in southwestern Wisconsin demonstrated that soil water storage increased as erosion severity increased but corn grain yields generally decreased, highlighting a reduction in plant available water (Fig. 4). An increase of 2.5 to 5% in rainfall amount during the growing season was needed to offset the reduction in plant available water storage capacity of the soil profile with increasing erosion level and maintain optimal corn grain yield. This work also concluded that corn grain production was more sensitive to changes in soil water storage with increasing erosion. Other research conducted at this same site measured a reduction of greater than 50% in organic matter storage within the soil profile to a 2-foot depth with increasing erosion level (Arriaga and Lowery, 2005). Although the use of amendments and manures can help increase the organic matter content in a soil and partially restore productivity, some of the negative impacts of erosion on soil properties are difficult to revert (Arriaga and Lowery, 2003b).

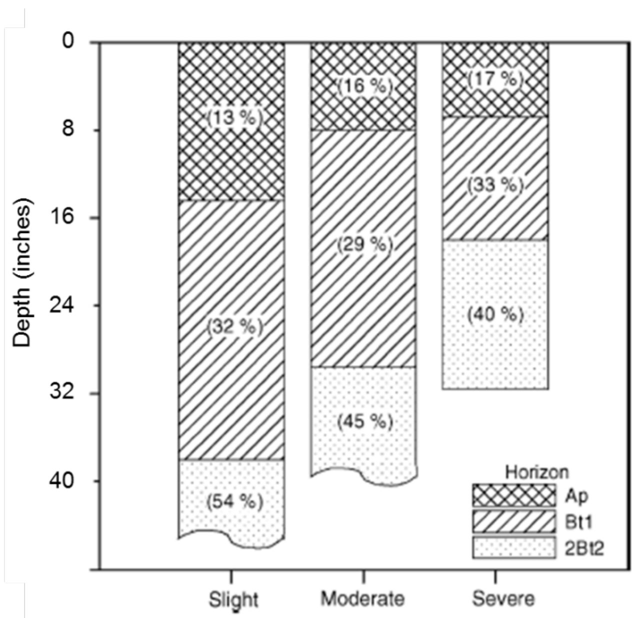

Figure 3. Thickness of different soil horizons for three levels of erosion (slight, moderate and severe). Note that the depth to undelaying subsoil horizons is reduced with increasing erosion level, and thus, clay content (shown in parenthesis) is increased near the surface. (Source: Arriaga and Lowery, 2005).

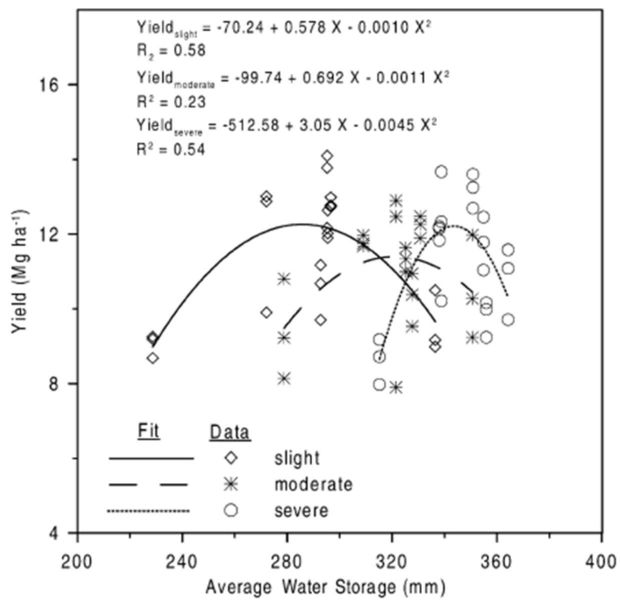

Figure 4. Impact of three soil erosion levels on average water storage in the soil profile and corn grain productivity. Note that the range of water storage is reduced and yield variability is increased with increasing erosion severity. The Pr>F for the slight, moderate and severe erosion level equations is <0.01, <0.01 and 0.10, respectively. (Source: Arriaga and Lowery, 2003a).

Soil erosion control is a top concern for reducing risk within a crop production operation from a soil management standpoint. Good soil management is at the center of an economically and environmentally sustainable operation. Soil management plans should consider soil type, topography, crops, tillage practices, and other crop production factors. The overall goal is to maximize economic crop production levels, maintain or increase land values, and minimize pollution. A management plan can be a useful tool to help achieve these goals.

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MANAGEMENT PRACTICES AND EMERGING TECHONOLGIES IN TILE DRAINED LANDSCAPES TO MITIGATE SEDIMENT AND NUTRIENT LOSS

Eric Cooley[1/], Matt Ruark[2/], and John Panuska[3/]

Subsurface drainage of agricultural land has the ability to improve yields and reduce surface runoff and erosion losses. However, with a reduction in surface runoff, more water infiltrates the soil and percolates through the soil profile. This is of particular importance to farmers, as this water can also transport essential plant nutrients, specifically nitrogen and phosphorus, out of the root zone. Once nutrients reach the tile drain, they have a direct conduit to surface waters.

Tile-drained agricultural land must be well-managed to reduce the loss of nutrients to surface waters. Nutrient management practices must be carefully followed to minimize the risk of nutrient loss and to maximize fertilizer use efficiency. Additional considerations need to be taken with manure applications on tile-drained land to both minimize nutrient loss and prevent manure entry into tile drains.

There are a variety of best management practices customizable to fit individual cropping systems and various tile-drained landscapes. We have identified twelve key elements that will lead to proper nutrient management on tile-drained land and thus minimize the potential to transmit manure to tile drains.

- **Understand and locate tile drainage system features:** A working knowledge of tile drainage systems and identification of tile outlets, surface inlets, vents, and other components of tile drainage systems can reduce the potential of inadvertent entry of manure, pesticides, fertilizer, and other soil amendments into the tile. Further information can be found in *Tile Drainage in Wisconsin: Understanding and Locating Tile Drainage Systems* (Ruark et al., 2009).

- **Maintain tile drainage systems:** Proper inspection and maintenance of tile drainage systems ensures that the tile system is functioning properly and reduces the potential of inadvertent entry of manure, pesticides, fertilizer, and other soil amendments into tile drainage systems. Annual inspections should be performed to identify tile blowouts and outlet blockages. Further information can be found in *Tile Drainage in Wisconsin: Maintaining Tile Drainage Systems* (Panuska et al., 2009).

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- **Assess soil conditions prior to liquid manure applications:** Both high and low soil moisture contents can be problematic for liquid manure applications to tile-drained land. Flowing tiles are often a good indicator of high soil moisture conditions and well-developed soil surface cracks are an indicator of low soil moisture conditions in clay soils with high shrink-swell capacity. Manure applications should be avoided during high soil moisture conditions. If manure applications are made during dry soil conditions with surface cracks apparent in the soil, either utilize pre-tillage before application or reduce initial application rate to slowly add moisture to the soil to facilitate closing of the cracks.

- **Review forecasted weather prior to liquid manure applications:** Avoid applications when rainfall is predicted to occur after application. Soil moisture levels are increased by liquid manure applications, and subsequent rainfall can result in tile flow and release of manure to tile drains. Also avoid applications soon after rainfall events because soil moisture levels are typically elevated.

- **Monitor tile outlets when applying liquid manure:** Tiles should be monitored before, during, and after liquid manure applications for potential discharge of manure. Tiles flowing before applications are an indication of high soil moisture conditions, in most circumstances, and applications should be avoided. Monitor during applications because water from the liquid manure increases soil moisture content and can result in a flow event. Tile outlets should also be monitored up to a few weeks after application, especially after subsequent precipitation that may cause tile flow.

- **Restrict tile discharge prior to manure application if possible:** If water level control structures are installed in tile systems, insert stoplogs (devices inserted to control water level) to prevent flow from tile drains before application. Subsequent to application, remove stoplogs and check for flow. If flow is present after application, reinsert stoplogs to prevent discharge. Stoplogs should also be reinserted if a large rainfall is predicted to occur within a few weeks of application. Tile plugs can also be used in systems without water level control structures, but they have been shown to fail 50% of the time (Hoorman and Shipitalo, 2006).

- **Use tillage to break up preferential flow paths prior to or concurrent with application:** Pre-tillage for surface and injected liquid manure applications or application methods that concurrently disrupt preferential flow paths below the manure injection depth should be utilized to prevent manure entry to tile drains. Soils should be tilled at least three inches below the injection depth to adequately disrupt preferential flow paths.

- **Take precautions when surface applying liquid manure to land under no-till or perennial crops:** Preferential flow paths are more developed in no-till systems and in later years of perennial crops. Split applications or reduced rates should be considered for liquid manure applications. Additionally, manure can be transported along growing or decayed roots of deep tap root crops like alfalfa.

- **Ensure precautions are taken for manure and pesticide applications in fields with surface tile inlets:** Surface inlets are commonly used in fields with closed depressions, that is areas without an outlet for surface water. Extra precautions need to be taken in proximity of surface tile inlets because they are a direct conduit to tile drainage systems. Check state and local setback requirements for surface tile inlets before applying manure and pesticides.

- **Use best management practices for fertilizer and manure management:** This includes applying nutrients based on A2809 guidelines (Laboski and Peters, 2012), delaying or splitting nitrogen fertilizer applications, and waiting to apply manure or anhydrous ammonia in the fall until soil temperatures are less than 50°F. If applications are necessary when soil temperatures are above 50°F, use nitrification inhibitors. Researchers in Indiana have shown that alternating the timing of liquid manure application from fall to spring can reduce nitrate leaching by 30% and that spring application of manure results in nitrate leaching losses similar to spring fertilizer applications (Hernandez-Ramirez et al., 2011).

- **Utilize conservation management practices such as cover crops, conservation tillage, and planting of grassed waterways:** This also includes any other management practice that increases nitrogen conservation in the soil and reduces erosion. These practices that reduce soil loss also reduce sediment-attached nutrient movement on the soil surface and will also help to reduce the potential of loss to tile drains.

- **Have an emergency plan in place:** If manure enters tile drains, take immediate steps to stop the flow and prevent discharge to fresh water systems. This can be performed by blocking or diverting the tile outlet, intersecting the tile system, and digging a pit directly downstream of the spill site to collect manure. Contact the Wisconsin DNR Spills Hotline at **1-800-943-0003** to report the spill and get assistance with subsequent remedial actions.

There are technologies available that can be used to retain water and nutrients in the soil profile. Drainage water management is the practice of controlling water table elevation to desired levels throughout the year. Water level control structures are used to maintain the water level higher in the soil profile after crops are removed to minimize nitrogen loss, predominantly in nitrate form, to surface water. The control elevation is then lowered in the spring to remove excess water from the soil profile and to allow the soil to dry out for field access and planting. Once crops are planted, the control elevation is often raised to hold the water level closer to the root zone (a practice known as subsurface irrigation), especially for crops that are prone to drought stress. Once crops are removed, the control elevation is raised farther to store more water and to prevent nutrient loss until spring. Additional information on drainage water management can be found in *Drainage water management for the Midwest: Questions and answers about drainage water management for the Midwest*.

Water table management in many of Wisconsin's tile-drained landscapes is limited by the slope of the land. Slopes of less than ½% are suitable for drainage control structures to be practical.

Slopes greater than ½% will only allow for drainage control on a small portion of the land surface and may result in high fluid head pressures in tile systems and tile blowouts. Many of Wisconsin's tile-drained landscapes have 2–6% slopes. New technologies allow for infield drainage control for lands with higher slopes (AgriDrain - Water Gates^{TM}). This type of system has two benefits: It is installed underground so as not to interfere with field operations (including deep tillage), and it can be "stair-stepped" to control drainage on higher sloped land up to 2%. The level in each of the structures is controlled by the downstream water control structure located either at a field boundary or tile outlet.

Constructed wetland treatment of tile drainage flow has been shown to be more effective for nitrogen (N) than phosphorus (P) removal, but there are many limitations with this practice (Miller et al., 2002). Constructed wetlands can take large amounts of land out of production for effective treatment sizing. Reported P removal and N concentration reductions vary due to a number of factors, including system design, retention time, and local climatic and physical conditions. Temperature effects on microbial activity may have large influence on N removal capacity, especially in the cold temperature extremes of the northern regions, such as Wisconsin (Jin et al., 2002). The P removal potential of constructed wetlands is limited and highly dependent on the nature of materials used for construction. In fact, during constructed wetland establishment, increases of ammonium N, dissolved reactive P, and total P have been seen in wetland effluent (Tanner et al., 2005).

For tile systems that outlet to drainage ditches, a two-stage drainage ditch can reduce the scouring of ditch banks and increase the removal of sediment, nitrogen and, phosphorus from tile drainage water. The two-stage design spreads flow over a larger area that decreases water velocity, allowing for sediment to settle out, and increases residence time for biological N removal. During low ditch flow periods, if the drainage ditch is constructed properly, tile water will spill onto vegetated benches, allowing for increased removal of sediment and nutrients.

Emerging technologies in drainage water management will likely provide increased options for reducing sediment and nutrient transport from tile drainage systems. Some of these technologies include blind and alternative surface inlets, bioreactors, and saturated buffers.

Contact your local National Resource Conservation Service or Land Conservation Department to obtain additional information on management practices to reduce nutrient loss from tile drainage systems and local regulations on manure application requirements and setbacks.

While there are current and emerging technologies to remove nutrients from tile drainage systems, many are limited in effectiveness, are unsuitable for the landscape, or are cost-prohibitive. Overall, the best method to minimize tile drainage release of nutrients to fresh water systems is to utilize management practices that prevent nutrients from reaching tile.

A series of three fact sheets on tile drainage are available for download at Discover Farms and The Learning Store websites.

Tile drainage in Wisconsin:

1. Understanding and locating tile drainage systems
2. Maintaining tile drainage systems
3. Managing Tile-Drained Landscapes to Prevent Nutrient Loss

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ON-FARM COVER CROP TRIALS: CLOVER, RYE, AND RADISH

Matt Ruark [1/], Kevin Shelly [2/], Richard Proost [2/], Jim Stute [3/],
Mike Ballweg [4/], and Bill Halfman [5/]

Clover

There has been much research using red clover as cover crop, frost-seeded in to winter wheat (Stute UWEX pub). Planting red clover into winter wheat provides a clear value for the subsequent corn crop in terms of greater yields and reduced need for nitrogen (N) fertilizer (Fig. 1.)

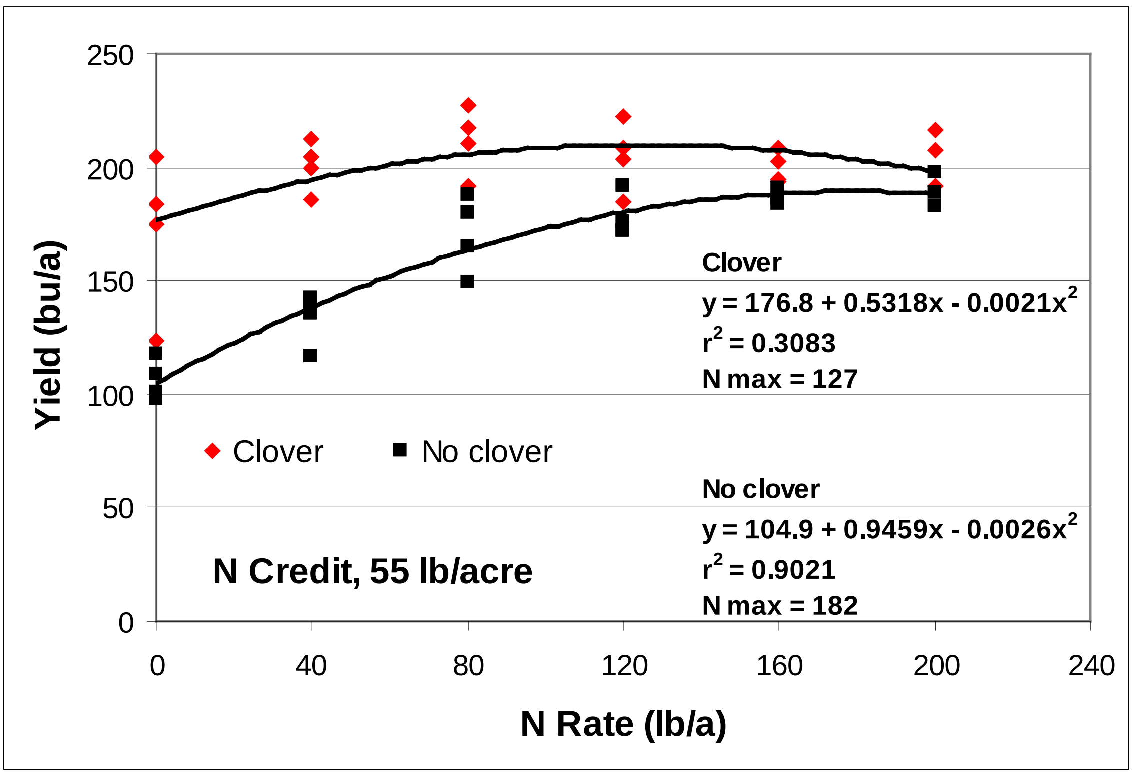

Figure 1. Corn yields following a red-clover green manure (red) or no green manure (black).

The drawback to using red clover is that it will not die during winters in Wisconsin and thus needs to be chemically terminated in the late fall or early spring. There are two other clover species that will winter kill and can be planted after

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winter wheat: berseem clover and crimson clover. Neither of these species has been well-researched in Wisconsin. In late-summer of 2013, berseem and crimson clover was planted in replicated strips on a farmer field in Sheboygan County. Preliminary findings suggest that both clover species established well. In 2014, this field will be planted to corn and a N rate study will be conducted.

Rye

Rye is a popular cover crop in Wisconsin as it establishes well, is easy to kill, and can be used for emergency forage if needed. Cover crop trials have been conducted at the Arlington Agricultural Research Station to evaluate the benefits and drawbacks to planting rye as a cover crop or forage crop after corn silage. Research results suggest that corn silage yields can be maintained as long as the rye cover crop is terminated early in the spring (Fig. 2).

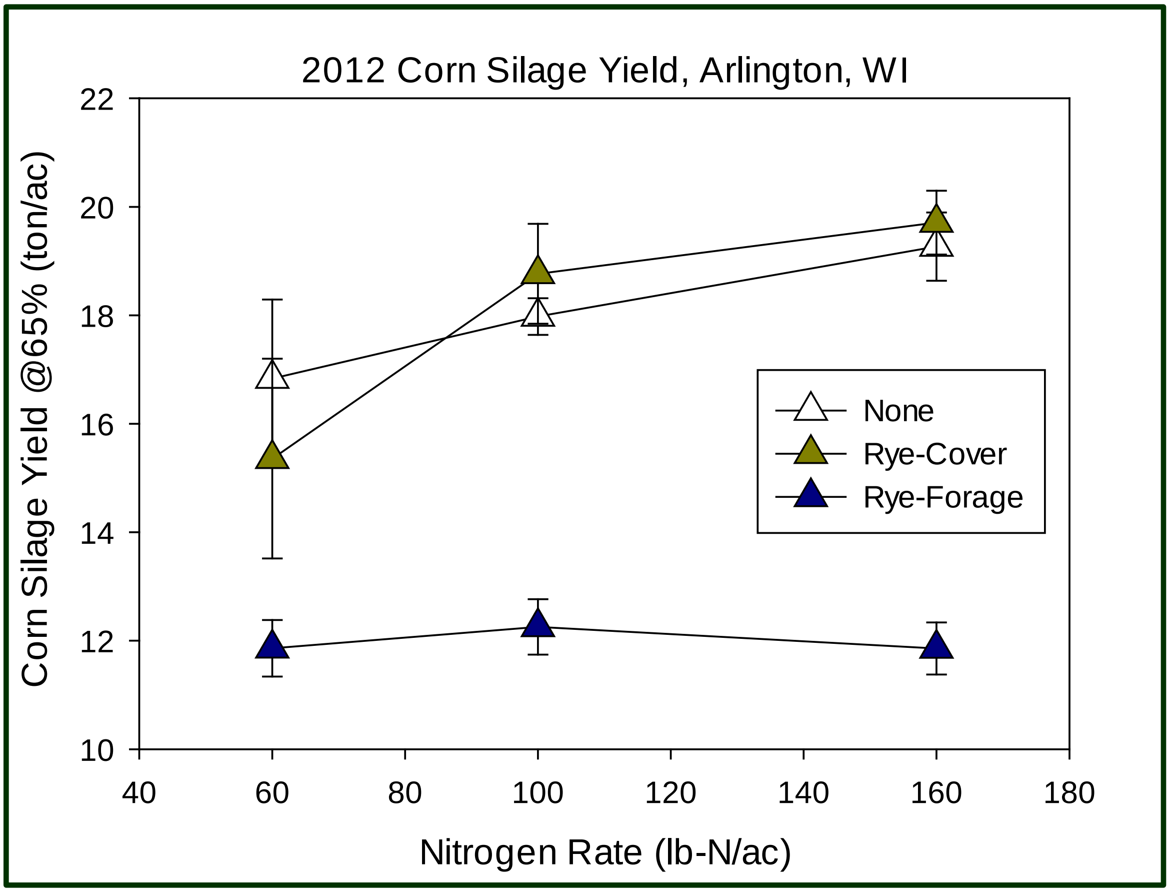

Figure 2. Corn silage yields in 2012 following no cover crop, a rye cover crop, or a rye forage crop.

In 2012, an on-farm trial was established in Monroe County, WI using the same sets of cover crop treatments: no cover crop, rye killed in early spring, or rye harvested as a forage crop. In 2013, due to the wet soil conditions, corn planting was delayed and the farmer switched the crop to soybean. Thus, no N was applied. Soybean yields were similar, but slightly lower where rye was planted (Table 1).

Radish

Radish is a popular cover crop with no-till farmers as its large tap roots can create biological soil disturbance. This cover crop can take up a lot of N, but will winter-kill, meaning the plant will start to decompose when temperatures warm in the spring. Little is known regarding the release of N (or the potential for a N credit) from this cover crop. In fall of 2012, radish in Sheboygan County accumulated 120 lb/ac of N in the above ground biomass and tap root. However, a nitrogen credit has yet to be determined based on yield results (Fig. 3).

Table 1. Soybean yields in 2013 following no cover crop, a rye cover crop, or rye forage crop.

Treatment	Soybean Yield
	bu/ac
No cover crop	56
Rye cover crop	53
Rye forage crop	53

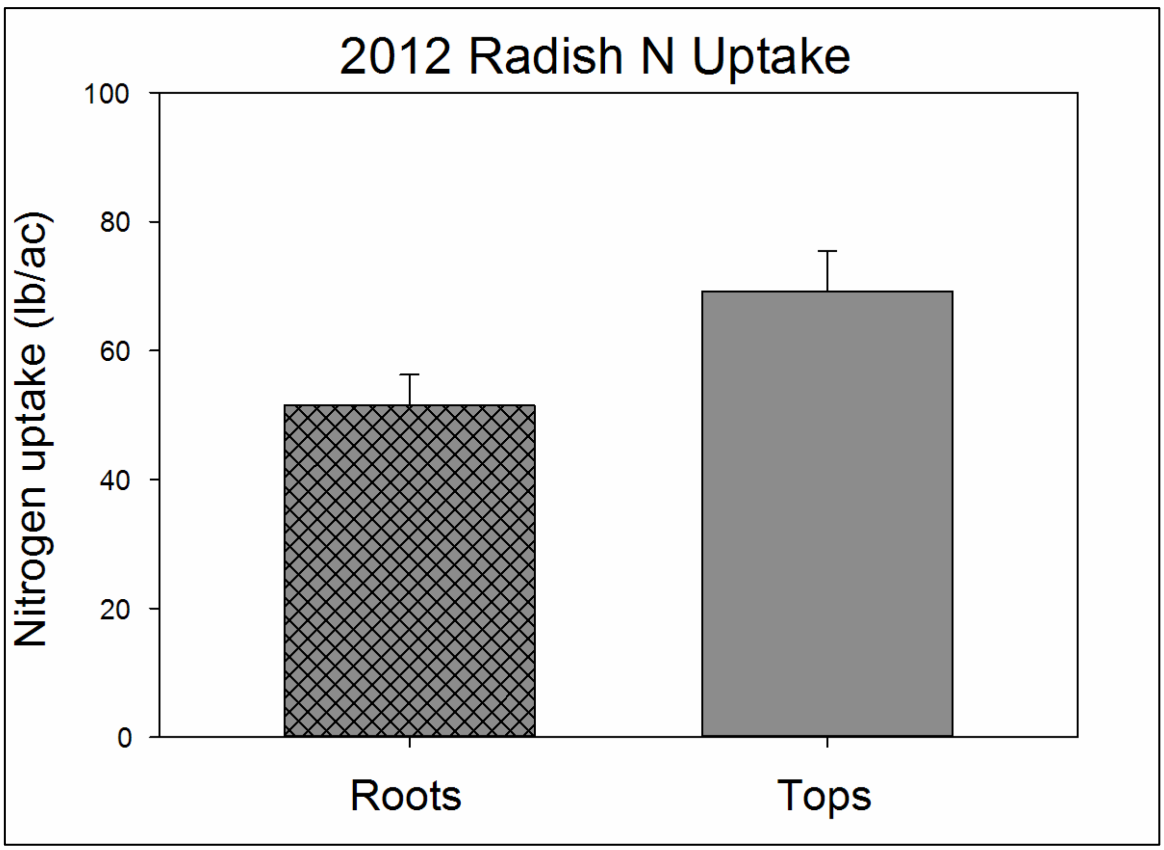

Figure 3. Nitrogen uptake by radish in fall 2012.

Presentation

The associated presentation at the 2014 Wisconsin Crop Management Conference will include a more comprehensive assessment of cover crops planted in fall of 2013 as well as research results from previous years.

THE VALUE OF YIELD MAPS AND PREDICTING FUTURE MANAGEMENT – PANEL

Mike Cerny, Bill Schaumberg, Nick Goesser [1/]

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OPTIONS FOR CORN WHEN FLOODING, DROUGHT, LATE-PLANTING, AND EARLY FROST ARE CONSPIRING AGAINST YOU

J.G. Lauer [1/]

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ECONIMIC RISK & PROFITABILITY OF SOYBEAN SEED TREATMENTS AT REDUCED SEEDING RATES

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Proceedings

Earlier soybean [*Glycine max* (L.) Merr.] planting coupled with increasing seed costs and higher commodity prices has led to a surge in the number of hectares planted with seed treatments (Esker and Conley, 2012). Furthermore, recent studies have suggested that growers should consider lowering seeding rates to increase their return on investment (De Bruin and Pedersen, 2008; Epler and Staggenborg, 2008). Ultimately, growers would like to know the value proposition of combining seed treatments with lowered seeding rates. Therefore, the objectives of this study were to quantify the effects of seed treatments and seeding rates on soybean seed yield and assess the economic risk and profitability of seed treatments and seeding rates, including the calculated economically optimal seeding rate (*EOSR*) for each seed treatment.

Trials were conducted at nine locations throughout Wisconsin during the 2012 and 2013 growing seasons, totaling 18 site-years. Syngenta brand S20-Y2 (\$50 unit^{-1}) soybeans were treated with either no seed treatment (UTC), ApronMaxx (\$5 unit^{-1}) (mefenoxam + fludioxonil at 0.0094 mg ai seed^{-1}), or CruiserMaxx (\$12 unit^{-1}) (mefenoxam + fludioxonil + thiamethoxam at 0.0858 mg ai seed^{-1}) at six seeding rates of 40000, 60000, 80000, 100000, 120000, and 140000 seeds acre^{-1}. The analysis used a soybean grain sale price of \$12 bu^{-1}.

Results indicate differences in yield, profitability and economic risk due to seed treatment and seeding rate. ApronMaxx showed no improvements in yield or profitability at any seeding rate compared to the UTC. CruiserMaxx provided increased yields and profitability over the UTC at all seeding rates. CruiserMaxx showed increased yields over ApronMaxx at all seeding rates except 100,000 seeds acre^{-1}, but higher profits at all seeding rates. ApronMaxx and the UTC required higher seeding rates (>120,000 seeds acre^{-1}) to achieve break-even probabilities >0.50 and their *EOSR's* showed the largest average profit increase for all outcomes over the base case. However, these average profit increases were minimal (<\$2 acre^{-1}). CruiserMaxx showed break-even probabilities >0.50 for all seeding rates except at 40,000 and 60,000 seeds acre^{-1}, but the lowest risk (0.87) and highest average profit increase (\$25 acre^{-1}) was achieved at its *EOSR* (101,000 seeds acre^{-1}), which was 18,000 seeds acre^{-1} less than ApronMaxx and the UTC.

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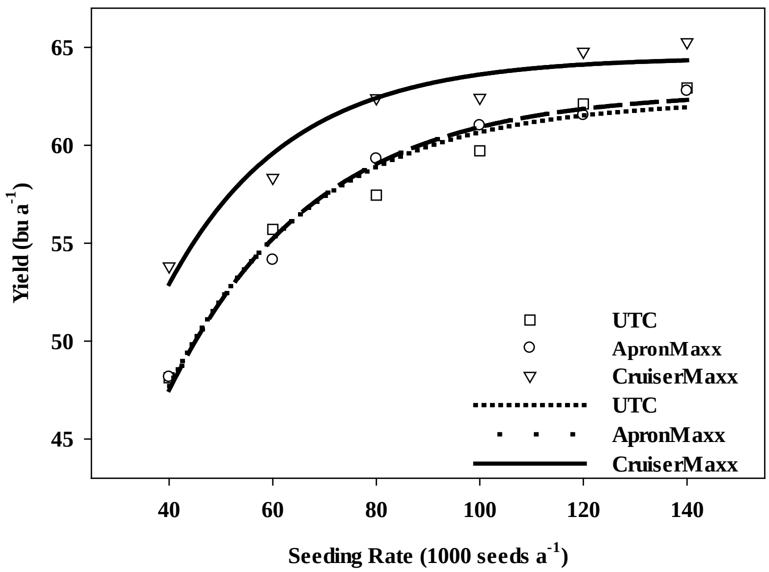

Figure 1. Yield modeled with a negative exponential model for three seed treatments across all seeding rates in 2012 and 2013.

Table 1. Seeding rate by seed treatment economic risk table for all location with a grain sale price of $12 bu^{-1}.

Treatment combination†		Break-even	Avg. profit increase over the Base Case‡		
Seed Treatment	**Seeding Rate**	**probability§**	**Positive outcomes**	**All outcomes**	**Negative outcomes**
	Seeds acre^{-1}			$ acre^{-1}	
UTC	120,000	0.77	3	2	-3
	100,000	0.44	4	-2	-7
	80,000	0.08	3	-17	-19
	60,000	0.00	1	-55	-55
	40,000	0.00	na¶	-138	-138
ApronMaxx	140,000	0.49	19	-1	-20
	120,000	0.52	19	1	-18
	100,000	0.44	17	-3	-19
	80,000	0.20	13	-18	-26
	60,000	0.01	8	-57	-57
	40,000	0.00	na	-142	-142
CruiserMaxx	140,000	0.76	27	17	-14
	120,000	0.84	29	23	-12
	100,000	0.87	30	25	-11
	80,000	0.80	26	18	-12
	60,000	0.38	16	-8	-22
	40,000	0.00	6	-79	-79
EOSR					
UTC	119,000	0.76	3	2	-3
ApronMaxx	119,000	0.52	19	1	-18
CruiserMaxx	101,000	0.87	30	25	-11

†Treatment combination includes all possible seed treatment and seeding rate combinations for comparison to the base case.

‡Base Case is untreated seed at 140,000 seeds acre^{-1}.

§Break-even probability is the probability a treatment combination will at least provide the same profit acre^{-1} as the base case.

¶na, no outcomes are possible.

80 YEARS OF BREEDING BY AGRONOMY INTERACTIONS

IN 30 MINUTES OR LESS

Shawn Conley [1]

{This page provided for note taking}

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ROLE OF ADJUVANTS AND NOZZLES IN MANAGING DRIFT: LESSONS FROM WIND TUNNEL, GREENHOUSE, AND FIELD STUDIES

Greg Kruger, Brad Fritz, Andrew Hewitt, Ryan Henry, and Cody Creech [1/]

Introduction

Since 1996, glyphosate has been the predominant herbicide used postemergence for weed control in corn, soybean and cotton in the United States. Because of that, glyphosate-resistant weeds have become increasingly more prevalent in glyphosate-resistant crops which have forced many growers to use other herbicides. Herbicide programs that relied primarily on glyphosate for weed control often used rates as low as 5 gallon/acre (GPA). The other herbicides being used in row crops often require a higher carrier volume according to the label when compared to glyphosate which can be burdensome to the applicator, requiring the transport of more water, more refills and more potential of mixing errors. Additionally, there is growing concern about off-target movement of pesticides and what can be done to mitigate pesticide drift. Both drift and efficacy can be affected by spray quality and application decisions such as nozzle selection, operating pressure and components of the spray solution.

Applicators should be aware that pesticide applications are complex and there are many applicator driven decisions which will impact both the efficacy and off-target movement of pesticides following the application (Figure 1). Every applicator should be aware of the potential effects starting with properly mixing and agitating the spray solution through the resulting droplet size and deposition from atomization of the spray contingent upon nozzle selection, operating pressure and spray solution composition. In general, every applicator should be aware of the weather conditions (especially wind speed), boom height, droplet size and distance away from susceptible vegetation.

Pesticide drift is defined as the movement of spray particles and vapors off-target causing less effective control and possible injury to susceptible vegetation, wildlife, and people (National Coalition of Drift Minimization 1997). With the concern for reduced efficacy and environmental

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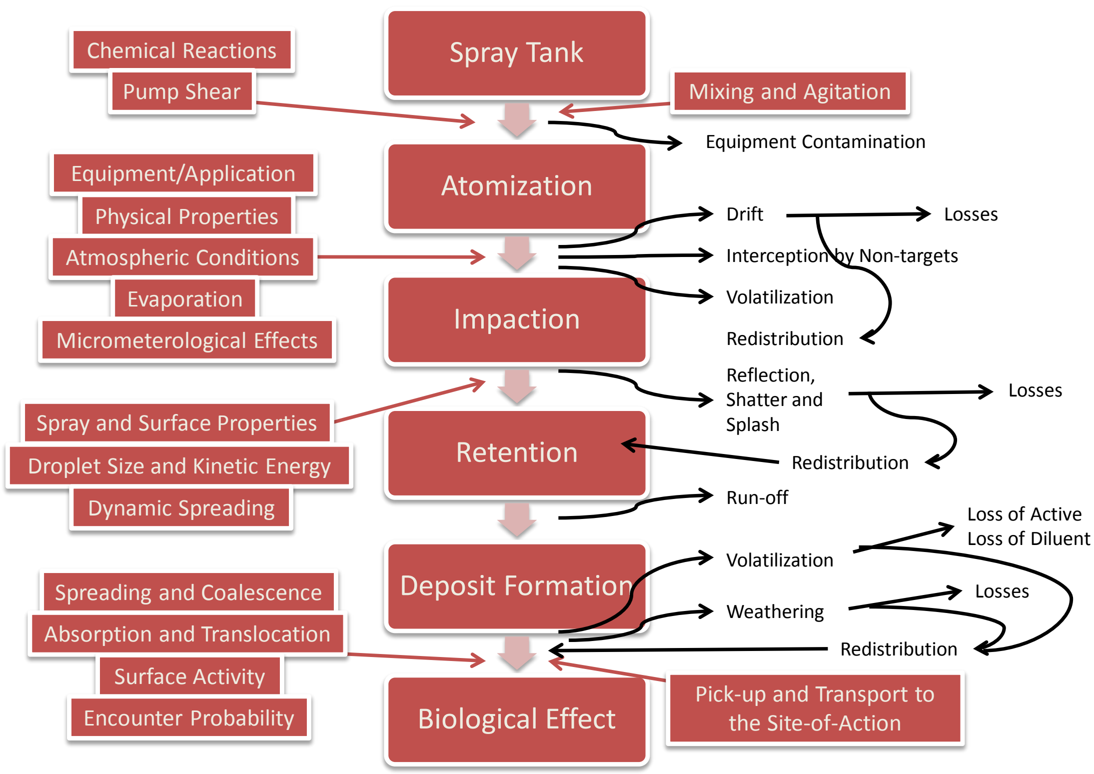
and legal ramifications of off-target movement, every applicator should strive to make as efficient and effective application as possible every time. Applicators should be cognizant that as wind speed doubles, research shows that in general we should expect the off-target movement at 90 ft. downwind to increase by as much as 700%. Also, it is important to recognize that wind speed and boom height are correlated. Wind speed is generally higher as you get further away from the intended target. Because the wind speed goes up as boom height increases and because the droplets take a longer period of time to reach the ground, research has shown that in general, we should expect to see approximately 350% increase in drift 90 ft. downwind when the boom height doubles. When applicators are making pesticide applications on days when wind conditions are nearly too high to make applications, they can manage drift more efficiently by getting the spray boom closer to the ground. Care must be taken so that the applications are not so close to the target that the pattern is lost however.



Ebert et al. 1999

Figure 1. Pesticide applications include many complex relationships on the input and output of various steps in the process. The figure above depicts the steps involved in pesticide applications from the spray tank to the biological effect as described by Ebert et al. 1999.

As we move into an era where there is a reliance on postemergence herbicides other than just glyphosate, it is imperative that we revisit the practices which provide efficient and effective applications while minimizing off-target movement. While new formulations have been reported to have reduced off-target movement, the formulations only have so much influence. Irresponsible applications will move off-target regardless of how good formulations are or how good the adjuvants that are being used with the application are.

Droplet Size

Droplet size is often the easiest factor for applicators to manage in terms of off-target movement. Droplet size is influenced by the tank mix composition (pesticide(s) formulation, carrier product, and adjuvant(s) as well as the rate of each of those components), nozzle type and orifice size, and the operating pressure at the nozzle tip. Figure 2 illustrates how nozzle design and spray solution interactions affect droplet size for water compared to Roundup WeatherMax plus various adjuvants.

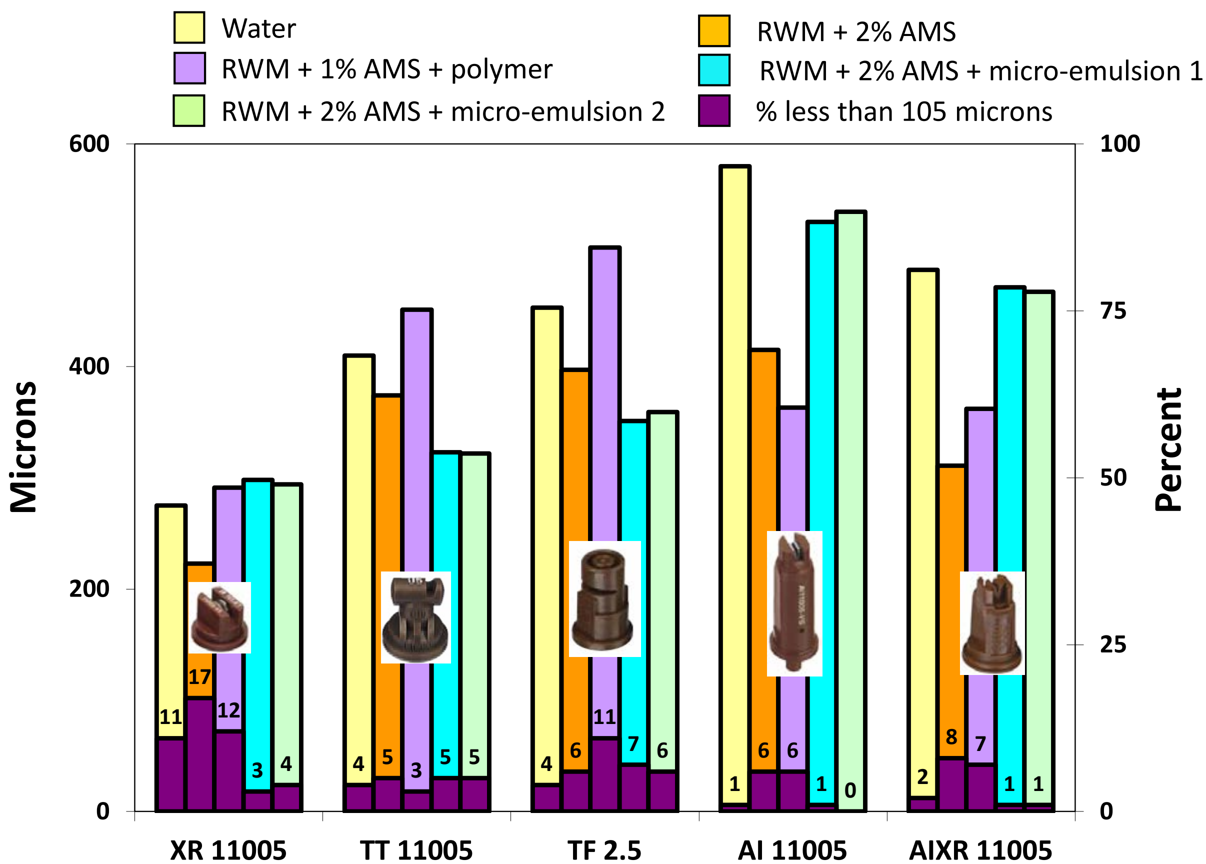


Figure 2. Influence of nozzle selection and adjuvant on the droplet size and % of the spray solution less than 105 microns. Interactions between spray solution and nozzle type can have a significant influence on droplet size distributions. Use of polymer adjuvants with Turbo TeeJet nozzles helped to manage the fines while the use of the same adjuvant with a Turbo Flood nozzle greatly increased the fines.

Nozzle selection, pressure, and orifice size can change droplet size as much as 100-fold (Figure 3). Nozzles such as the flat fan have been used for decades for pesticide applications. These nozzles however produce many fines which have a much greater propensity to move off-target than larger droplets. By decreasing the pressure at which these nozzles are operated there will be an increase in droplet size. In the example in Figure 3, the % fines went from 26% to 15% when pressure on an XR110025 nozzle was decreased from 60 psi to 30 psi. The use of larger orifice nozzles and alternative nozzle designs can also lead to larger droplet size.

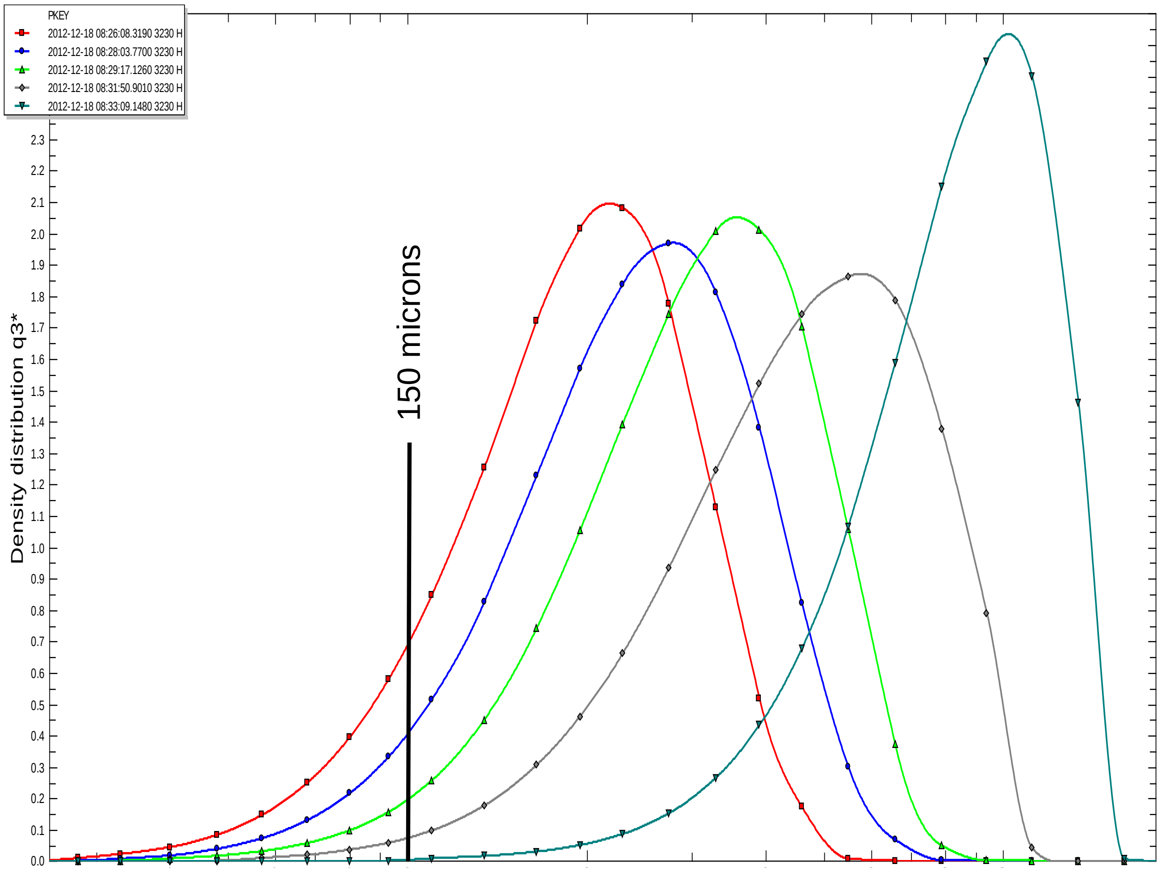


Figure 3. Droplet size distribution curves for a XR110025 at 60 psi (red), XR110025 at 30 psi (blue), XR11005 at 30 psi (green), TT11005 at 30 psi (grey), and TTI1005 at 30 psi (teal). The graphic shows that reducing pressure and increasing orifice size will increase droplet size and decrease the % fines less than 150 microns. The graphic also demonstrates how nozzle selection and the use of air inclusion nozzles can be utilize to increase droplet size.

Carrier Rate

In 2012, a series of studies were conducted to measure the influence of carrier volume on droplet size and weed control using four different postemergence herbicides commonly used for weed control in soybeans that use different herbicide modes-of-action. Field studies were set up at three locations across Nebraska. RoundUp PowerMax (glyphosate at 32 oz/ac), Liberty (glufosinate at 22 oz/ac), Cobra (lactofen at 12.5 oz/ac), and Weedone (2,4-D at 32 oz/ac) were applied at different carrier volumes. The four herbicides are an EPSP synthase inhibitor, glutamine synthase inhibitor, PPO inhibitor, and synthetic auxin, respectively. The four herbicides were each sprayed with appropriate adjuvants and were each applied at five carrier volumes (5, 7.5, 10, 15, 20 GPA). Droplet size of each treatment was evaluated at the wind tunnel facility in North Platte, NE, using a diffraction laser. Weed control ratings were recorded at three field sites located across Nebraska (Lexington, O'Neill, and Platte Center) at 14 and 28 days after treatment. The sprayed plots were 10 ft. wide and 30 ft. long. Planted across each plot were rows of non-herbicide resistant corn and soybean, velvetleaf, and grain amaranth. Treatments were replicated four times at each site.

Generally, the performance of the systemic herbicides (glyphosate and 2,4-D) on weed control was not influenced by different carrier volumes. The abnormal behavior of the 10 GPA treatment of 2,4-D on soybean was likely because of the droplet size. That treatment was applied with an XR11001 nozzle using high pressure which would produce a high amount of fine droplets when compared to the other treatments. These small droplets are more prone to drift but provided better coverage. There was a lot of variability of glyphosate activity in general on the amaranth population which is not surprising as in the United States, amaranth has had considerable variability, a lot of genetic diversity and has been prone to evolve resistance. An interaction between the effect of carrier volume and the contact herbicides glufosinate and lactofen was clearly present. Herbicide efficacy in controlling velvetleaf increased from 52 and 37%, respectively, for these two contact herbicides, to 83 and 85% as carrier volume increased from 5 to 20 GPA (Figure 4). Control of the amaranth by glufosinate and lactofen increased from 56 and 81% to 80 and 100%, respectively (Figure 5). This is not too surprising since the Cobra and Liberty labels recommend 15 and 20 GPA, respectively. As applicators starting using products other than glyphosate for weed control, it will be important to understand the products that are being applied and what can be done to maximize the efficacy of those products.

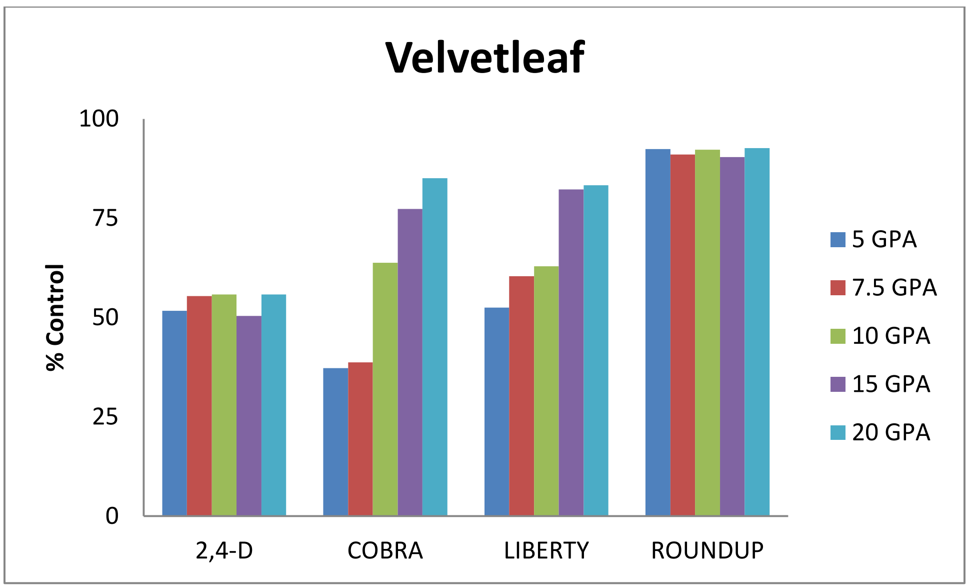


Figure 4. Visual ratings of 2,4-D, Cobra, Liberty and Roundup PowerMax injury on a velvetleaf at 5, 7.5, 10, 15, and 20 GPA.

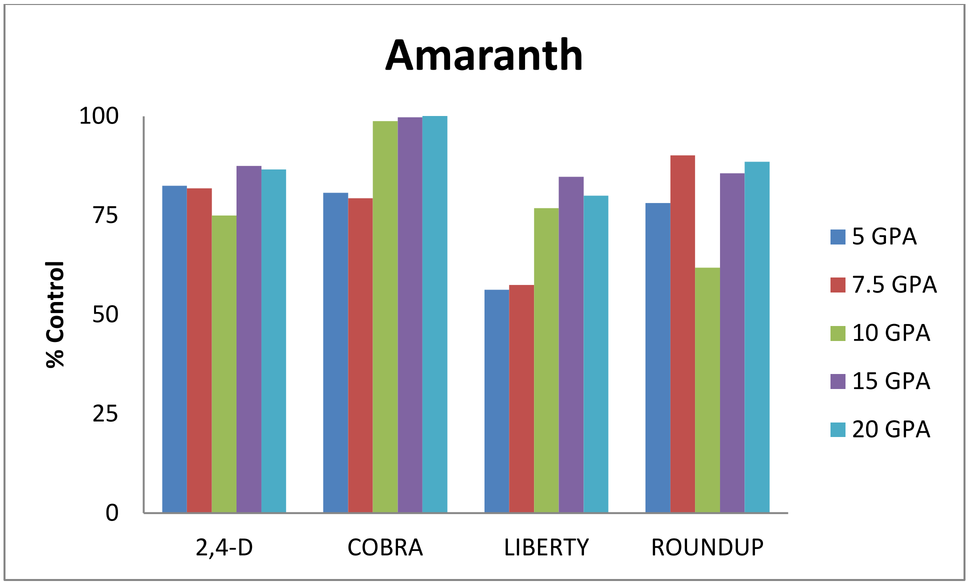


Figure 5. Visual ratings of 2,4-D, Cobra, Liberty and Roundup PowerMax injury on a grain type amaranth at 5, 7.5, 10, 15, and 20 GPA.

Spray Quality

In 2011, similar studies were conducted across Nebraska to investigate spray quality. Four locations (Elba, Courtland, Clay Center and Bancroft) had four replications. In each plot we planted non-traited corn, non-traited soybean, a crop type amaranth, velvetleaf, flax and quinoa.

In the studies, we sprayed Roundup PowerMax at 11 oz/ac (glyphosate), Clarity at 4 oz/ac (dicamba), FirstRate at 0.15 oz/ac (cloransulam-methyl), Flexstar at 13 oz/ac (fomesafen), and Select MAX at 6 oz/ac (clethodim). All of these herbicides were used with the recommended adjuvants and all applications were made at 10 GPA. It is important to note that the rates used are approximately half of the recommended rate for each of these products. The use of these rates for weed control is never recommended, but for the purpose of observing differences in weed control these rates were necessary.

Each herbicide treatment was sprayed through an XR1003 flat-fan nozzle at 43.5 psi, an XR11002 flat-fan nozzle at 40 psi, a TT11002 nozzle at 40 psi, an AIXR11002 nozzle at 40 psi and an AI11002 nozzle at 40 psi. The five nozzles when tested in water at these pressures should give Fine/Medium, Fine, Medium, Coarse and Very Coarse size spray qualities (droplet size ranges), respectively.

For each of these nozzles and spray solutions, we determined the droplet size using a low-speed wind tunnel in College Station, TX. The droplet sizes were determined using a 7.5 mph wind speed across the nozzle and droplet sizes were measured using a SympaTec laser diffraction instrument. For the purpose of this article, the $D_{v0.1}$ or the size of the 10^{th} percentile of droplets is reported. This value is useful as proxy for the potential for drift of each spray solution.

As expected, certain herbicides preformed as well or better with large droplets while other herbicides performed poorly when droplet size was too large. Interactions between spray solution and nozzle type existed lending to the need for not only considering the ideal droplet size when making a spray application, but also using the most appropriate nozzle type. Further work in this area will be necessary to fully understand the interaction.

For the Roundup PowerMax, a systemic herbicide, 16 oz/ac was effective at controlling all five species observed. Greater than 90% efficacy was observed using all five nozzles. This observation lends evidence to the potential shift in the tolerance of weed species that have been continuously exposed to glyphosate applications, even in fields where little or no glyphosate-resistance has been observed. However, because of the high level of efficacy, it was difficult to make comparisons between spray qualities.

Since Roundup Ready systems have been widely adopted, the recommendation for glyphosate applications in these crops has generally been toward using nozzles and pressures which would give larger droplets. Our findings would support this recommendation as larger droplets would provide less potential for drift while delivering equal or better efficacy.

The $D_{v0.1}$ values for glyphosate ranged from 70 to 230 for the nozzles using the glyphosate spray solution. As glyphosate concentration increases in the spray solution, it would be expected that the droplet size would change. When increasing Roundup PowerMax concentration in the spray solution from 22 oz/ac to 44 oz/ac, the droplet size would likely decrease.

Clarity applications tended to have a similar trend as Roundup PowerMax in respect to the use of the different nozzles. There was little difference between the nozzles and therefore, the nozzles producing the largest droplets would provide a superior application, as the drift potential would be lower with these nozzles. This result is not of much surprise as dicamba (Clarity) is a systemic herbicide as well.

FirstRate was similar to Clarity and Roundup PowerMax in that there really was not much difference in control between nozzles that produced different droplet sizes. The results from the FirstRate were somewhat dependent upon species. For example, the AI11002 nozzle provided the greatest control of the amaranth while the XR11003 flat-fan nozzle provided the greatest control of the velvetleaf.

For both Flexstar and Select MAX, the larger droplets had reduced efficacy on the weed species for which we would expect control. An interesting observation was that the XR11002 flat-fan nozzle was not nearly as effective as the XR11003 or the TT11002 which both give slightly larger droplets, indicating that the droplet size can get too small for maximizing efficacy. This is a critical finding because these products are important as tank mixtures for postemergence applications to control glyphosate-resistant weed populations in soybeans.

Impacts of Application Decisions on Efficacy and Drift

Drift and efficacy are two critical components of any pesticide application. Without a high level of pesticide efficacy, there is no reason to make a pesticide application. Additionally, if there is a high amount of pesticide drift there is also no need to make a pesticide application. The problem is that for many different pesticides, the two components work in contrast to one another.

For many of the pesticides that we use, although clearly not all, the smaller the droplet the greater the efficacy will be (at least to a limit). However, the smaller droplets are the ones most prone to drift. In cases where the pesticide is most effective with small droplets, there is a need for finding a balance between pesticide efficacy and drift potential.

When making a pesticide application, wind speed and direction, distance to nearest susceptible species, and the toxicity of the pesticide should all be carefully evaluated and considered. Furthermore, intensive scouting and detail recording keeping should be done so that applicators are aware of how they made the application and the results that they obtained so that they can maximize their applications. While there are trends that can be followed such as reducing droplet size to minimize pesticide drift or following the label to make sure that adequate carrier rates, nozzles and pressures are used, much of what needs to be done to maximize the efforts of applicators needs to be made through tweaking the system based on scouting and observations.

Conclusions

As we move to more sophisticated cropping systems where multiple herbicide modes-of-action are utilized simultaneously, applicators should be aware of the ideal application conditions for managing off-target movement and pesticide efficacy for each product they are spraying. Particularly, as 2,4-D- and dicamba-resistant crops are developed, basic principles of pesticide applications should not be forgotten. While tools such as the Enlist Duo, Engenia and Roundup Xtend will provide growers with newer and safer options, they like all pesticide applications, have the propensity to move off-target and should be stewarded in a safe and responsible manner.

Following label recommendations, spraying in appropriate wind speeds, keeping the boom at the correct height above the target, minimizing small droplets, and being cautious of environmentally sensitive areas near the application site are always recommended.

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NOT JUST GLYPHOSATE: ALTERNATIVE PROGRAMS APPROACH TO WEED MANAGEMENT

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WHY?

WHY?

WHY?

WHY?

WHY?

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WHAT DO WISCONSIN'S ATRAZINE PROHIBITION AREAS TELL US ABOUT WEED MANAGEMENT?

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INFLUENCE OF MANAGEMENT AND ATRAZINE USE ON LATE-SEASON WEED ESCAPES IN WISCONSIN CORN AND SOYBEAN FIELDS [1]

Ross A. Recker and Vince M. Davis[2]

Introduction

Atrazine provides effective control of many small and large seeded broadleaf weeds, as well as some grass weed species, in numerous grass crops such as corn. In Wisconsin, the use of atrazine is prohibited in areas where atrazine total chlorinated residues were once found in concentrations greater than 3 parts per billion in drinking water wells. Glyphosate-resistant weeds, confirmed in 32 states, continue to be a major threat to corn and soybean production across the Nation and Wisconsin. In Wisconsin, a population of both giant ragweed (*Ambrosia trifida*) and horseweed (*Conyza canadensis*) has been confirmed to be resistant to glyphosate (Stoltenberg et al. 2012; Recker et al. 2013). Integrated weed management tactics, including the use of multiple effective modes-of-action (MOA) against troublesome weeds are important to delay the onset of glyphosate resistance (Norsworthy et al. 2012). Identifying geographies that may be most vulnerable to glyphosate resistance development could help direct attention and pro-active resistance management tactics before wide-scale control failures occur (Davis et al. 2008). A pro-active survey of late-season weed escapes in corn and soybean fields was conducted throughout Wisconsin in 2012 and 2013. The objective of the late-season weed escape survey was to compare weed community composition in different types of management, including previous atrazine use, as well as identify areas where glyphosate-resistant weeds may first appear.

Materials and Methods

An online questionnaire was distributed through electronic newsletters and email list-serves to Wisconsin producers in June 2012 and 2013 to generate contact and field history information as well as permission to sample fields. Fields were sampled for weed escapes in late-July through mid-September with methods similar to those described by Thomas (1985). The surveyor walked 100 paces along the edge of the field and then 100 paces into the field. From there, an inverted W pattern was followed, and individual weeds were counted at five, one m^2 quadrats evenly spaced along each arm of the W for a total of 20 quadrats per field, spaced approximately 20 m apart. Weeds counted during the in-field sampling procedure were categorized as “expected escape” or “newly emerged” depending on whether they were mature weeds expected to produce seed or late-season weed seedlings. Only expected escapes are discussed in the results of this paper. Unadjusted frequency, uniformity (all fields), density (all fields), and density (occurrence fields) were calculated for each weed species according to Equation 1, 2, 3, and 4, respectively. Relative abundance was also calculated for each weed species as described by Thomas (1985). Relative abundance is an index that uses relative values of unadjusted frequency, uniformity (all fields), and density (all fields) to allow comparisons of the overall abundance between one species versus another. This index assumes that frequency, uniformity, and density are of equal importance.

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$$\text{Equation [1]} \quad \text{Unadjusted Frequency} = \frac{\text{number of fields where species occurred}}{\text{number of fields sampled}} \times 100$$

$$\text{Equation [2]} \quad \text{Uniformity All Fields} = \frac{\text{number of quadrats where species occurred}}{20 \times \text{number of fields sampled}} \times 100$$

$$\text{Equation [3]} \quad \text{Density All Fields} = \text{Number of plants m}^{-2} \text{ averaged across all fields}$$

$$\text{Equation [4]} \quad \text{Density Occurrence Fields} = \text{Number of plants m}^{-2} \text{ averaged across fields where the weed species was present}$$

Fields were grouped separately by region and past atrazine use. Region designations were modified from the National Agricultural Statistic Service (NASS) reporting districts as described in Table 1. Past atrazine use categories were defined as “recent” for fields where atrazine had been applied in the current (i.e. the year sampled) or the previous growing season (0-1 years), or “discontinued” for fields where atrazine had not been applied for ≥ 10 years. Fields not defined by those categories (22% of data) were not included for the comparisons of past atrazine use. Unadjusted frequencies were subject to either a chi-square test or Fisher’s exact test. Fisher’s exact test was used when the expected weed species frequency was less than 5, and therefore chi-square may not have been a valid test. Differences in density (occurrence fields) for each weed species were quantified using t-tests. Density data were transformed prior to analysis as suggested by the BoxCox method. Backtransformed data are presented for clarity.

Table 1. Region definitions based on NASS reporting districts

Region	NASS District
North Central (NC)	20
West (W)	40 & 70
Central (C)	50
South Central (SC)	80
East (E)	60 & 90

Results & Discussion

There were responses describing 357 fields from the on-line survey. Problematic weeds as indicated by the survey respondents are presented in Table 2. Only weeds that were reported as the most problematic for more than 10 fields are shown for brevity. The problematic weeds reported most often were common lambsquarters, foxtail species (primarily giant and yellow), velvetleaf, giant ragweed, and pigweed species (primarily redroot pigweed and waterhemp).

Table 2. Problematic weeds as indicated by on-line survey respondents.

Common Name	Number of responses	Percentage of fields
Common lambsquarters	256	72%
Foxtail	163	46%
Velvetleaf	149	42%
Giant ragweed	138	39%
Pigweed	105	29%
Yellow nutsedge	92	26%
Common ragweed	72	20%
Dandelion	47	13%
Quackgrass	40	11%
Wild proso millet	31	9%
Crabgrass	26	7%
Woolly cupgrass	26	7%
Common chickweed	24	7%
Thistles	23	6%
Fall panicum	18	5%
White cockle	17	5%
Common burdock	12	3%

The in-field survey consisted of sampling 343 fields. The number of fields in each categorical variable is displayed in Table 3. Eighty-nine different weed species were documented in total, of which, 64 were broadleaf species and 25 were grass species or plants resembling grass species. The weed species that had the highest relative abundance in all fields sampled were dandelion, common lambsquarters, giant foxtail, yellow nutsedge, and yellow foxtail. The unadjusted frequencies of weed species found are summarized by region in Table 4. To be concise, only weeds that occurred in more than four percent of the total number of sampled fields are shown in Table 4. Unadjusted frequency, uniformity (all fields), and density (all fields), and relative abundance are shown for both recent and discontinued atrazine use fields in Tables 5 and 6, respectively. The unadjusted frequencies of weed species and chi-square test results are summarized by past atrazine use in Table 7. Differences in density (occurrence fields) between fields with recent and discontinued atrazine use are summarized in Table 8. The top 20 most abundant weeds are shown in Tables 5 – 8 for brevity.

Table 3. The number of fields surveyed by past atrazine use and region.

	---------Tillage Practice---------			---------------------Region---------------------				
	Recent[1]	Transition[2]	Discontinued[3]	NC	W	C	E	SC
Fields Surveyed	160	71	109	42	97	51	52	101

[1] Fields where atrazine was applied during the current or previous growing season
[2] Fields where atrazine had not been applied for 2 – 9 years
[3] Fields where atrazine had not been applied for ≥ 10 years

Table 4. Unadjusted frequency of weed species that occurred in more than four percent of all fields, separated by region.

	Weed frequency by region						
Common Name	State	NC	W	C	E	SC	P-value[1,2]
	------------------------- % --------------------------						
Dandelion	32	64	20	41	19	33	**< 0.0001 ******
Common lambsquarters	27	38	18	35	27	27	**0.0648 ***
Velvetleaf	15	17	11	2	27	17	**0.0065 *****
Yellow nutsedge	15	26	15	8	12	14	0.1416
Fall panicum	13	17	14	8	12	14	0.7323
Giant foxtail	13	12	13	8	21	12	0.3561
Yellow foxtail	12	14	12	10	15	10	0.8367
Volunteer corn	9	2	12	4	10	10	0.2528
Nightshade	8	0	7	14	10	8	0.1282
Quackgrass	8	21	7	6	4	6	**0.0378 ****
Barnyardgrass	8	10	5	6	8	10	0.7305
Large crabgrass	8	2	10	18	2	5	**0.0141 ****
Common ragweed	7	10	1	18	12	4	**0.0007 ******
Giant ragweed	7	0	13	2	2	8	**0.0079 *****
Green foxtail	7	2	2	0	15	12	**0.0005 ******
Wild proso millet	6	5	2	12	8	8	0.1442
Ladysthumb	6	10	3	8	12	4	0.1607
Redroot pigweed	6	14	6	4	0	5	**0.0521 ***
Common waterhemp	5	2	5	0	2	11	**0.0328 ****
Woolly cupgrass	5	0	2	6	8	7	0.1641
Smooth crabgrass	4	14	3	10	2	0	**0.0003 ******

[1] P-Value Significance: 0 to 0.001 = '****'; 0.001 to 0.01 = '***'; 0.01 to 0.05 = '**'; 0.05 to 0.1 = '*'
[2] A significant p-value indicates a correlation between weed species frequency and region.

Table 5. Relative abundance of top 20 weed species in fields with recent atrazine use.

Common Name	Unadjusted Frequency	Uniformity (All fields)	Density (All Fields)	Relative Abundance	Recent[1] Rank
	--------- %	---------	plants m^{-2}		
Giant Foxtail	17	4.1	0.12	34.5	1
Dandelion	23	3.7	0.08	30.8	2
Yellow Nutsedge	14	1.8	0.09	21.9	3
Fall Panicum	16	2.5	0.05	20.9	4
Common lambsquarters	19	2.0	0.05	20.0	5
Yellow foxtail	10	2.2	0.06	18.1	6
Green foxtail	7	1.6	0.07	16.1	7
Volunteer corn	10	0.8	0.02	9.3	8
Waterhemp	4	1.0	0.04	9.1	9
Woolly cupgrass	4	0.8	0.03	8.5	10
Quackgrass	7	0.7	0.03	8.3	11
Velvetleaf	9	0.8	0.01	8.0	12
Wild proso millet	6	1.0	0.02	7.7	13
Giant ragweed	8	0.9	0.01	7.4	14
Black nightshade [2]	9	0.6	0.01	6.8	15
Common ragweed	5	0.9	0.01	6.7	16
Ladysthumb	5	0.7	0.01	6.0	17
Barnyardgrass	5	0.5	0.02	5.7	18
Smooth crabgrass	3	0.7	0.02	5.7	19
Volunteer soybean	2	0.8	0.02	4.9	20

[1] Recent refers to the 160 fields where atrazine had been applied in the current or previous growing season
[2] Black nightshade includes both black nightshade (*Solanum nigrum*) and eastern black nightshade (*Solanum ptychanthum*)

Table 6. Relative abundance of top 20 weed species in fields with discontinued atrazine use.

Common Name	Unadjusted Frequency	Uniformity (All fields)	Density (All Fields)	Relative Abundance	Discontinued[1] Rank
	--------- %	---------	plants m^{-2}		
Dandelion	31	6.0	0.13	31.8	1
Common lambsquarters	33	5.3	0.14	31.8	2
Giant foxtail	13	2.8	0.18	22.9	3
Velvetleaf	23	2.8	0.06	17.0	4
Large crabgrass	10	2.2	0.11	15.7	5
Fall Panicum	15	2.6	0.05	13.9	6
Yellow foxtail	16	2.1	0.06	13.7	7
Volunteer corn	10	1.2	0.08	11.3	8
Waterhemp	5	1.7	0.08	11.2	9
Yellow nutsedge	8	1.2	0.07	10.3	10
Barnyardgrass	13	1.6	0.03	9.7	11
Giant ragweed	8	1.7	0.03	8.4	12
Green foxtail	9	1.5	0.03	8.4	13
Quackgrass	6	1.3	0.04	7.5	14
Woolly cupgrass	6	1.3	0.03	6.7	15
Wild proso millet	6	1.0	0.02	5.8	16
Black nightshade [2]	9	0.9	0.01	5.6	17
Smooth crabgrass	4	0.8	0.03	5.4	18
Common ragweed	8	0.8	0.01	5.1	19
Volunteer alfalfa	5	1.1	0.02	4.9	20

[1] Discontinued refers to the 109 fields where atrazine has not been applied in ≥ 10 years
[2] Black nightshade includes both black nightshade (*Solanum nigrum*) and eastern black nightshade (*Solanum ptychanthum*)

Table 7. Unadjusted frequency of the top 20 abundant weed species statewide, separated by past atrazine use.

Common Name	Weed frequency by past atrazine use		
	Recent[1]	Discontinued[2]	P-value[3,4]
	---------------%---------------		
Dandelion	23	31	0.1107
Common lambsquarters	19	33	**0.0075 *****
Giant foxtail	17	13	0.3665
Yellow nutsedge	14	8	0.1660
Yellow foxtail	10	16	0.1696
Fall panicum	16	15	0.8321
Large crabgrass	3	10	**0.0324 ****
Velvetleaf	9	23	**0.0021 ****
Green foxtail	7	9	0.4901
Quackgrass	7	6	0.8839
Common waterhemp	4	5	0.7336
Volunteer corn	10	10	0.9804
Common ragweed	5	8	0.2811
Smooth crabgrass	3	4	1.0000
Barnyardgrass	5	13	**0.0212 ****
Wild proso millet	6	6	0.9546
Giant ragweed	8	8	0.8203
Woolly cupgrass	4	6	0.4581
Black nightshade[5]	9	9	0.9046
Ladysthumb	5	4	0.7669
All broadleaves	60.6	73.4	**0.0302 ****
All grasses	53.8	62.4	0.1599

[1] Recent refers to the 160 fields where atrazine had been applied in the current or previous growing season

[2] Discontinued refers to the 109 fields where atrazine has not been applied in ≥ 10 years

[3] P-Value Significance: 0 to 0.001 = '****'; 0.001 to 0.01 = '***'; 0.01 to 0.05 = '**'; 0.05 to 0.1 = '*'

[4] A significant p-value indicates a correlation between weed species frequency and past atrazine use.

[5] Black nightshade includes both black nightshade (*Solanum nigrum*) and eastern black nightshade (*Solanum ptychanthum*)

Table 8. Density (occurrence fields) of the top 20 abundant weed species statewide, separated by past atrazine use.

Common Name	Density by past atrazine use Recent[1]	Discontinued[2]	Tansformation[3]	t-test
	----------plants m^{-2} -----------			P-value
Dandelion	0.11	0.12	1/√(x)	0.5439
Common lambsquarters	0.09	0.15	1/√(x)	**0.0434 ****
Giant foxtail	0.35	0.38	ln(x)	0.8432
Yellow nutsedge	0.24	0.21	ln(x)	0.8283
Yellow foxtail	0.28	0.19	ln(x)	0.3275
Fall panicum	0.18	0.15	ln(x)	0.7377
Large crabgrass	0.09	0.17	1/√(x)	0.2549
Velvetleaf	0.07	0.12	1/√(x)	**0.0571 ***
Green foxtail	0.37	0.21	ln(x)	0.3815
Quackgrass	0.21	0.52	ln(x)	0.1016
Common waterhemp	0.21	0.76	ln(x)	0.2837
Volunteer corn	0.13	0.26	ln(x)	0.1959
Common ragweed	0.10	0.09	ln(x)	0.7341
Smooth crabgrass	0.22	0.35	ln(x)	0.6663
Barnyardgrass	0.07	0.08	1/x	0.8543
Wild proso millet	0.09	0.17	1/√(x)	0.1852
Giant ragweed	0.12	0.28	ln(x)	**0.0210 ****
Woolly cupgrass	0.29	0.29	ln(x)	0.9768
Black nightshade[4]	0.07	0.10	1/√(x)	0.1367
Ladysthumb	0.15	0.08	1/√(x)	**0.0965 ***
All broadleaves	0.19	0.40	ln(x)	**0.0001 ******
All grasses	0.48	0.39	ln(x)	0.3934

[1] Recent refers to the 160 fields where atrazine had been applied in the current or previous growing season
[2] Discontinued refers to the 109 fields where atrazine has not been applied in ≥ 10 years
[3] Type of transformation as suggested by BoxCox method
[4] Black nightshade includes both black nightshade (*Solanum nigrum*) and eastern black nightshade (*Solanum ptychanthum*)

Many species had a frequency that was correlated to region, including both giant and common ragweed. Interestingly, the frequencies of these weeds are inversely related. Common ragweed has higher frequencies in regions where giant ragweed frequencies were low, and vice versa. Waterhemp, a weed of national glyphosate-resistance concern, was found in all regions of the state besides the central region. The statewide frequency of expected waterhemp escapes was 5% and its highest frequency was in the south central region at 11%.

There were differences in the rankings of weed species between recent and discontinued atrazine use fields. The overall trend was that many grass species had a higher relative abundance in fields where atrazine has been recently used, while many broadleaf species had a higher relative abundance in fields where atrazine has not been applied for ≥ 10 years. Total broadleaf escapes were more frequent in fields where atrazine use had been discontinued compared to recent use, primarily driven by more common lambsquarters and velvetleaf escapes. Total broadleaf escapes were more dense, especially common lambsquarters, velvetleaf, and giant ragweed, in fields where atrazine use had been discontinued compared to recently used. In conclusion, weed communities are comprised of more frequent, dense, and in some cases abundant broadleaf weed species in fields where atrazine use has been discontinued compared to recent atrazine use.

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BIG EQUIPMENT AND SPRAY TECHNOLOGY

Greg Kruger [1/]

Overview

Applying pesticides efficiently and effectively is critical for the success of the application. Both management of the pest and mitigation of deleterious effects (drift mitigation) are essential for every pesticide applicator to consider. An in-depth write-up on pesticide applications can be found under "Role of adjuvants and nozzles in managing drift: Lessons from wind tunnel, greenhouse and field studies". In that section, information on nozzle selection, droplet size, adjuvants and other equipment related inputs can be found.

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GRAIN AND WAREHOUSING UPDATES

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FEED UPDATES

Lori Bowman [1/]

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OSHA ISSUES NEW SWEEP AUGER INTERPRETATION POLICY MEMO

Jim Nolte [1/]

Over the past several years there has been uncertainty within the grain handling industry on what type of sweep-auger equipment can be used and the types of procedures the Occupational Safety and Health Administration (OSHA) may find acceptable.

In 2009, OSHA issued a letter of interpretation that essentially created a new policy for operating sweep augers inside grain bins. In the letter, OSHA stated an employee cannot work inside a bin with an energized sweep auger, unless the auger was "completely guarded." The Agency did not offer any acceptable alternative procedures for removing grain from a bin if a partially guarded auger cannot be used, nor did OSHA define what is meant by completely guarded or unguarded. Prior to the letter, it was common practice in the industry to "guard", or cover the top and back of the auger while in operation. Following the letter, OSHA stated that the entire auger, including the front, needed to be covered. However, a sweep-auger cannot properly function if it is completely guarded.

As a result, OSHA issued numerous citations to grain-handling facilities for allowing employees to work around "unguarded" sweep augers. This caused confusion within the industry since many were unsure of what type of sweep-auger equipment could be used and the types of procedures OSHA may find acceptable.

Not long ago, an Illinois grain company legally challenged OSHA citations they had received based on the 2009 letter of interpretation. Following a settlement agreement in early 2013, OSHA released a sweep auger policy memo in May of 2013. In total, there are 10 criteria outlined in the memo regarding employee entry into bins with mobilized sweep augers. The entire document is based mostly upon the existing requirements under 29 CFR 1910.272 or OSHA's Grain Handling Standard as well as both engineering and administrative controls.

This presentation will review these 10 criteria in detail and provide examples of engineering controls that can be utilized to comply with OSHA's new sweep auger interpretation policy memo. The PowerPoint presentation is available for viewing on the WABA website at www.wiagribusiness.org. The May 3rd 2013 policy memo can be viewed on OSHA's website at www.osha.gov.

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LEGISLATIVE UPDATES ON ISSUES IMPORTANT TO AGRICULTURE

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RUNOFF LOSSES FROM CORN SILAGE-MANURE CROPPING SYSTEMS

Bill Jokela[1], Mike Casler[2], and Mike Bertram[3]

Introduction

Transport of phosphorus (P), nitrogen (N), sediment, and pathogens via runoff from crop fields, especially where manure has been applied, can contribute to degradation of surface waters, leading to eutrophication and potential health effects. In the dairy cropping system of Wisconsin and most of the northern dairy belt, the silage corn phase of the rotation is the most susceptible to runoff and erosion losses because of the lack of protective crop residue and regular applications of livestock manure. We initiated this study to evaluate cropping systems to minimize adverse water quality impact, while maintaining or increasing nutrient efficiency and productivity.

The objective of this study was to evaluate field runoff losses of nutrients and pathogens from different manure/crop/tillage management systems for silage corn production. We chose to use a paired watershed design, rather than conventional replicated field plots, because the larger field-scale units provide data that more adequately reflects the more complex hydrology of the real-world landscape.

Methods

The 16-acre field site is at the UW/USDA-ARS Research Station near Marshfield in central Wisconsin. The soil is a somewhat poorly drained Withee silt loam soil with 1-3% slope and is representative of soils used for dairy farm production in that area. Surface drainage on this somewhat poorly-drained soil is accomplished using drive-through diversions and berms, which also served to divide the field into four drainage areas or “watersheds” of approximately 4 acres each (Fig. 1). Initial soil tests showed pH values of 5.9-6.3 and soil test P of 25-34 mg/kg Bray P_1.

Runoff monitoring stations set up in each of the fields consisted of a 24-inch H-flume with an approach channel, wing-walls, and earthen berms. Time-based runoff samples were collected by an automated 24-bottle (1 liter) refrigerated ISCO sampler. A datalogger was used to control sampling scheme and data collection, radio telemetry facilitated remote access and program modification, and tipping bucket rain gages provided precipitation data. Runoff samples from individual bottles were combined into flow-weighted composites and analyzed for total P (TP), dissolved P (DP), total N, NO_3-N, NH_4-N, and suspended sediment (SS). For more detail about methods see Jokela and Casler (2011). The focus of this paper will be on SS and P in runoff. Additional samples for pathogen analysis were collected using a flow-through glass wool filter system but pathogen data is not reported in this paper.

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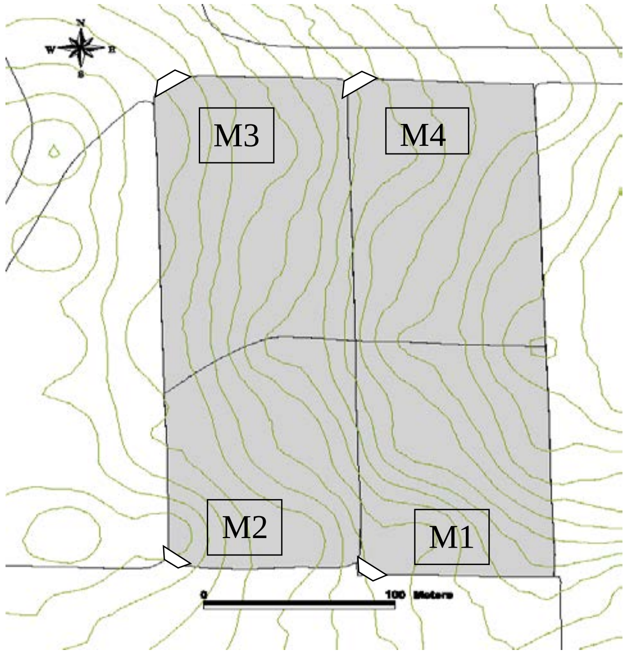

Figure 1. Map of field site showing four drainage areas, or fields, and runoff monitoring stations (trapezoid symbols). Contour lines represent 1 foot elevation differences.

The paired watershed technique used in this study requires two or more similar watersheds (control and one or more treatment watersheds) and two periods of study -- calibration and treatment. The term "watershed", in this case, refers to individual fields or portions of fields that comprise well-defined surface drainage areas that can be separately monitored for runoff. During the calibration period, all four "watersheds", or fields, were managed the same and event-based runoff and nutrient data were collected. The calibration period for our study began in August 2006 after installation of runoff monitoring and sampling stations for each of the four fields. Management during the calibration period, typical of that on dairy operations in central WI, consisted of fall application of liquid dairy manure, in this case applied at a rate to meet approximately 80% of the crop N need, chisel plowing the same day, and spring field cultivation. The calibration period ended and the treatment period began in early October 2008. Regression equations were developed for each runoff variable between the control field and each of the other three fields.

During the treatment period, management remained the same in the control field, which served as a check on weather and other year-to-year variation, and different management systems were implemented on the others. Treatments were as follows: 1) Control - fall manure, fall chisel plow (M1), 2) Cover crop (fall-seeded rye), spring manure and chisel plow (M2), 3) Fall surface-applied manure with spring chisel plow (over-winter manure, M3), and 4) Fall manure and chisel plow with permanent vegetative buffer strips/grassed waterways (M4). Manure application rates averaged 5100 gal/acre with average nutrient application rates of 145, 75, 53, and 148 lb/acre of total N, NH_4-N, P_2O_5, and K_2O and average solids content of 13.3%.

The treatment period ended in April 2012 and regression equations between each treatment field and the control field were developed for each variable. Treatment and calibration period regressions were compared statistically using a permutation test to determine if there was a significant effect of each treatment. A quantitative measure of the treatment effect, e.g. the increase or decrease of runoff total P concentration, was determined by comparing the percent change during the treatment period compared to the change that would have been expected based on the calibration period relationship. With the paired-watershed design, statistical comparisons can only be made between each treatment and the control, not between all combinations of treatments.

Results and Discussion

Runoff concentrations during the treatment period varied by field and averaged 1.4 mg/liter (or ppm) total P and 0.24 mg/L dissolved P. Concentrations from snowmelt-derived events only were lower in total P (0.6 mg/L) but higher in dissolved P (0.35 mg/L), reflecting the lower concentration of suspended sediment in snowmelt runoff (about 20% of that for all events). Annual export, or load, during the treatment period also varied with treatment but averaged 3.2 lb total P and 0.33 lb dissolved P per acre. Snowmelt-derived runoff averaged almost 40% of the total but contributed only 11% of the export of total P, most of which is associated with eroded sediment. This is in contrast to dissolved P, close to half (45%) of which was snowmelt-derived.

Cumulative runoff, suspended sediment load, and total P load from the four watersheds for the entire study period, both calibration and treatment periods are shown in Figures 2 and 3. Two main observations can be made:

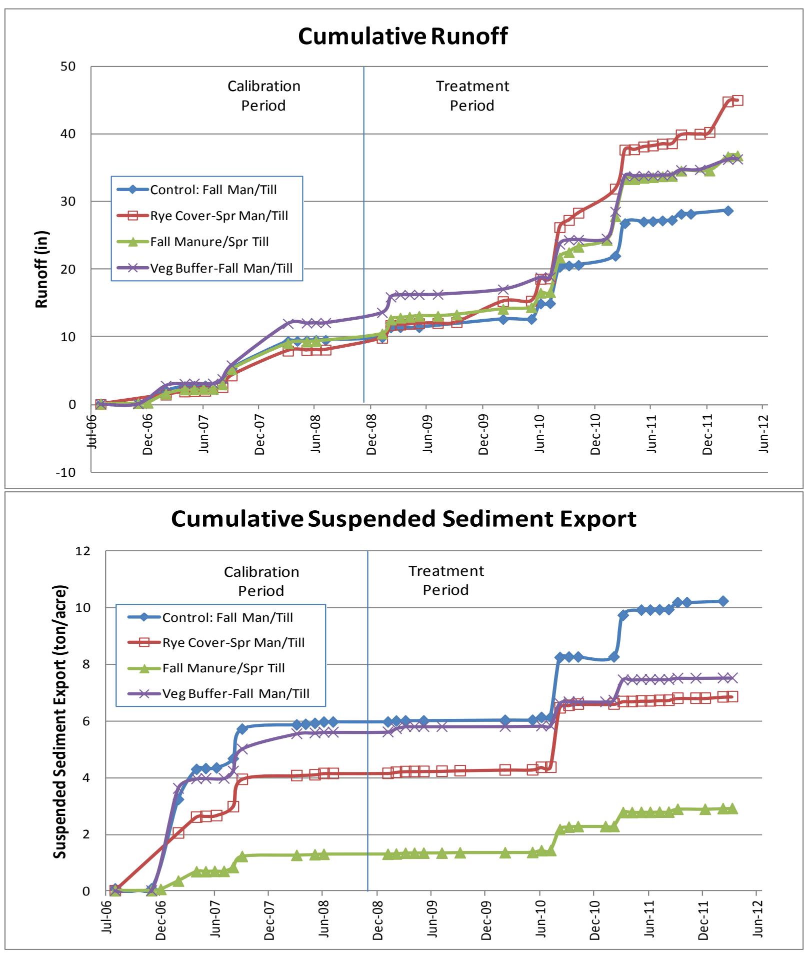

Figure 2. Cumulative runoff and export of suspended sediment for each of four fields during the calibration and treatment periods.

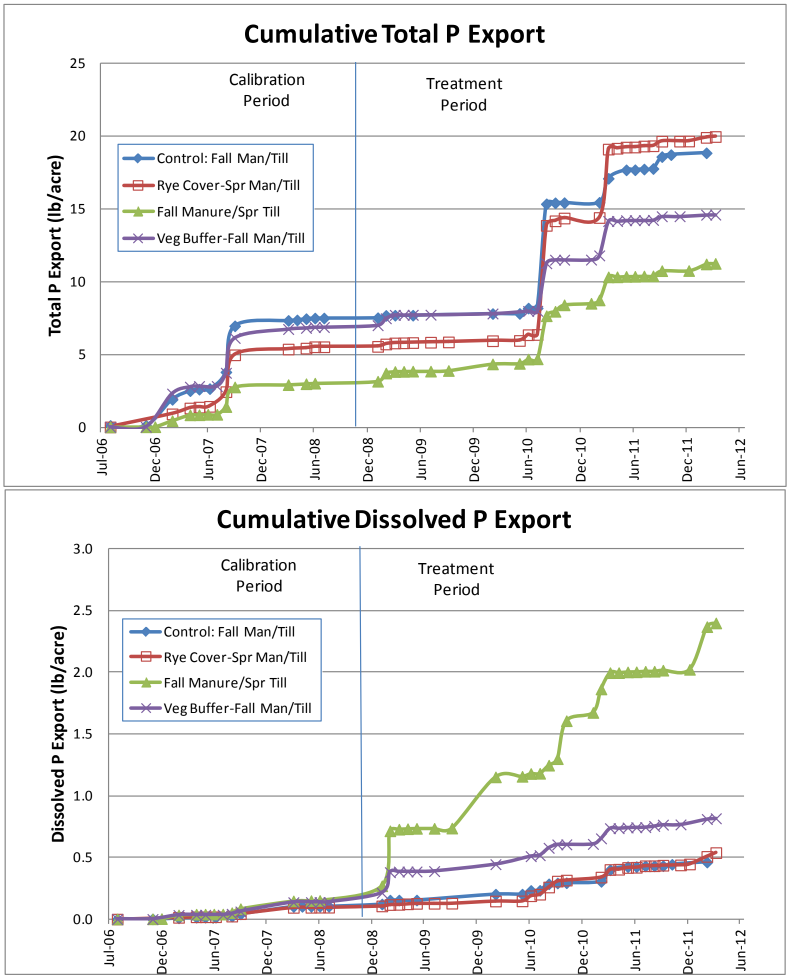

Figure 3. Cumulative export of total P and dissolved P for each of four fields during the calibration and treatment periods.

a) Most of the runoff and export occurred in relatively large events during snowmelt periods or, in some cases, in the fall. A particularly large fall runoff event occurred in September of 2010 when heavy rains resulted more than twice the monthly average precipitation.
b) Patterns over time were relatively similar for all four fields during the calibration period. However, during the treatment period when management was different for each field, some shifts in position relative to the control occurred, suggesting effects due to the change in management. Most pronounced was the dramatic increase in dissolved P export from the fall manure/spring till (over-winter manure) treatment. Note also that almost all of the export from that treatment occurred during snowmelt (primarily March) events.

Regression analysis showed that all three treatments significantly reduced SS concentrations in runoff, and the rye cover-spring manure and vegetative buffer treatments reduced TP concentrations. However, not unexpectedly, concentrations of TP and DP increased in the over-winter manure treatment (fall manure-spring till), DP more than two-fold.

There were fewer significant treatment effects on sediment and nutrient export, or load, which is the product of concentration and runoff volume. Greater variability affected statistical significance and, in some cases, an increase in runoff counteracted a reduction in runoff concentration. The rye cover treatment resulted in a small (9%) decrease in SS export, and the vegetative buffer reduced both SS (62%) and TP (42%) export. Dissolved P export increased in all management treatments, most markedly by three-fold from over-winter manure, a result to be expected from manure left on the soil surface during winter and early spring snowmelt and rain runoff events. This is consistent with observations noted earlier based on graphs of cumulative dissolved P export (Fig. 3). The lack of beneficial effects on dissolved P from the other treatments is not totally unexpected because cover crops and vegetative buffers are designed primarily for erosion control, so are more effective for sediment-bound nutrients than for dissolved forms. Furthermore, at least at our site, leaving the soil surface untilled through the winter-spring period, combined with minimal growth of the rye cover, resulted in an increase in runoff quantity compared to the fall chisel plowed control, which provided some storage for runoff due to the rough surface.

Summary

- Snowmelt-derived runoff was important, representing 11 to 45% of the P and N export, averaged across treatments. It may be more difficult to control with conventional practices designed for control of erosion from rain-derived runoff.
- Surface-applied over-winter manure (fall manure/spring till treatment) increased total P and, especially dissolved P, runoff concentrations and dissolved P export (3 x Control). Over-winter manure decreased suspended sediment concentrations, presumably due to the mulching effect of the surface manure.
- Rye cover crop with spring manure and tillage decreased runoff suspended sediment, total P, and dissolved P concentrations and suspended sediment export, but not total P or dissolved P export. Reduced concentrations indicate a potential for beneficial effects, but effectiveness was limited by poor rye growth and increased runoff volume.
- The vegetative buffer/waterway system was the most effective management system in this study, resulting in (slightly) decreased runoff and decreased concentration and export of suspended sediment and total P (but not dissolved P).
- None of the manure-crop management systems were effective in controlling dissolved P in runoff. This poses a challenge to develop systems that go beyond those practices designed for control of erosion and sediment-bound nutrients.

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MONITORING AND PREDICTING PHOSPHORUS LOSS FROM WISCONSIN DAIRY GRAZING FARMS

Peter Vadas and Mark Powell [1/]

Non-point source pollution of surface water by nutrients such as phosphorus can degrade water quality for drinking, recreation and industry. When excess nutrients accumulate in lakes and reservoirs, water quality issues such as algal blooms often result. Because agriculture has been identified as a source of non-point phosphorous pollution, there has been a strong push to identify and manage farm sources of phosphorus runoff. On dairy farms, possible sources of this runoff include cropland, grazed pastures and outside cattle holding areas such as feedlots, barnyards and overwintering lots. In the United States, research on phosphorous loss due to runoff from grazed pastures has been limited.

Physically monitoring phosphorous loss from farms is an expensive, lengthy process. Simulation models are potentially a more rapid, cost-effective way to estimate phosphorous loss from farms. Agriculture Research Service soil scientist Peter Vadas, who works at the U.S Dairy Forage Research Center in Madison, worked with a team of USDA scientists to develop the Annual Phosphorous Loss Estimator (APLE) spreadsheet, which predicts the phosphorous lost through runoff for diverse types of farms and field conditions. APLE is free to download at http://ars.usda.gov/Services/docs.htm?docid=21763.

Building on this work, Vadas, along with Mark Powell and Geoff Brink from the Dairy Forage Research Center and Dennis Busch from UW-Platteville, monitored phosphorus loss in runoff from grazed pastures and used APLE to predict phosphorus runoff from grazing farms. This research took place from 2010-2012 at the UW-Platteville Pioneer Farm and four Wisconsin grazing farms, and was funded by the WI DATCP Grazing Lands Conservation Initiative (GLCI). The researchers monitored phosphorous loss due to runoff from beef and dairy grazed pastures at the Pioneer Farm. They used this data to validate that APLE can reliably predict phosphorus loss from grazed pastures. They then used APLE to simulate phosphorous loss from the four farms, all of which use managed grazing. The focus of this brief is on the modeling results from these farms.

The researchers visited each farm three times in January, June and November 2011 to gather seasonal information about farm management. Questionnaires completed by each farm provided snapshot assessments of cattle, feed, fertilizer, manure and cropping management. Using this information, the researchers modeled year-round, whole-farm phosphorus losses under typical management for each farm.

The Four Study Farms

Farm A, located in southwestern Wisconsin, has an annual average of 40 milking cows, 20 heifers and one or two dry cows. This farm has about 100 acres of cropland in a six-year rotation, with one year of corn silage (20 acres), and one year of an oats/grass/alfalfa seeding mix followed by four years of an alfalfa/grass hay mix (80 acres). The farm has 44 acres of pastures rotated for milking cows and 28 acres of non-rotated pastures for dry cows and heifers; the hay ground is also grazed. There are two outdoor lots totaling 1.5 acres used for overwintering cows. Soils are mostly silt loams, with some fairly steep slopes. There is no manure storage on this farm.

Farm B, also in southwestern Wisconsin, has an annual average of 118 milking cows, 92 heifers, 23 dry cows and 20 beef steers. The farm rents 200 acres of cropland under no-till management with a five-year rotation: two years of corn silage (80 acres), and one year of an oats/grass/alfalfa seeding mix, followed by two years of an alfalfa/grass hay mix (120 acres). The home farm has about 120 acres of rotated pasture for lactating cows, and 100 acres of non-rotated pasture are rented locally for dry cows, heifers and steers. There is one quarter-acre barnyard, and 2.5 acres of lots on the home farm are used for overwintering and housing young stock year-round. Soils are mostly silt loams, often on steeper slopes. There is a small pit on the home farm that stores manure from the parlor, barn and half of the barnyard.

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Farm C in north-central Wisconsin has an annual average of 164 lactating cows, 130 heifers and 17 dry cows. There are 226 acres of pasture at the home farm, and the farm locally rents 70 acres of grass hay ground. A two-acre dry lot next to the barn is used for freshening cows and, infrequently, for milking cows in the winter. Milking cows are in the barn, barnyard and dry lot from December 1 to February 1. As they dry off, they are moved to overwintering areas until April 1. These overwintering areas are several-acre portions of pasture, with a different area used each winter. From April 1 to December 1, milk cows graze pastures with some time spent in the barn on hot days. Soils are silt loams with mild slopes. There is a pit on the home farm that stores manure from the parlor, barn and barnyard.

Farm D, also in north-central Wisconsin, annually averages 60 milking cows, 46 heifers, 21 calves and nine dry cows. It has 110 acres of cropland in a six-year rotation, with three years of corn (30 acres in corn silage and 30 acres in grain), and one year of an alfalfa/grass seeding mix followed by two years of an alfalfa/grass hay mix (50 acres). The farm has 70 acres of rotated pasture for lactating cows and 30 acres of non-rotated pasture for dry cows, heifers and calves. The heifers also graze about 70 acres of woods near the crop ground. There is one 0.2-acre barnyard and one half-acre dry lot for cows and heifers. Soils are silt loams with mild slopes. Manure from the parlor and barn is stored in a pit.

Details of APLE-simulated total P lost from four Wisconsin grazing dairy farms

Land use	Acres	Total P loss (lbs/acre)	% of farm area	% of Total Farm P Loss
		Farm A		
Corn silage	16.7	4.9	9.6	22.0
Hay, all*	83.5	2.0	48.1	44.8
Pastures	72	0.7	41.4	13.1
Cattle lots	1.5	50.2	0.9	20.1
Whole farm		2.4		
		Farm B		
Corn silage	80	1.8	18.8	21.2
Hay, all	120	1.3	28.2	23.4
Pasture, all	221.5	0.6	52.1	18.6
Cattle lots and barnyard	3.5	79.2	0.9	36.7
Whole farm		1.6		
		Farm C		
Hay, all	70	0.2	21.5	5.6
Pasture	226	0.5	69.3	37.3
Overwintering pasture	28	2.2	8.6	20.7
Cattle lot	2.0	54.1	0.6	36.4
Whole farm		1.2		
		Farm D		
Corn, all	60	5.4	21.4	60.9
Hay, all	50	1.7	17.9	15.7
Pastures	169	0.5	60.4	15.6
Cattle lots and barnyard	0.7	59.1	0.3	7.7
Whole farm		1.9		

*Runoff, erosion, and total P loss was always higher in the seed year of hay than in established hay fields

Findings from the Simulations

Whole-farm phosphorus loss per unit of land on the grazing farms was relatively low, ranging from 1.2 to 2.4 lbs./acre. This compares well to the WI 590 Nutrient Management Standard 590 where the risk of runoff phosphorus as determined by the Phosphorus Index must be at or below 6 lb/acre in order to apply manure to a field. Phosphorus loss from pastures was consistently very low. This demonstrates that these types of grazing farms as a whole may not represent significant sources of phosphorus loss to the environment.

However, some land uses on these grazing farms have the potential for significant phosphorous loss. While barnyards, dry lots and overwintering areas tend to be a small portion of each farm, phosphorus loss per unit of land area can be high. This is expected, since these areas can have high manure and animal densities. These areas represented seven to 57 percent of total farm phosphorus loss, depending on lot management and phosphorus loss from other farmland uses. Farm management options to decrease phosphorus loss in these areas include frequent cleaning of barnyards and containing runoff in a storage area. Corn fields and and hay fields in a seeding year also have the potential for high phosphorus loss due to the increased risk of soil erosion and sediment loss. In general, the simulation results showed that the greatest variability in phosphorous loss was due to erosion. When erosion was low, total phosphorous loss was also low. No till practices are a management option to reduce phosphorus loss due to erosion in cropland.

Overall, the project demonstrates how simulation models can be reliably used to identify areas on dairy farms with the high potential for phosphorus loss, which in turn helps to target cost and environmentally effective management alternatives.

PLANT TISSUE TESTING IN WISCONSIN: WHAT'S NEW?

John B. Peters[1] and Carrie A. M. Laboski[2]

Interest in plant tissue testing as a tool to help diagnose the plant nutrient status of crops has increased greatly in the past few years. Results of tissue testing along with a soil test can provide a valuable guide to more efficient crop production. Soil tests provide a good estimate of lime and general fertilizer needs. By adding tissue analysis data, the user is able to better evaluate fertilizer and management practices more accurately by providing a thorough nutritional view of the crop. Several key uses of plant analysis include: evaluation of fertilizer efficiency, determination of availability of elements for which reliable soil tests are not available, and the ability to evaluate the interaction among plant nutrients.

In a healthy plant, all essential elements are present at appropriate levels and in proper proportions relative to each other. Plant growth is restricted when: not enough of one or more elements is present; too much of one or more elements is present, including toxic levels of nonessential elements such as aluminum, arsenic, selenium, or sodium; or the levels of one or more elements is adequate but out of balance with other elements. Typically, the first result of nutrient deficiency, toxicity or imbalance is a reduction in the growth of the plant. If the condition worsens, visible deficiency symptoms appear and plant yield is further reduced. Severe deficiencies or toxicities can kill plants or weaken them to the point that they are more vulnerable to other stresses, such as disease or insect attack.

Plant Analysis in the Midwest

Of the twelve states making up the North Central region, eight maintain some form of public soil and plant analysis laboratory. All of these states provide plant analysis services to research and in many cases commercial clients as well (Table 1). Of these states, two provide only raw data to clients while the others provide an interpretation of sufficiency levels based on in-state research results in combination with interpretations derived from the literature.

Table 1. Status of plant tissue analysis in the North Central Region.

State	Data Only	Interpretation from literature + local data	Field research ongoing
Iowa	X		Yes
Kansas		X	Yes
Michigan		X	Yes
Minnesota		X	Yes
Missouri		X	No
North Dakota	X		Yes
South Dakota		X	Yes
Wisconsin		X	Yes

Nearly all states have some active research ongoing to help refine and update the interpretation levels used in their state. Most states are gathering data on corn, soybeans and wheat but many are also working on specialty crops where little previous data had existed.

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Sampling Guidelines for Wisconsin

Collecting a proper sample is critical for plant tissue analysis as plant nutrient composition varies with age, the portion of the plant sampled, and many other factors. The standards against which the samples are evaluated, have been selected to represent the plant part and time of sampling that best define the relationship between nutrient composition and plant growth. Deviating from the prescribed protocol severely limits the ability to interpret results. Therefore, it is critical to follow a standard sampling procedure.

Table 2 lists the proper stage of growth, plant part, and number of plants to sample for some key agronomic and horticultural crops. If the tissue sample is collected at any other time in the growing season, it may not be possible to interpret the results properly. However, when plant analysis is being used to confirm a suspected nutrient deficiency, the samples should be taken as early in the season as possible so that the deficiency can be corrected and minimize the potential yield loss. Plants showing abnormalities usually continue to accumulate nutrients even if growth is impaired by some limiting factor. Samples should not be taken from plants that obviously have been stressed from causes other than nutrients. Do not take samples from plants that; 1.) are dead or insect damaged, 2.) are mechanically or chemically injured, 3.) have been stressed by too much or too little moisture, or 4.) have been stressed by abnormally high or abnormally low temperature.

Table 2. Recommended stage of growth, plant part and sample size for tissue testing

	Stage or growth	Plant part	No. of plants to sample
<u>Field crop</u>			
alfalfa	bud to first flower	top 6 inches	35
alfalfa	harvest	whole plant	25
barley	prior to heading	newest fully developed leaf	50
bluegrass	prior to heading	newest fully developed leaf	50
bromegrass	prior to heading	newest fully developed leaf	50
corn, field	12 inches tall	whole plant	20
corn, field	pre-tassel	leaf below whorl	15
corn, field	tassel to silk	ear leaf	15
pea, canning	prior to or at initial flower	newest fully developed leaf	25
potato	prior to or at initial flower	4th petiole and leaflet	40
potato	tuber bulking	4th petiole and leaflet	40
red clover	bud to first flower	top 6 inches	35
soybean	prior to or at initial flower	newest fully developed leaf	25
wheat	tillering - prior to heading	newest fully developed leaf	50
<u>Veg crop</u>			
beet, red	mid-season	youngest mature leaves	20
cabbage	mid-season	wrapper leaves	20
carrot	mid-season	youngest mature leaves	20
ginseng	mid-season	youngest mature leaves	35
onions	mid-season	tops, no white portion	20
squash	prior to or at early fruit development	newest fully developed leaf	25
tomato	mid-season	newest fully developed leaf	40

Fruit crop			
apple	current season shoots (July 1-15)	fully developed leaf at mid-point of new shoots	4 lvs
blueberry	new summer growth	fully developed leaf	35
cherry, sour	current season shoots (July 1-15)	fully developed leaf at mid-point of new shoots	4 lvs
cranberry	Aug 15 - Sept 15	current season growth above berries	200 uprights
grape	full bloom	newest fully developed petiole	5 from each of 10 vines
raspberry	Aug 10- Sept 4	6th and 12th leaf blade and petiole from tip	2-3 lvs from 10 canes
strawberry	at renovation before mowing	fully developed leaflets and petioles	40

When a nutrient deficiency is suspected, or there is a need to compare different areas in a field, it is recommended that similar plant parts be collected separately from both the affected plants and adjacent normal plants that are at the same stage of growth. In this way, a better evaluation can be made between the nutritional status of healthy and abnormal plants of the same variety grown under the same conditions.

Interpretation of Tissue Analysis Values for Wisconsin

Depending on the crop, plant part and stage of growth sampled, there are a number of ways in which tissue analysis data is reported and interpreted. The UW Soil and Plant Analysis Laboratory uses three approaches for interpreting tissue analysis results. These include the use of a sufficiency range approach (SR), the diagnosis and recommendation integrated system approach (DRIS), and the plant analysis with standardized scores (PASS) system. Essentially, the SR approach looks at one element at a time using critical levels for that element. The DRIS system uses two or more elements at a time to develop an index. PASS attempts to combine the fixed and variable features of the SR and DRIS systems.

The SR system uses the critical level approach in which the critical level corresponds to 90-100% of maximum yield on a yield vs. nutrient concentration graph. The sufficiency approach interprets the plant nutrient levels as being in a range considered to be adequate (sufficient) or below (deficient) or above that range (high). The advantages of this approach include that it is simple to determine and interpret and the values are independent as the level of one nutrient does not affect the classification of another nutrient. Some disadvantages include the fact that there are too few categories to adequately distinguish a low from a very low for example, it does not rank the nutrients to determine which is most limiting, it is very sensitive to plant maturity and plant part sampled. The following crops can be interpreting by SPAL using the sufficiency approach. Alfalfa; apple; asparagus; barley; bean, dry; bean, lima; bean, snap; beet, red; black oak; blueberry; bluegrass; broccoli; brome grass; brussel sprouts; buckwheat; cabbage; canola; carrot; cauliflower; celery; cherry; cranberry; cucumber; fescue, fine; field corn; ginseng; grape; lettuce; lupine; millet; mint; muskmelon; oat; onion; orchard grass; pea, canning; pea, chick; pepper; post oak; potato; pumpkin; raspberry; red clover; red clover hay; rye; sorghum, grain; sorghum-sudan; soybean; spinach; squash; strawberry; sugar beet; sunflower; sweet corn; tobacco; tomato; trefoil; triticale; vetch, crown; watermelon; and wheat.

The DRIS system is based on taking the ratio of all possible pairs of nutrients. These sample ratios are compared with ratios that are normal for high-yielding crops using a relatively complicated standardization formula. The standard scores for each nutrient are averaged to get one index per nutrient. Zero is the optimum, while negative index values indicate that the nutrient level is below optimum and the more negative the index the more deficient the nutrient. Similarly, the more positive the index, the more excessive the nutrient is above normal. The advantages of DRIS include that the nutrients are ranked from most deficient to most excessive and the scale is continuous and easily interpreted. Disadvantages include that the computations are complicated and the indices are not independent. Because of this, the level of one nutrient can have a marked effect on the other indices. DRIS interpretations can be made by SPAL for alfalfa; apple; field corn; lettuce; and soybeans.

The PASS system is a hybrid system that has two components. One is based on the independent nutrient index approach as in the SR system, and the other based on a dependent nutrient index approach as in the DRIS system. In Wisconsin, data is available to perform PASS analysis on alfalfa; field corn; and soybeans.

Summary of Sufficiency Range Results

The results for tissue analyses performed at the UW Soil and Plant Analysis Laboratory in the past eleven years are summarized in tables 3-8. Only the results of plant materials that were tested at least 100 times or more are included in these tables. Since plant analysis is used as the primary guide for making nutrient application recommendations for fruit crops, it is not surprising to see many of the most commonly grown fruit crops on this list. In addition, the dominant agronomic crops for the state are also represented as tissue testing is used to help diagnose nutrient deficiencies or imbalances for these crops under certain circumstances.

Table 3.	**Nitrogen (%)**				**Phosphorus (%)**			
Crop	**Min**	**Max**	**Median**	**Sufficiency Range**	**Min**	**Max**	**Median**	**Sufficiency Range**
Cranberry	0.04	9.7	0.91	0.9 - 1.1	0.04	1.17	0.15	0.10 - 0.20
Apple	0.61	3.22	1.96	1.9 - 2.2	0.09	2.24	0.19	0.20 - 0.21
Field corn-tassel to silk	0.35	5.23	2.46	2.5 - 3.33	0.10	1.17	0.31	0.25 - 0.34
Field corn-12" tall	0.97	6.59	3.43	3.5 – 5.0	0.09	4.00	0.41	0.30 - 0.50
Alfalfa	0.07	6.16	3.46	2.5 – 4.0	0.12	0.86	0.40	0.25 - 0.45
Soybean	0.35	6.37	3.94	4.2 - 5.4	0.08	2.11	0.43	0.30 - 0.70
Field corn-pre-tassel	0.76	5.09	3.04	3.0 - 3.5	0.14	1.12	0.35	0.25 - 0.45
Grape	0.45	4.71	0.92	0.85 - 1.25	0.03	1.03	0.29	0.14 - 0.30
Strawberry	0.88	2.95	1.53	2.1 - 2.9	0.08	0.45	0.26	0.24 - 0.30
Blueberry	0.91	2.57	1.58	1.7 - 2.1	0.07	0.80	0.10	0.10 - 0.40
Cherry	1.64	3.81	2.33	2.1 - 2.6	0.07	0.42	0.18	0.20 - 0.25

Table 4.	Potassium (%)				Calcium (%)			
Crop	**Min**	**Max**	**Median**	**Sufficiency Range**	**Min**	**Max**	**Median**	**Sufficiency Range**
Cranberry	0.11	1.75	0.59	0.4 - 0.75	0.10	9.91	0.76	0.3 - 0.8
Apple	0.30	10.3	1.22	1.0 - 1.6	0.40	9.96	1.11	0.6 – 1.0
Field corn-tassel to silk	0.03	4.79	1.83	1.75 - 2.63	0.03	2.16	0.49	0.3 - 0.55
Field corn-12" tall	0.30	10.6	3.26	2.5 – 4.0	0.04	3.00	0.48	0.3 - 0.7
Alfalfa	0.38	4.99	2.30	2.25 - 3.5	0.45	3.65	1.43	0.7 - 2.5
Soybean	0.26	5.35	2.45	2.15 - 3.25	0.14	2.99	1.05	0.8 - 1.3
Field corn-pre-tassel	0.19	5.21	2.57	2.0 - 2.5	0.10	1.47	0.38	0.25 - 0.5
Grape	0.23	7.48	1.73	1.2 - 2.5	0.53	2.94	1.36	1.2 - 2.5
Strawberry	0.32	2.17	1.50	1.2 - 1.7	0.45	1.90	0.92	0.6 – 1.0
Blueberry	0.33	1.50	0.54	0.4 - 0.7	0.17	1.27	0.47	0.35 - 0.8
Cherry	0.60	2.72	1.57	1.0 - 1.6	0.56	2.44	1.41	0.6 – 1.0

Table 5.	Magnesium (%)				Sulfur (%)			
Crop	**Min**	**Max**	**Median**	**Sufficiency Range**	**Min**	**Max**	**Median**	**Sufficiency Range**
Cranberry	0.01	0.40	0.20	0.15 - 0.25	0.03	1.12	0.12	0.08 - 0.25
Apple	0.12	0.94	0.31	0.30 - 0.50	0.05	0.22	0.15	0.14 - 0.18
Field corn-tassel to silk	0.03	1.27	0.26	0.16 - 0.34	0.02	0.39	0.18	0.16 - 0.25
Field corn-12" tall	0.03	5.00	0.29	0.15 - 0.45	0.06	7.00	0.25	0.15 - 0.50
Alfalfa	0.12	1.20	0.37	0.25 - 0.70	0.01	0.67	0.27	0.25 - 0.50
Soybean	0.11	1.54	0.46	0.23 - 0.55	0.08	0.46	0.27	0.38 - 0.50
Field corn-pre-tassel	0.03	1.66	0.24	0.13 - 0.30	0.08	0.71	0.22	0.15 - 0.50
Grape	0.08	1.95	0.71	0.30 - 0.50	0.04	0.36	0.13	0.15 - 0.25
Strawberry	0.24	0.65	0.34	0.30 - 0.50	0.04	0.92	0.11	0.14 - 0.18
Blueberry	0.06	0.40	0.14	0.12 - 0.25	0.10	0.61	0.14	0.12 - 0.30
Cherry	0.21	0.96	0.51	0.30 - 0.50	0.10	0.20	0.14	0.14 - 0.18

Table 6.	Zinc (ppm)				Boron (ppm)			
Crop	**Min**	**Max**	**Median**	**Sufficiency Range**	**Min**	**Max**	**Median**	**Sufficiency Range**
Cranberry	4.0	171	27.1	15-30	2.3	188	46.0	15-60
Apple	4.6	8084	16.1	25-35	0.2	115	32.5	30-40
Field corn-tassel to silk	7.0	256	23.6	19-34	0.2	223	10.7	6-13
Field corn-12" tall	4.0	2930	34.3	20-60	0.05	152	8.1	5-25
Alfalfa	7.4	328	29.7	20-60	0.06	103	37.1	25-60
Soybean	10.9	795	40.7	25-88	0.2	116	34.3	27-224
Field corn-pre-tassel	8.9	959	25.4	15-60	0.06	108	9.3	4-25
Grape	5.6	229	50.1	30-50	0.2	183	35.0	25-50
Strawberry	7.8	78	15.7	25-35	0.06	245	34.6	30-40
Blueberry	5.4	33	10.3	9-30	17.5	152	45.0	25-70
Cherry	4.1	36	12.7	25-35	13.1	254	27.7	30-40

Table 7.	Manganese (ppm)				Iron (ppm)			
Crop	**Min**	**Max**	**Median**	**Sufficiency Range**	**Min**	**Max**	**Median**	**Sufficiency Range**
Cranberry	8.9	1340	282	10 - 200	2.0	4309	113	20 - 300
Apple	8.0	385	39.9	30 - 50	2.0	1896	50.9	90 - 120
Field corn-tassel to silk	4.9	576	42.0	19 - 68	17.9	3524	86.8	21 - 170
Field corn-12" tall	4.0	1368	59.4	20 - 300	5.0	7465	222	50 - 250
Alfalfa	4.0	1781	36.2	20 - 100	12.6	12385	78.8	30 - 250
Soybean	2.0	3601	57.6	54 - 300	19.6	4576	115	50 - 300
Field corn-pre-tassel	4.0	1259	51.2	15 - 300	18.0	5265	120	10 - 200
Grape	9.9	2468	116	30 - 1000	0.1	3936	21.8	30 - 100
Strawberry	27.2	890	74.2	30 - 50	20.6	20032	55.9	90 - 120
Blueberry	40.5	812	285	50 - 60	23.1	231	56.7	70 - 200
Cherry	6.9	80	15.0	30 - 50	32.9	1210	50.2	90 - 120

Table 8.

Crop	Min	Max	Median	Sufficiency Range
		Copper (ppm)		
Cranberry	0.04	1050	3.2	4 - 10
Apple	0.49	218	5.3	7 - 10
Field corn-tassel to silk	0.49	187	7.5	3 - 7.5
Field corn- 12" tall	0.40	182	7.0	5 - 20
Alfalfa	0.49	20	8.0	3 - 30
Soybean	0.49	18	6.9	6 - 15
Field corn-pre-tassel	0.40	76	7.0	3 - 15
Grape	0.49	233	5.9	5 - 15
Strawberry	0.49	14	4.2	7 - 10
Blueberry	0.49	7.9	3.2	5 - 10
Cherry	1.71	358	7.7	7 - 10

Summary

There are a number of limitations to the use of plant tissue testing as a tool to manage crop production in Wisconsin. In general, tissue testing is most common on relatively high value horticultural crops, such as cranberries and apples and relative to the acreage of these crops much less common on traditional agronomic crops such as alfalfa and corn. The use of the technology also differs as tissue testing is used routinely to guide nutrient applications on horticultural and fruit crops, but when used on more traditional agronomic crops such as corn or alfalfa, it is normally to help diagnose a plant production problem.

Field research is ongoing in Wisconsin and many other Midwestern states in an attempt to update the database that is being used to interpret plant tissue results. Much of the data is relatively old and may not reflect modern crop genetics or the changes that have occurred in production practices. Even if no or outdated plant tissue norms are available for a crop, tissue testing can be used effectively by comparing plants with normal and abnormal growth when sampled and tested separately.

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IMPORTANCE OF POTASSIUM FOR WISCONSIN CROPPING SYSTEMS

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Potassium is important for crop production in Wisconsin particularly in rotations with alfalfa and corn silage. Unfortunately when potash prices increased dramatically in 2008 many growers chose not to apply potash or apply less than recommended rates. Recently, soil test K levels have been decreasing throughout much of Wisconsin even before potash prices increased (Fig. 1). Though changes in soil test K over time vary by county (Fig. 2).

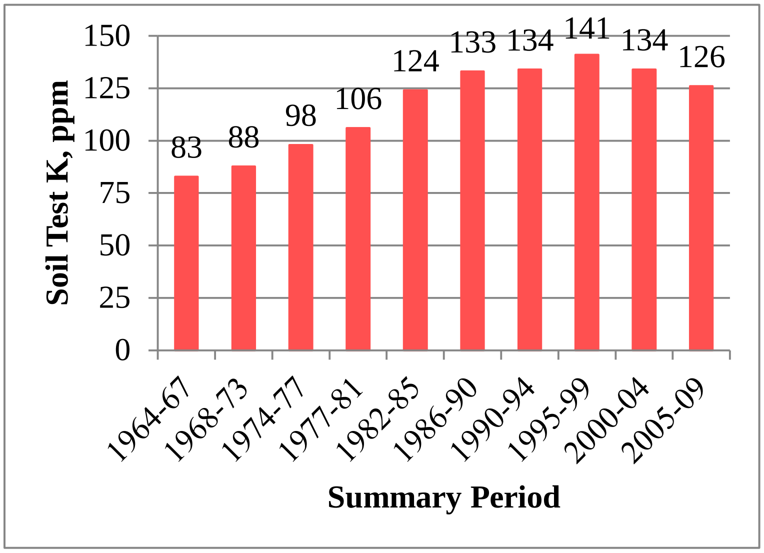

Figure 1. Average Wisconsin soil test K values from 1964 through 2009. Summary of all soils analyzed by Wisconsin Department of Agriculture, Trade, and Consumer Protection certified laboratories.

A few case studies highlight the need to pay attention to soil test K levels and apply recommended rates of potash. The first case study is from a soybean field in 2005. The soybeans exhibited potassium deficiency symptoms in linear patterns spaced about 30 inches apart with half of the field exhibiting the symptomology more strongly (Fig. 3). The field was planted to corn in 2004 and half of the field was harvested for grain and the other half for silage. Where silage was harvested in 2004, K deficiency on soybean was much more apparent. Starter fertilizer was applied to the corn in 2004. It was hypothesized that the more normal looking soybeans were growing over the old starter bands and the soil test K levels would be higher where the soybeans exhibited no deficiency symptoms. Soil sample results confirmed this hypothesis. Within the corn row, soil test K was 57, 71 and 52 ppm (average 60 ppm) and between the rows soil test K was 48, 62, 54 ppm (average 55 ppm). Less deficiency was observed where corn grain was harvested the previous years because some K taken up by the corn would have been recycled back into the soil as the residue aged and rainfall leached K from the residue into the soil. On medium- and fine-textured (loamy) soils like this one, soil test K levels below 90 ppm are considered very low for rotations, which contain alfalfa, corn silage, and wheat; while soil test K less than 70 ppm is considered very low in corn grain and soybean rotations (Table 1). It is very interesting that K deficiency symptomology was so much greater soil test K

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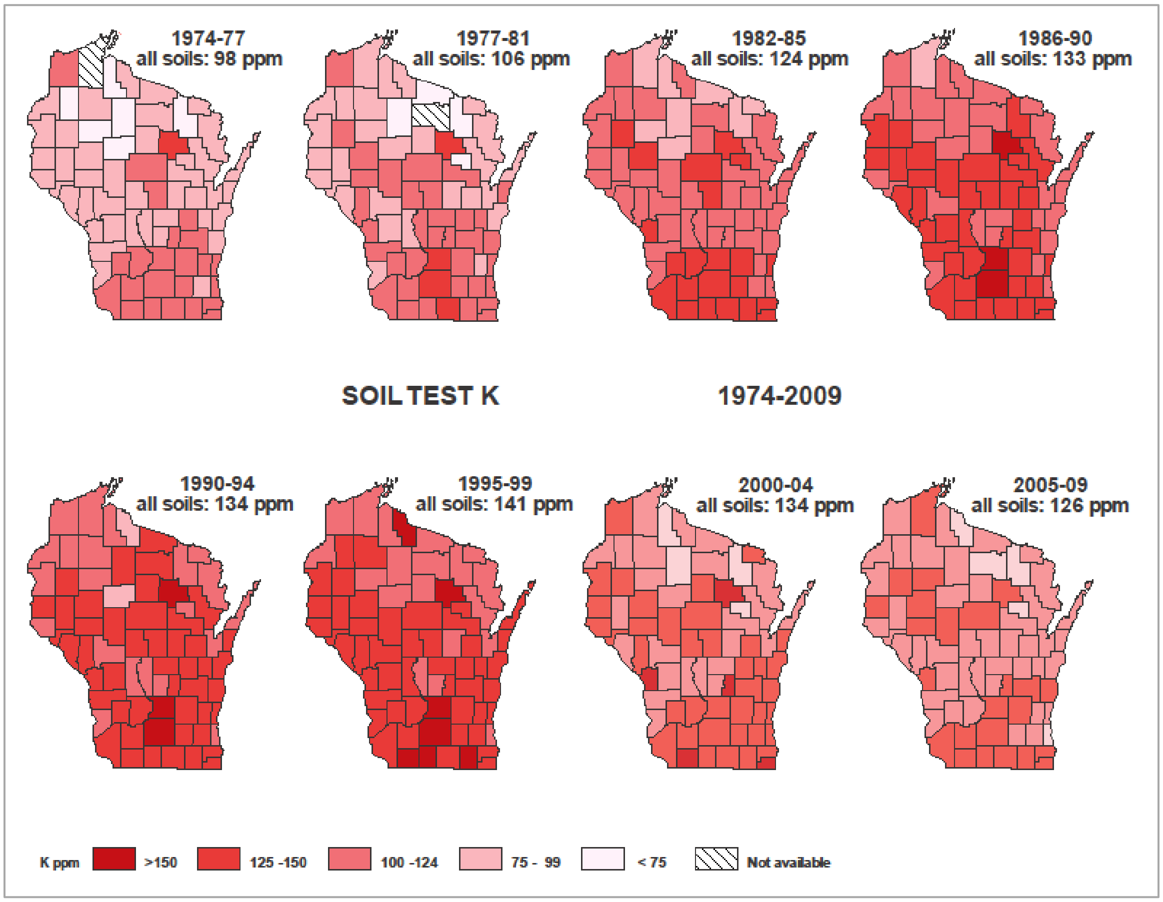

Figure 2. Average soil test K values in Wisconsin by county from 1974 through 2009. Summary of all soils analyzed by Wisconsin Department of Agriculture, Trade, and Consumer Protection certified laboratories.

Figure 3. Potassium deficiency symptoms are apparent on soybeans in a linear pattern repeating approximately every 30 inches (left photo). Potassium deficiency was more apparent in the left side of the field compared to the right (right photo). Photo credits: Mike Ballweg.

averaged 55 ppm compared to 60 ppm. One should not assume that yield was not affected by low soil test K because of a lack of symptomology where soil test K was 60 ppm. It was not possible to harvest this field to determine yield differences between affected and unaffected strips.

Table 1. Potassium soil test interpretation categories for major field crops in Wisconsin. The highest demanding crop in the rotation sets the soil test interpretation category for the rotation. Data taken from UWEX Publication A2809 Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin.

Soil Group	Soil test K category					
	Very Low	Low	Optimum	High	Very High	Excessively High
	Soil test K, ppm					
Demand level 1: corn grain, soybean, clover, small grains (but not wheat)						
Loamy	< 70	70-100	101-130	131-160	161-190	> 190
Sandy, Organic	< 45	45-65	66-90	91-130	--	> 130
Demand level 2: alfalfa, corn silage, wheat						
Loamy	< 90	90-110	111-140	141-170	171-240	> 240
Sandy, Organic	< 50	50-80	81-120	121-160	161-200	> 200

The second case study comes from 2013. In mid-September concern was expressed about a corn field with poor growth and chemical injury or nutrient deficiency. Photos taken at this time show necrotic tissue on leaf margins of all leaves and short, stunted, spindly plants. Root mass near the stalk appeared to be smaller than expected. Soil samples taken in early August 2013 revealed that soil test K was 42 ppm. Clearly this is a very low K test regardless of crop rotation.

Figure 4. Late season potassium deficiency symptoms in corn. Short, stunted, spindly plants with necrosis on all leaf margins, and a smaller than expected root mass. Photo credits: Jim Turner.

Growers need to keep in mind that crop growth without application of nutrients or with applications less than crop removal of the nutrient will result in soil tests declining over time. The amount of K_2O removed per unit of yield for major field crops in Wisconsin is given in Table 2.

Table 2. Crop removal of K_2O per unit of yield for major field crops in Wisconsin. Data taken from UWEX Publication A2809 Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin.

Crop	Yield units	Reporting moisture content	Crop removal of K_2O
		%	lb K_2O/ unit yield
Alfalfa	ton/a	dry matter	60
Corn, grain	bu/a	15.5	0.29
Corn, silage	ton/a	65	8.3
Soybean	bu/a	13	1.4
Wheat	bu/a	13.5	0.35

University of Wisconsin potassium application rate guidelines for soils testing optimum are approximately equal to crop removal of K_2O. Soils testing high and very high have recommended rates of K_2O that are one-half and one-quarter of crop removal, respectively. For soils testing less than optimum, K recommendations are based on crop removal plus and additional K_2O to build soil test levels to optimum. For more details see chapter 7 of Laboski and Peters (2012).

Effect of crop removal exceeding K inputs on soil test levels in the subsoil.

Soil test data from the Wisconsin Integrated Cropping Systems Trial (WICST) at Arlington and Walworth Co. were evaluated to determine how subsoil soil test K levels change when K additions are less than K removal from the system. The corn-corn and corn-soybean systems were sampled in 1989, 1996, 2001, and 2007 in the 0- to 6-, 6- to 12-, 12- to 24- and 24- to 36-inch depths. Walworth Co. was not sampled in 2007. At both locations soil test K in the 0- to 6-inch sample decreased significantly over time as more K was removed from the system (Table 3). This same trend continued for all other sampling depths at Arlington, but not at Walworth Co. These data clearly suggest that the subsoil will supply K to a crop and that the subsoil can become depleted over time when potassium is not applied.

Response of corn and soybean to P and K applications at Arlington, WI

In spring 2011 a P and K response trial (trial A) was initiated at the Arlington Ag Research Station. It was a randomized complete block design with four rates of P_2O_5 (0, 30, 60, 90 lb P_2O_5/a) and four rates of K_2O (0, 40, 80, 120 lb K_2O/a) in a full factorial. Soybean was planted. In spring 2012 the same rates of fertilizer were applied to the same plots and an additional treatments were added that consisted on 160 lb K_2O/a at each rate of P. This resulted in four rates of P and five rates of K. Corn was planted in 2012. In spring 2013, the same rates of P and K were applied to the same plots as in previous years and soybean was planted.

In spring 2012 a second trial (trial B) was initiated also at the Arlington Ag Research Station on a field next to trial A. It was a randomized complete block design with four rates of P_2O_5 (0, 30, 60, 90 lb P_2O_5/a) and five rates of K_2O (0, 40, 80, 120, 160 lb K_2O/a) in a full factorial. Soybean was planted. In spring 2013, the same rates of P and K were applied to the same plots as in previous years and corn was planted.

Fields A and B were in no-till production. The previous crop for both fields was an alfalfa grass mixture for more than five years. Nutrient applications were surface broadcast.

Soil test P and K levels in field A in spring 2011 prior to treatment application were 8 ppm P (very low) and 59 ppm K (very low). In field B soil test P and K prior to treatment application in spring 2012 was 1 ppm P (very low) and 48 ppm K (very low).

Even though soil test P levels were very low initially, there was no significant effect of P application on soybean or corn yield in each year of the study on each field (Tables 4 – 8). There was a significant effect of potash application on yield for each crop each year where increasing rates of potash increased crop yield, through yields at the 120 lb K_2O/a rate were not different than the 160 lb K_2O/a rate for either crop in 2012 and 2013. The economics of the annual potash applications are clear, with the yield increase from the first 40 lb/a increment paying for the entire 160 lb K_2O/a.

Summary

Potassium is important for crop production in Wisconsin. Failure to apply K at rates approximately equal to crop removal will result in soil test decline in both surface and subsoils. Very low soil test levels can be found after a period of neglect. In these situations, K applications greater than crop removal are needed to maximize profitability. Soil testing can be used to guide profitable K fertilization.

Table 3. Effect of cropping system on soil test K in the WICST plots at Arlington (Plano silt loam) and Walworth Co. (Pella/Griswold silt loam). In all cropping systems, crop removal exceeded the amount of K applied.

Crop Sequence	Year	Soil depth			
		0-6”	6-12”	12-24”	24-36”
		Soil test K (ppm)			
Arlington					
CC	1989	257 a†	143 a	125 a	135 a
	1996	257 a	100 b	74 c	
	2001	194 b	83 b	88 b	121 ab
	2007	204 b	81 b	89 b	112 b
CS	1989	199 a	121 a	134 a	155 a
	1996	214 a	91 b	83 c	
	2001	126 b	90 b	99 b	118 b
	2007	121 b	75b	92 bc	103 c
Walworth Co.					
CC	1989	196 a	134	126	124
	1996	191 a	105	114	
	2001	144 b	113	127	129
CS	1989	178 a	118	126	115
	1996	132 b	86	103	
	2001	93 c	105	125	102

† With a column at a given location, mean values followed by the same letter are not significantly different at the 0.10 probability level.

Table 4. Soybean grain yield response to applied P and K fertilizer on very low testing soils of field A at Arlington, WI, 2011.

	K_2O rate, lb/a				
P_2O_5 rate	0	40	80	120	Mean †
lb/a	-- bu/a --				
0	38	45	48	51	45
30	34	44	51	54	46
60	36	46	50	54	47
90	38	43	48	58	47
Mean ‡	37 d §	44 c	49 b	54 a	

† P_2O_5 rate p = 0.77.
‡ K_2O rate p <0.01. P_2O_5 rate x K_2O rate p = 0.77.
§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

Table 5. Soybean grain yield response to applied P and K fertilizer on very low testing soils of field B at Arlington, WI, 2012.

	K_2O rate, lb/a					
P_2O_5 rate	0	40	80	120	160	Mean †
lb/a	-- bu/a --					
0	9	15	18	20	22	17
30	18	12	16	18	23	17
60	11	17	18	17	19	16
90	13	13	16	18	17	16
Mean ‡	13 c §	14 c	17 b	18ab	20 a	

† P_2O_5 rate p = 0.57.
‡ K_2O rate p <0.01. P_2O_5 rate x K_2O rate p = 0.33. CV = 29%.
§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

Table 6. Soybean grain yield response to applied P and K fertilizer on very low testing soils of field A at Arlington, WI, 2013. Spring 2013 soil test P levels averaged 8, 10, 14, and 19 ppm at the 0, 30, 60, and 90 lb P_2O_5/a rates, respectively; while soil test K levels averaged 59, 65, 70, 80, and 88 ppm at the 0, 40, 80, 120, and 160 lb K_2O/a rates, respectively.

	K_2O rate, lb/a					
P_2O_5 rate	0	40	80	120	160	Mean †
lb/a	--- bu/a ---					
0	46	58	63	62	56	57
30	36	57	52	64	65	55
60	51	61	55	57	73	59
90	40	60	63	55	57	55
Mean ‡	43 b §	59 a	58 a	60 a	63 a	

† P_2O_5 rate p = 0.47.
‡ K_2O rate p <0.01. P_2O_5 rate x K_2O rate p = 0.34. CV = 19%.
§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

Table 7. Corn grain yield response to applied P and K fertilizer on very low testing soils of field A at Arlington, WI, 2012. Spring 2012 soil test P levels averaged 7, 9, 12, and 15 ppm at the 0, 30, 60, and 90 lb P_2O_5/a rates, respectively; while soil test K levels averaged 55, 59, 58, and 64 ppm at the 0, 40, 80, and 120 lb K_2O/a rates, respectively.

	K_2O rate, lb/a					
P_2O_5 rate	0	40	80	120	160	Mean †
lb/a	----------	----------	---------- bu/a	----------	----------	----------
0	54	84	109	124	129	100
30	51	91	122	130	120	103
60	46	85	125	126	130	102
90	56	91	113	152	124	107
Mean ‡	52 d §	88 c	117 b	133 a	126 ab	

† P_2O_5 rate $p = 0.72$.
‡ K_20 rate $p < 0.01$. P_2O_5 rate x K_2O rate $p = 0.85$. CV = 19%.
§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

Table 8. Corn grain yield response to applied P and K fertilizer on very low testing soils on field B at Arlington, WI, 2013. Spring 2013 soil test P levels averaged 6, 7, 9, and 13 ppm at the 0, 30, 60, and 90 lb P_2O_5/a rates, respectively; while soil test K levels averaged 49, 52, 57, 60, and 64 ppm at the 0, 40, 80, 120, and 160 lb K_2O/a rates, respectively.

	K_2O rate, lb/a					
P_2O_5 rate	0	40	80	120	160	Mean †
lb/a	----------	----------	---------- bu/a	----------	----------	----------
0	38	89	158	198	203	137
30	28	116	162	206	214	145
60	46	119	162	194	223	149
90	43	85	159	213	211	142
Mean ‡	39 d §	102 c	160 b	203 a	212 a	

† P_2O_5 rate $p = 0.55$.
‡ K_20 rate $p < 0.01$. P_2O_5 rate x K_2O rate $p = 0.84$. CV = 18%.
§ Mean values followed by the same letter are not significantly different at the 0.10 probability level.

References

Laboski, C.A.M. and J.B. Peters. 2013. Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin. University of Wisconsin-Extension Publication A2809. p.88. http://learningstore.uwex.edu/assets/pdfs/A2809.pdf

FERTILIZER INDUSTRY UPDATE

Lara Moody [1/]

{This page provided for note taking}

[1/] The Fertilizer Institute.

Alfalfa Winterkill
Winter of 2012-2013

Dr. Dan Undersander
University of Wisconsin

Alfalfa Winterkill in 2012-2013

- Winterkill generally in portions of fields as at left.
- In severe cases entire fields as above.

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Alfalfa Winter Survival

- Genetic winterhardiness
  - Morphological
  - Physiological
- Development of winter survival potential
- Management to enhance winterhardiness
- What happened in 2012-2013 winter?

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Morphological Basis
– deeper crowns

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Morphological Basis
- Fall Dormancy

- Fall dormancy is determined by height of growth during September.
  - measure plant height 25 to 30 days in late Sept
  - rate dormancy from 1 to 11 based on regrowth height relative to a series of checks.
- Less fall dormancy (higher number)
  - Earlier spring greenup
  - Faster greenup after cutting
  - Increased yield are higher in less dormant varieties
  - Higher crowns

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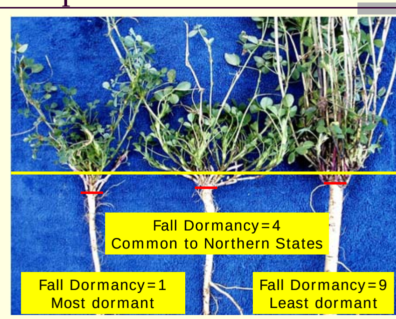
Morphological Basis
– deeper crowns



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Physiological basis
- Cold adaptation

- Cold-adapted plants have evolved mechanisms to allow:
  - supercooling of the cell solution (cooling below 32ºF without freezing)

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Non winterhardy alfalfa is like diet soda

Regular vs Diet Soda

– which freezes first?

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Physiological basis
- Cold adaptation

- Cold-adapted plants have evolved mechanisms to allow:
  - supercooling of the cell solution (cooling below 32ºF without freezing)
    - accumulation of soluble sugars
    - root and crown starches breakdown to produce sugars
    - reduce the amount of water lost during extracellular freezing
    - stabilize larger molecules and membranes within the cell.

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Physiological basis
- Cold adaptation

- Cold-adapted plants have evolved mechanisms to allow:
  - For supercooling of the cell solution (cooling below 32ºF without freezing)
  - To initiate ice formation in outside the cell rather than inside the cell.
  - freezing damage is largely a result of extracellular freezing that dehydrates unfrozen cells and ultimately kills them
    - at -1.5°F, which cold-acclimated alfalfa can tolerate for short period of time, about 90% of cell water has been lost with a corresponding reduction in cell volume

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Physiological basis -
Dehydration & cell rupture

Both dehydration and/or cell rupture from crushing can cause membrane breakdown during the thawing that releases toxic compounds from the vacuole which kills the tissue.

This is why plants often look healthy until spring greenup.

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Development of Winter Survival Potential

- Dormant cultivars harden up to 3 times faster than non-dormant cultivars
- Hardening begins when crown temperature is 60°F
  - with maximum hardening rate occurs between 40 and 50°F.
  - Hardening is increased by fluctuating temperatures with highs around 50°F and lows near freezing.
- De-hardening occurs:
  - at temperature greater than 60°F and
  - when soil temperature at 2 to 4 inches is above 40°F.

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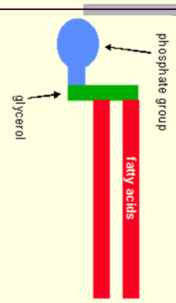
Hardening

- Cell membrane is composed of phospholipids



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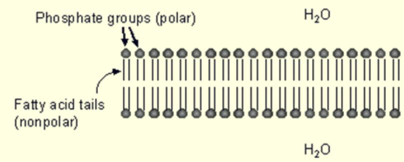
Hardening

- Membrane is chain of phospholipids



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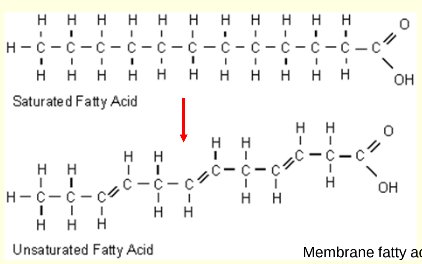
Alfalfa Hardening



Membrane fatty acids become more unsaturated with hardenning

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Alfalfa Hardening

- How much the plant hardens depends on
  - plant's genetic potential
  - proper weather conditions
- Hardening will be greater in some years than other years depending on the fall weather with the same variety.

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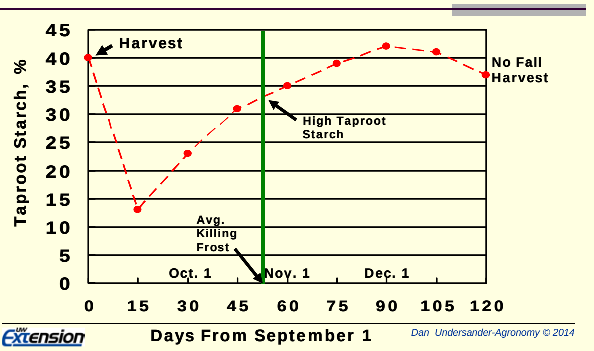
Alfalfa Taproot Reserves Accumulate in Autumn and are Necessary for Winter Survival



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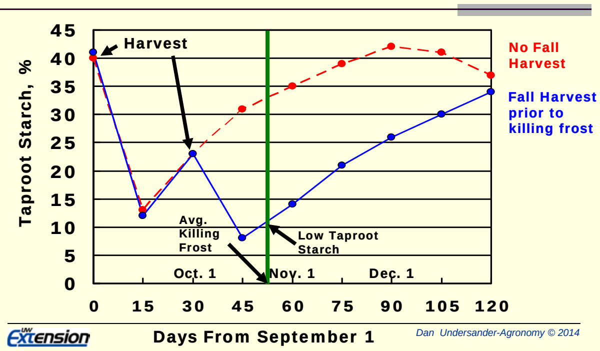
Fall Cutting Management Influences Alfalfa Taproot Reserves and Winter Survival



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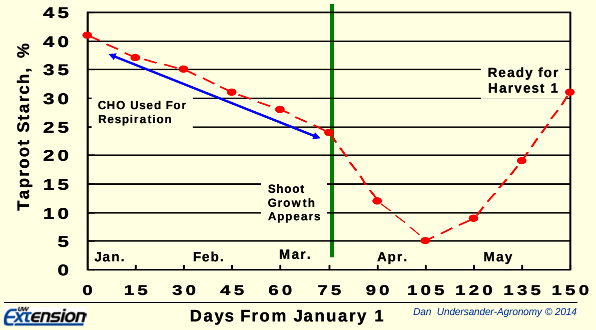
Plant Survival Over Winter and Shoot Growth in Spring Depends on Taproot Reserves



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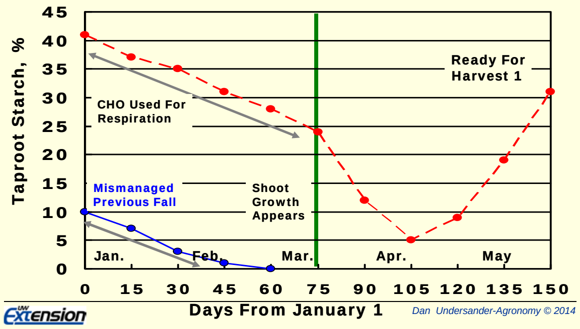
Plant Survival Over Winter and Shoot Growth in Spring Depends on Taproot Reserves



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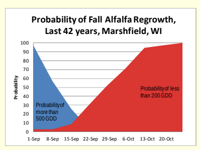
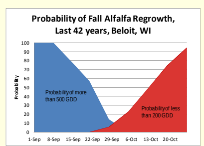
Fall Growth and Last Cutting

Timing of last cutting not related to killing frost

Determined by growing degree days (base 41F)

- If more than 500 –good growth and recovery
- If less than 200 – little reserve use





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Winterhardiness Needed

- Location
  - Temperature
  - Snow cover

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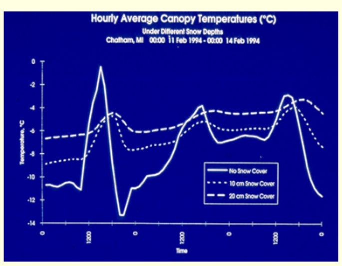
Snow insulates



Data From Richard Leep, MI State Univ

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Winter kill

- meristematic tissue killed from exposure to low temperature (< 5º F)
- frost heaving: repeated freezing and thawing pushes crown and root above soil surface and/or breaks roots
- ice sheeting: meristematic tissue suffocates (no soil oxygen for respiration) below ice sheet
- breaking dormancy repeatedly during winter: root reserves become depleted and plant starves

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Winterhardiness Needed

- Location
  - Temperature
  - Snow cover
- Management for winter survival
  - Winter survival reduced by:
    - Low soil fertility
    - More frequent cutting
    - Late fall cutting

Low K & P High K & P

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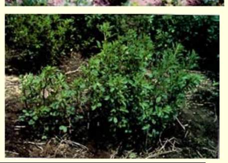
Winter Kill

Alfalfa Winter injury

- Buds from fall killed
- Slow to green up
- Reduced stems/plant
- Lost yield



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What happened in Winter of 2012-2013?

The 'Perfect Storm'

- Low root reserves in fall due to drought of 2012
- Much fall cutting in 2012 due to forage shortage
- Long winter dormancy (late spring) – more respiration
- Some snow melting at periods over winter
- Some soil waterlogging

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Alfalfa has high tolerance to physical stress - Management often makes a difference

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REDUCED LIGNIN ALFALFA TECHNOLOGY UPDATE

Jeremy R. Hayward [1/]

Forage Genetics International, the Samuel Roberts Noble Foundation and the U.S. Dairy Forage Research Center began working together in 2000 to produce transgenic alfalfa plants with reduced lignin content and improved fiber digestibility. This team of ~ 12 scientists collaborated in using gene silencing technology to systematically "knock out" each of the twelve genes in the lignin biosynthetic pathway and to compare the effect of these individual gene knockouts on alfalfa forage composition, fiber digestibility (NDFD) and agronomic performance. We were able to develop a gene knockout that gave the desired improvement in forage quality, without any negative impact on forage yield and standability. Multiple transgenic events were created containing this commercial gene silencing construct, and in 2009 a single commercial event was selected after extensive field and laboratory testing.

This commercial transgenic event has been introgressed into a wide variety of FGI germplasm to produce Reduced Lignin (RL) alfalfa. RL alfalfa has now been tested in multiple genetic backgrounds for multiple years and in multiple locations. When compared both to the non-transgenic control and to appropriate commercial check cultivars, RL alfalfa has consistently shown a ~15% reduction in whole plant lignin content and a 10 to 15% increase in NDFD and RFQ. In current trials, forage yield potential of current RL alfalfa experimentals is similar to appropriate commercial check cultivars. There is no difference in incidence of lodging of RL alfalfa compared to the non-transgenic control or conventional commercial varieties.

In cutting management trials the decreased lignin content of RL alfalfa has resulted in increased flexibility in harvest timing. A 2011 trial (Fig. 1) compared performance of a RL alfalfa breeding population to two commercial check cultivars, under two harvest treatments: 3 cuts/yr (harvest interval ~38 days) and 4 cuts/yr (harvest interval ~31 days). In this trial, and in similar trials designed to look at changes in forage quality associated with increased physiological maturity, NDFD in RL alfalfa was equal to or higher than NDFD in conventional alfalfa harvested 7-10 days earlier.

It appears that RL alfalfa may benefit forage producers in two ways:

1) Increase the likelihood of harvesting alfalfa hay/haylage with high forage quality. The proven benefits of improved forage quality can be captured both by the dairy producer end-user and by the cash crop hay producer through forage quality premiums well established in U.S. hay markets.

2) Improve flexibility in alfalfa harvest management by extending the time period in which high quality hay/haylage can be harvested. Delaying harvest for several days (e.g. harvest at 10% bloom vs late bud stage), may result in reducing the number of harvests/yr without sacrificing forage quality of the hay harvested. Flexibility in harvest timing will also give growers more flexibility in timing harvest around weather or other farming operations.

[1/] Brand Manager, WL Alfalfa, PO Box 1610, Ozark, MO, 65721; 417-616-1013; jrhayward@wlresearch.com.

This project is on a commercial track. We have generated considerable amounts of data required for securing regulatory approvals and have made application for deregulation in the U.S., Canada and key export markets. Product development is also well underway. Reduced Lignin alfalfa will be sold in a trait stack with Genuity® Roundup Ready® alfalfa, and is expected to be available for U.S. commercial release ~ 2016.

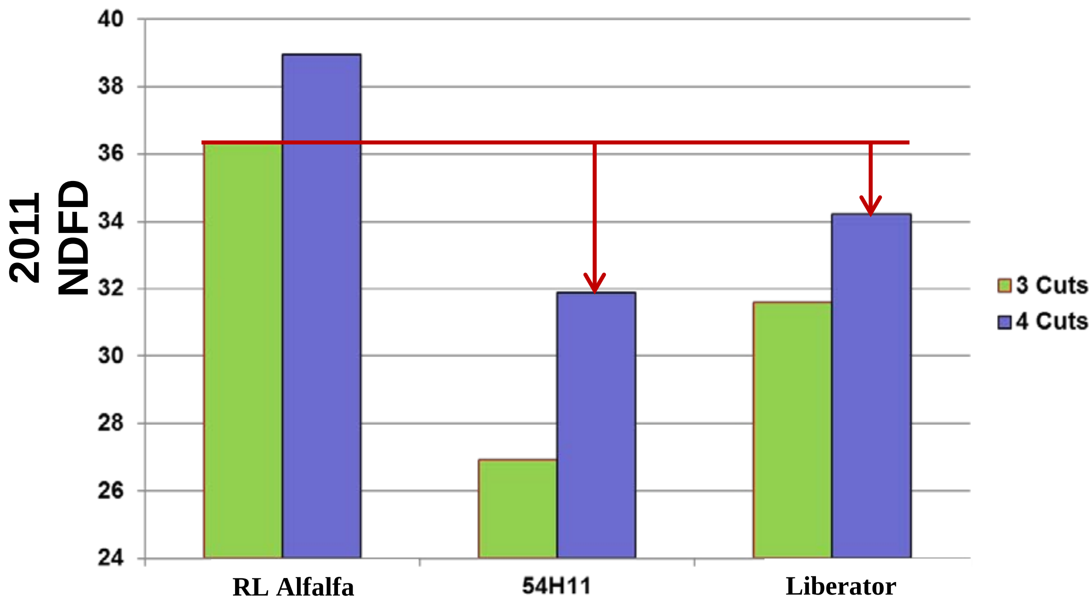

Figure 1. NDFD in RL Alfalfa vs. Commercial checks in three- vs. four-cut management West Salem, WI (established 2010, harvested 2011).

Alternative Forages: When and How to Utilize Them

Dr. Dan Undersander
University of Wisconsin

Determine Forage Need

- What is primary forage yield objective?
1. High tonnage to replace first cutting
2. High total season yield
   a. Chopped
   b. Baled
3. Late Season Planting

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A mouthful of forage when supply is low

may be worth more than two mouthfuls when forage is plentiful

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Determine Forage Need

- What is primary forage yield objective?
1. High tonnage to replace first cutting
2. High total season yield
   a. Chopped
   b. Baled
3. Late Season Planting

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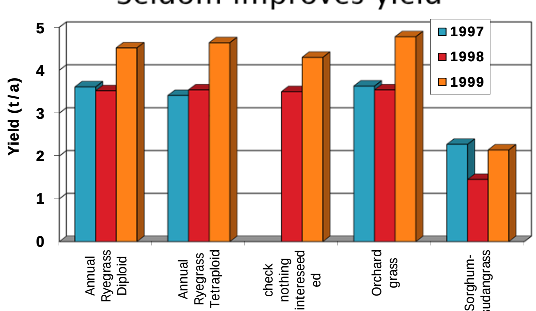
Interseeding into thin alfalfa stands – Seldom improves yield



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Interseeding into thin alfalfa stands – Seldom improves yield

- Interseeding grasses into alfalfa
  - Ryegrass responds quickly but does not grow well in summer heat or drought
  - Orchardgrass and tall fescue take 60 to 90 days to begin producing yield

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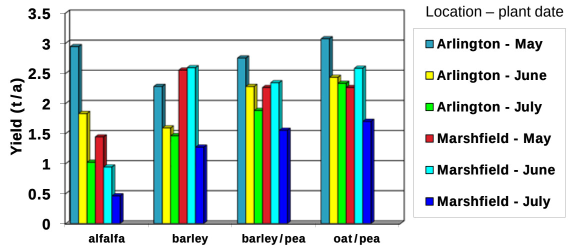
Forage to Replace First Cutting



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Small grain cereals as forage

- Hay, greenchop, silage, pasture
- Plant early, add peas for palatability
- Harvest according to maturity based on animal nutrient demands
  - Boot stage for dairy
  - Soft dough for heifers/steers
- Rapid growth; regrow if harvested prior to heading, greater with earlier harvest

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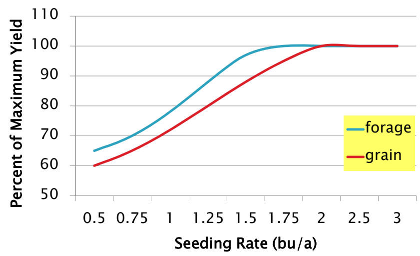
Effect of Oat Seeding Rate on Forage and Grain Yield



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Average forage quality values for oats harvested at different maturity stages.

Harvest Stage	Crude Protein	NDF
Boot	16-18	52-54
Heading	14-16	56-58
Milk	12-14	59-61
Dough	10-12	59-61

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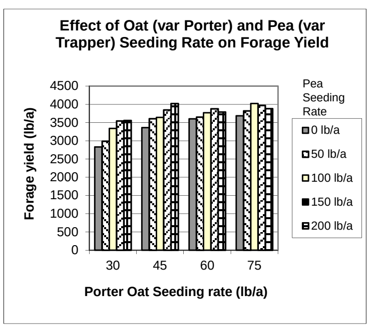
At oat seeding rate of 60 lb/a or higher no yield effect of adding peas.



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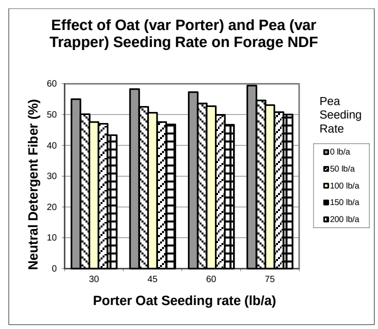
Adding peas lowered NDF of mixture

Pea size varies considerably

Pea seeding rate should be 4 seeds/ft²



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Small grain cereals to replace first cutting

- Hay, greenchop, silage, pasture
- Plant early, add peas for palatability
- Harvest according to maturity based on animal nutrient demands
- Rapid growth; regrow if harvested young

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Determine Forage Need

- What is primary forage yield objective?
1. High tonnage to replace first cutting
2. High total season yield
   a. Chopped
   b. Baled
3. Late Season Planting

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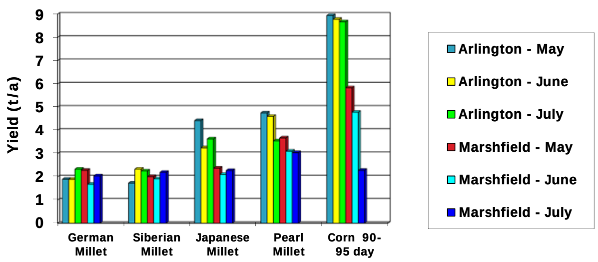
High total Season Yield

Millets for emergency forage



Millets need warm weather for high yield

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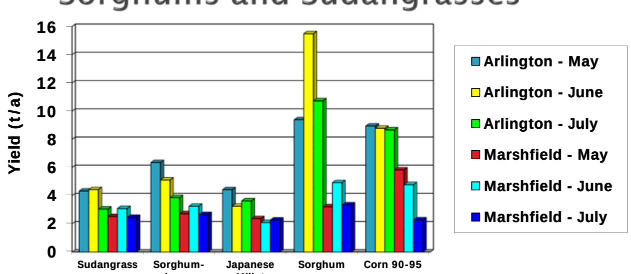
Foxtail Millet

High total Season Yield

Sorghums and Sudangrasses



sorghums need warm weather for high yield

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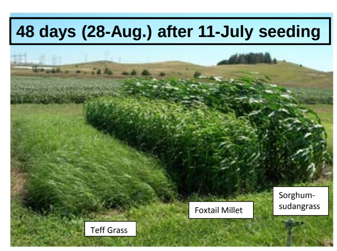
Teff Grass

- Warm season annual grass
- Good hay or pasture crop when late season plantings are required due to a crop failure.
- High quality hay for horse owners with excellent palatability and animal acceptance.



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Summer annual grasses

- Require high temperatures
- Drought tolerant
- High yield potential but lower quality
- Regrowth

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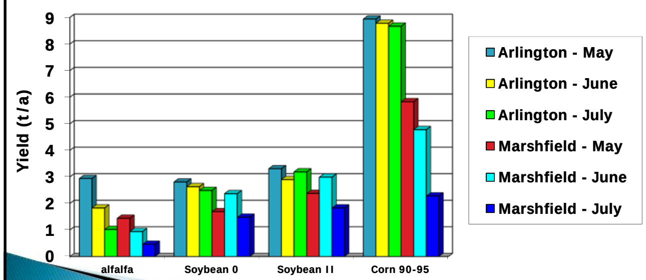
High total Season Yield
Alfalfa and Soybeans



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Summary

- Oats and barley best for quick yield
- Adding peas to small grain does not increase yield
- Corn silage best choice for tonnage when late planted
- Sorghums are warm weather crops for Southern Wisconsin only
- Sudangrass and sorghum-sudangrass hybrids yielded equal to or slightly less than corn silage.

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Determine Forage Need

- What is primary forage yield objective?

1. High tonnage to replace first cutting
2. High total season yield
   a. Chopped
   b. Baled
3. Late Season Planting

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Late Season Planting

Summer or late-summer seeded (for fall forage):

Oats and/or Turnips
- Planting date: late July through August
- Seeding rate: Oats: 3+ bu/acre; Turnips 2-3 lb/ac

Rye, triticale, winter wheat
- Planting date: late August – September
- Minimal fall forage, but primarily the following spring

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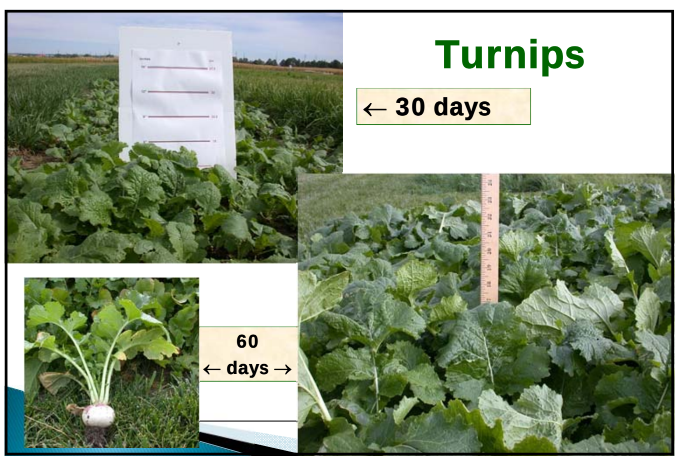


Brassicas
'Pulsar' rapeseed
'Purple Top' turnips
'Dwarf Essex' rapeseed
Extension
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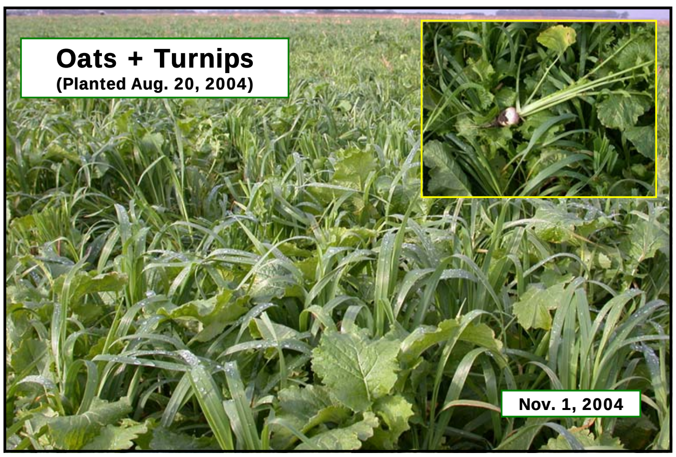
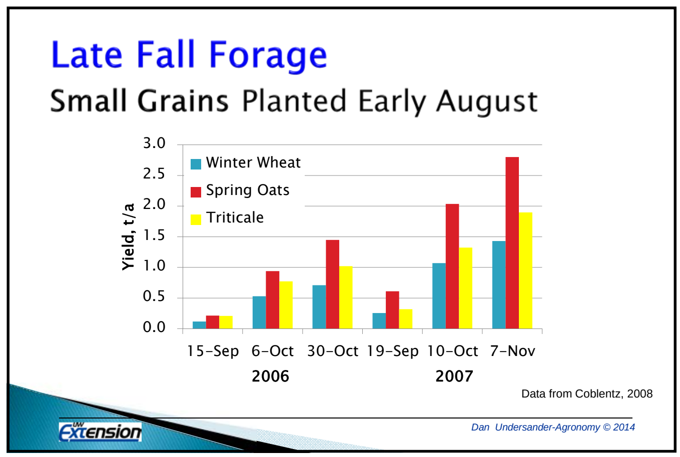

Oats + Turnips
(Planted Aug. 20, 2004)
Nov. 1, 2004


Late Fall Forage
Small Grains Planted Early August
Yield, t/a
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Winter Wheat
Spring Oats
Triticale
15-Sep
6-Oct
30-Oct
19-Sep
10-Oct
7-Nov
2006
2007
Data from Coblentz, 2008
Extension
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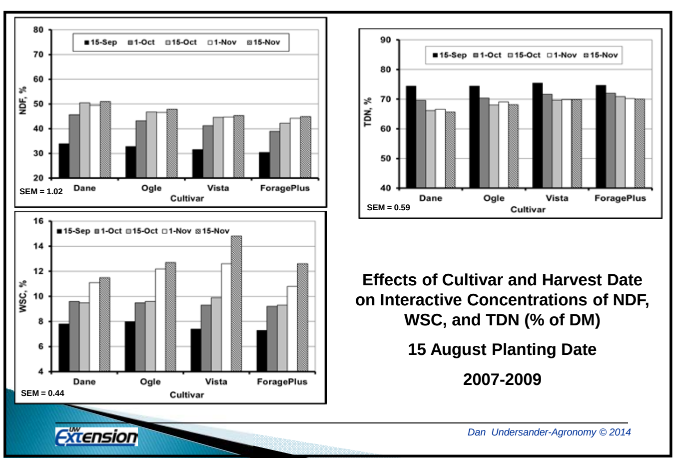
NDF, %
TDN, %
WSC, %
15-Sep 1-Oct 15-Oct 1-Nov 15-Nov
Dane
Ogle
Vista
ForagePlus
Cultivar
SEM = 1.02
SEM = 0.59
SEM = 0.44
Effects of Cultivar and Harvest Date on Interactive Concentrations of NDF, WSC, and TDN (% of DM)
15 August Planting Date
2007-2009
Extension
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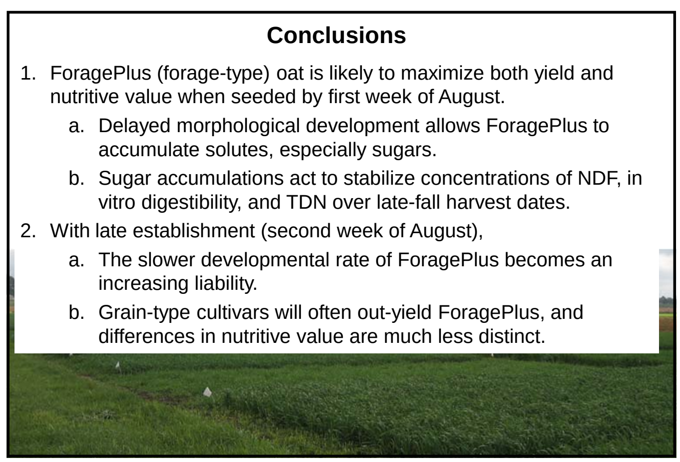
Conclusions
1. ForagePlus (forage-type) oat is likely to maximize both yield and nutritive value when seeded by first week of August.
a. Delayed morphological development allows ForagePlus to accumulate solutes, especially sugars.
b. Sugar accumulations act to stabilize concentrations of NDF, in vitro digestibility, and TDN over late-fall harvest dates.
2. With late establishment (second week of August),
a. The slower developmental rate of ForagePlus becomes an increasing liability.
b. Grain-type cultivars will often out-yield ForagePlus, and differences in nutritive value are much less distinct.

Late Fall Forage

Legumes

Crop dry weight for plantings in Lincoln, NE		
	Aug 7, 1985	Aug 26, 1986
	tons/acre	
Austrian winter pea	0.45	0.35
Hairy vetch	1.40	0.41
Alfalfa	0.47	0.15
Rye	0.57	0.62
Black medic	0.60	0.08
Arrowleaf clover	0.40	0.04

Data from Power and Koerner, 1994, Agron J

Legumes seeded after Aug 7 had greatly reduced yield

Seldom did nitrogen accumulation offset seed cost.

Fall plantings of legumes not recommended

Extension

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Summary

- Oats, triticale and barley best for quick yield in spring
- Adding peas to small grain does not affect yield
- Corn silage best choice for tonnage until July 31
- Sorghums are warm weather crops for Southern Wisconsin only
- Oats for late fall forage.

Extension

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ALFALFA, CLOVERS, AND GRASSES AS COMPANION CROPS FOR SILAGE CORN

John H. Grabber [1/]

Introduction

Corn silage is commonly fed to dairy cattle and other types of ruminant livestock, but its production can leave cropland vulnerable to nitrate leaching and runoff of nutrients and sediment. As result, a wide variety of cover crops or living mulches (collectively referred to here as “companion crops”) have been developed and promoted to mitigate the adverse environmental impacts of corn production and to improve crop yields, nutrient cycling, and soil quality. Based on a review of the literature, a few of the more promising companion crops for corn in north-central states such as Wisconsin include winter rye, Italian ryegrass, red clover, alfalfa, and kura clover.

Winter rye is commonly seeded in the fall after corn harvest. Although it often provides little ground cover in the fall and winter, fall-seeded rye grows vigorously during the spring to protect soil and remove residual soil nitrate. Rye can be grazed or harvested for forage prior to a late planting of corn, but earlier spring termination is often used because more mature rye can in some cases deplete soil moisture, immobilize nitrogen, and depress corn yields.

Italian ryegrass is usually interseeded in June about 4 to 6 weeks after corn planting to permit establishment without excessive competition with corn. In the fall, interseeded ryegrass usually provides greater ground cover and soil nitrate scavenging than fall-seeded rye and it can be grazed or harvested for forage. Ryegrass often winterkills to provide short-lived mulch for spring-seeded crops such as corn and it tends to have a neutral effect on corn yields unless its growth and uptake of soil nitrate are too vigorous.

Red clover or alfalfa are also typically interseeded in June to prevent excessive competition with corn, but such seedings are prone to fail during dry summer conditions or if corn growth is especially vigorous. If successfully established, interseeded red clover or alfalfa will normally overwinter to provide moderate ground cover and uptake of soil nitrate during both the fall and spring. Red clover and alfalfa cover crops supply nitrogen and often boost yields of subsequent corn crops. A seemingly overlooked option would be to keep interseeded red clover or alfalfa in production for at least one year after corn to provide high quality forage and to further boost subsequent corn yields through greater nitrogen and non-nitrogen rotational effects. This system would be most workable if forage legumes could be interseeded immediately after corn planting, but new approaches are needed to lessen yield-killing competition between the co-planted crops.

Kura clover may also serve as a dual-purpose crop that can be used one year as a living mulch for corn and then kept in production in following years as a forage crop. Corn grown in kura clover can produce yields comparable to corn grown after killed kura clover, but excessive competition from the living mulch can depress corn yields. Following corn production, kura clover living mulch can recover to full forage production by midsummer of the following year. The performance of the kura-corn system has not, however, been directly compared to other companion crop systems for corn.

Objectives and Methods

Experiment 1

Although the abovementioned corn-companion crop systems are often recommended to producers, few if any studies have directly compared their agronomic and environmental performance across several cropping seasons. Therefore in a four-year study on a silt loam soil near Prairie du Sac Wisconsin, we compared two rotations where Roundup-Ready corn was no-till planted in early May and grown one year with herbicide-suppressed/strip killed kura clover living mulch or with June drill interseeded red clover. After a September silage corn harvest, the legume companion crops were kept in production and harvested the following year for forage before rotating back to corn. These rotations were also compared to Roundup-Ready continuous corn, which was planted no-till in early May, harvested for silage in September, and grown each year with June drill-interseeded Italian ryegrass, September-seeded winter rye, or no cover crop. Crops were planted at normal recommended seeding rates and weeds during corn production were controlled primarily with glyphosate. Manure slurry was band-applied yearly on a phosphorous basis to all crops yearly in November or early April. In addition to manure nitrogen credits, continuous corn plots received additional fertilizer at planting to supply recommended levels of nitrogen (160 lb per acre) while manure plus legume credits provided excess nitrogen for rotated corn (225 lb per acre) at the site. Additional experimental details are provided in Grabber and Jokela (2013) and Grabber et al. (2014).

Experiment 2

Our goal in a second study was to identify plant growth regulator (PGR) treatments that would boost successful establishment of interseeded alfalfa while limiting yield depression of corn. An initial screening of foliar-applied PGRs suggested that prohexadione-calcium might be useful for limiting excessive top growth of interseeded alfalfa during its establishment in corn. (Prohexadione is currently labeled for several orchard crops, peanuts, and grass seed production to limit shoot growth.) Field studies were therefore carried out for four years on a silt loam soil near Prairie du Sac Wisconsin to evaluate prohexadione applications on alfalfa that was planted with Clearfield or Roundup-Ready corn. Each year, corn was planted no-till in early to mid May at about 35,000 seeds per acre and conventional or Roundup-Ready alfalfa was drill interseeded one or two days later, usually at a seeding rate of 16 lb per acre. Depending on the herbicide tolerance of corn and alfalfa, weeds were controlled with post-emergence spray applications of imazethapyr or glyphosate. Recommended rates of nitrogen were applied to corn (160 lb per acre), but 50% was banded with starter fertilizer at planting and the balance was sidedressed in June to favor uptake by corn. Prohexadione-calcium was sprayed at 10 to 40 oz per acre with drop nozzles onto alfalfa seedlings about 4 to 6 weeks after planting. Whole plant corn yields were determined in September and alfalfa yields were determined the following year using a three-cut harvest management. Alfalfa topgrowth and stand density was evaluated 4 weeks after prohexadione application, 4 to 6 weeks after corn harvest, and after the final alfalfa harvest the following year.

Results and Discussion

Experiment 1

The results of this study were reported and discussed in recent publications (Jokela et al., 2009; Grabber and Jokela, 2013; Grabber et al., 2014). Below is a summary of our major findings.

The corn-interseeded red clover system produced the highest and most stable yields of silage corn across years and often the highest clover yields. Relatively low competition from red clover and weeds likely contributed to high corn yields. Unfortunately, red clover forage production was often hampered by late summer stand failures during its establishment in corn. Modest growth following corn and preceding forage production also made red clover less effective than other companion crops for limiting runoff from cropland. Under favorable growth conditions at the onset of our study, the corn-kura clover rotation produced silage corn yields similar to the corn-red clover rotation, and among the systems we examined, it came the closest to providing reliable year-round groundcover for protecting soil. As the study progressed, corn yields were reduced by excessive spring growth of kura clover living mulch, while slow regrowth of kura clover following corn limited its forage production potential and permitted substantial ingress of weeds that further limited forage yields. Excessive nitrogen credits for corn grown with either clover resulted in only modest increases in total residual fall nitrate to a depth of 4 ft, likely because excessive nitrogen was incorporated into the organic nitrogen pool. Clover production the following year also appeared to draw down nitrate throughout the soil profile to levels far below that of continuous corn. Consequently, the manured corn-clover systems may have a lower risk of nitrate leaching than continuous corn systems. Draw down of nitrate during clover production, however, contributed to low pre-sidedress nitrate test estimates of available nitrogen, particularly for corn grown with kura clover living mulch.

Manured continuous corn grown with or without annual grass companion crops usually produced greater overall dry matter yields than corn-clover rotations, but crude protein yields of rotations exceeded continuous corn treatments. Unlike other cropping systems we examined, yields of corn grown with grasses were sensitive to the timing of manure application; fall manure promoted higher yields with ryegrass while spring manure favored higher yields with rye. As with kura clover, yields of continuous corn treatments declined over rotation cycles, due in part to increasing weed pressure. Continuous corn systems had relatively high pre-sidedress nitrate test concentrations that were not affected by the presence or absence of grass companion crops. The presence or absence of grass companion crops also did not appreciably influence the total quantity of residual fall nitrate in soil to a depth of 4 ft.

Among the companion crops examined, surface runoff and losses of phosphorus and sediment in the spring were least with rye followed by ryegrass if manure was applied in the fall. Shifting surface-applied manure application to spring in this no-till system largely negated companion crop effects on spring runoff and substantially increased loading of dissolved reactive phosphorus. The use of kura clover, red clover, ryegrass, or rye as companion crops for corn improved several chemical, physical, and microbial soil properties and overall soil quality. While some specific companion crops performed better for individual soil properties, none stood out as better for the whole range of soil attributes or for overall soil quality. Taken as a whole, no companion crop or manure management system was clearly superior in all attributes related to forage production, nitrate leaching potential, runoff, and soil quality. Thus the most appropriate choice of companion crops and manure management for no-till silage corn will depend on producer requirements for feed production and on site-specific requirements to remediate nitrate leaching and runoff of soil and nutrients from cropland.

Experiment 2.

Prohexadione-calcium applied at 10 to 14 oz per acre to interseeded alfalfa in June typically reduced alfalfa top growth by about 20% in July and doubled or tripled alfalfa seedling stand density by mid October compared to non-treated controls. Alfalfa interseeding reduced dry matter yields of silage corn by about 10% compared to corn grown without interseeded alfalfa. Prohexadione application on alfalfa had no effect on corn yields. First-year yields of alfalfa established the previous year by interseeding were two-fold greater than alfalfa conventionally spring-seeded after corn. Prior year prohexadione applications increased first year alfalfa yields by about 12% and fall stand densities by 37 to 130% compared to untreated interseeded controls. Higher rates of prohexadione did not further improve alfalfa top growth suppression, stand density, or forage yields. Overall as illustrated in Figure 1, the primary benefit of prohexadione treatment was to substantially improve stand establishment of interseeded alfalfa and this would be expected to markedly improve the reliability and forage yield potential of this cropping system. Additional studies with prohexadione and other PGRs are, however, needed to find ways of lessening yield reductions in corn and to develop workable production systems for farms. We are, for example, now conducting studies with Mark Renz and Joe Lauer (Agronomy Department, UW-Madison) to see if lower, more economical rates of prohexadione in single or split applications can be effective for boosting stand density and subsequent yields of interseeded alfalfa. Finally, an economic analysis suggests a reliable and cost-effective method for establishing interseeded alfalfa in corn could improve the profitability of first year alfalfa by about $100 per acre compared to conventional spring-seeded alfalfa (Grabber and Vadas, 2011, unpublished).

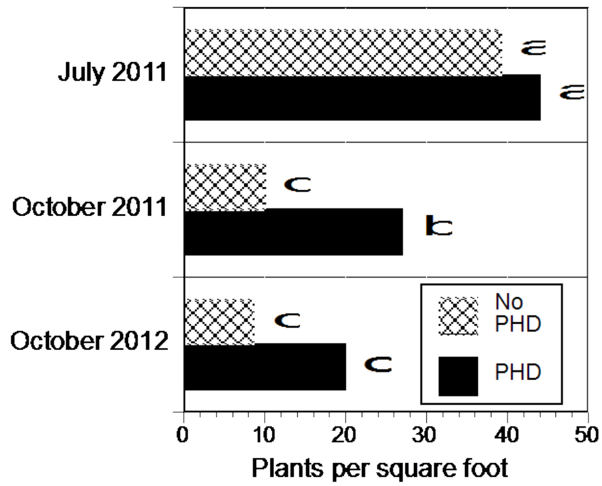

Figure 1. Impact of prohexadione (PHD) spray treatment on plant density of conventional alfalfa interseeded into Clearfield corn in 2011. Bars followed by unlike letters differ at P = 0.05.

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Jokela W.E., J.H. Grabber, D.L. Karlen, T.C. Balser, and D.E. Palmquist. 2009. Cover crop and liquid manure effects on soil quality indicators in a corn silage system. Agron. J. 101:727–737.

APHANOMYCES ROOT ROT MANAGEMENT IN ALFALFA

Damon L. Smith [1/] and Quinn Watson [2/]

Introduction

Alfalfa is an important crop for Wisconsin and the Midwestern, United States. Commodity records, as of February 1, 2013 report alfalfa prices reaching $265 per ton for hay (1). Nationwide, alfalfa was planted across 55.6 million acres in 2012, the 3rd field crop in terms of acreage after corn and soybean, and has an $8 billion dollar production value (15). Furthermore, alfalfa is the single largest source of protein for livestock, especially for the dairy industry (13). Wisconsin is the second largest producer of dairy in the United States, and since dairy feed is the single largest cost to the milk producer, the yield and consequent price of alfalfa is understandably important to the Wisconsin dairy industry (16).

Aphanomyces euteiches is a soil-borne oomycete that causes the disease, Aphanomyces root rot. *A. euteiches* can infect a variety of field crops worldwide, but in Wisconsin, the most important commodity is alfalfa. *A. euteiches* is most threatening in poorly drained soil conditions because it proliferates with water-motile zoospores. *A. euteiches* germinates in response to chemical signals from its host's roots during early seeding, penetrates its host, and causes stunted, chlorotic hypocotyls and cotyledons due to necrosis of the roots early after emergence (12, 13). Although this disease does not cause immediate damping off, the pathogen stunts growth and reduces alfalfa's ability to compete with weeds. This monocyclic oomycete is persistent and it is suspected that its oospores can survive as many as 30 years in soil that has not been planted with alfalfa. This suggests that *A. euteiches* can parasitize other hosts. Furthermore, *A. euteiches* has adapted to have increasingly more virulent phenotypes, beginning with race 1, race 2, and possibly now the most virulent race, race 3 (6, 12).

Currently, there exists no chemical treatment to manage *A. euteiches* infestations in alfalfa. The fungicide metalaxyl has been found ineffective against *A. euteiches* even though it effectively inhibits *Phytophthora medicaginis*, a second oomycete pathogen that frequently occurs in alfalfa fields (9). Farmers are left two management options for Aphanomyces root rot; crop rotations and planting with alfalfa cultivars that are selectively bred for resistance to specific races of *A. euteiches*. Currently, the commercial cultivar with the highest resistance available is only against race 2, which will be ineffective in prevention of *A. euteiches* of the putative race 3. Selectively breeding resistance to *A. euteiches* in alfalfa has aided in increased alfalfa yields; however breeding is a slow and costly process, especially since more virulent phenotypes than race 2 are predicted to exist (6). In addition, interest has peaked into using alfalfa varieties with the Roundup Ready trait. Anecdotal reports suggest that these Roundup Ready varieties lack the level of resistance to *A. euteiches* race 2 that exists in conventional varieties. This should be investigated further.

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Interestingly, recognition of *A. euteiches* as a growing threat to alfalfa yields in 1987 and 1990 by Delwiche, Grau, and Holub coincided with reductions of sulfate deposition through precipitation (7, 9, 14). This was a result of the Clean Air Act of 1970 that put restrictions on sulfur oxide emissions. Subsequently sulfur deficiency in soil has been reported in several alfalfa producing states that have also isolated *A. euteiches,* including Wisconsin, Iowa, and Indiana (2, 5). This development suggests a relationship between sulfur availability and alfalfa susceptibility to *A. euteiches* infection.

In alfalfa, sulfur deficiency may interfere with sulfur-induced resistance against fungal pathogens (8). Sulfur deficiency is exhibited in alfalfa by uniform yellowing of leaves and stems. Each cutting of alfalfa removes 5-7 lbs of sulfur per ton of alfalfa hay. Alfalfa requires up to 25-50 lbs/acre actual sulfur during the seeding year, especially in deficient areas (11). The most inexpensive source of supplemental sulfur is $CaSO_4 \cdot 2H_20$ at 20 ppm of actual sulfur applied to soil. Calcium is typically not an element considered to be limited in Wisconsin soils; however $CaSO_4$ supplies sufficient levels of sulfur at a semi-soluble rate, allowing for useable sulfur over multiple growing seasons (10). The research presented here investigated other forms of sulfur fertilizers in addition to the standard. This included K_2SO_4, $(NH_4)_2SO_4$, and elemental sulfur, and at different soil concentrations to determine which fertilizer and concentration most effectively improved alfalfa health and/or inhibited *A. euteiches* growth. K_2SO_4 and $(NH_4)_2SO_4$ have additional nutritional benefits because they provide K and NH_4 respectively, are more soil-soluble, and are more readily absorbed by alfalfa. Elemental sulfur is an inaccessible form of sulfur for alfalfa; however it has been documented to increase spore dormancy and have other inhibiting effects on certain fungal pathogens (8), but there is no data on the potential relationship between elemental sulfur and *A. euteiches* or other oomycetes. This could be because there is no proven detrimental effect of sulfur on these particular plant pathogens (3). Additionally resistance to the three races of *A. euteiches* was investigated.

The objectives of this research were as follows:

1. Evaluate the effect of $CaSO_4 \cdot 2H_20$, K_2SO_4, $(NH_4)_2SO_4$, and elemental sulfur at 10, 20, 30, or 40 ppm, or no sulfur, on the growth of different isolates of *A. euteiches* in culture.

2. Investigate the development of Aphanomyces root rot in alfalfa seeded to growth medium amended with $CaSO_4 \cdot 2H_20$, K_2SO_4, $(NH_4)_2SO_4$, and elemental sulfur at 10, 20, 30, or 40 ppm.

3. Determine the level of resistance to all races of *A. euteiches* in select Roundup Ready alfalfa varieties.

Methods

In order to test sulfur toxicity from different sulfur sources on *A. euteiches,* isolates of *A. euteiches* from race 1 and 2 were incubated on Petri plates with varying sulfur concentration. The *A. euteiches* specimens included the isolates Larsen MF-1 (race 1) and Larsen NC-1 (race 2). One 5-mm diameter plug of each isolate was transferred from Petri plates with cornmeal agar to five different Petri plates with cornmeal agar amended with different levels of sulfur: a no sulfur treatment, and 10, 20, 30, and 40 ppm sulfur. Four different sulfur sources were used and include K_2SO_4 (potassium sulfate), Ca_2SO_4 (calcium sulfate), $(NH_4)_2SO_4$ (ammonium sulfate), and elemental sulfur, with which each isolate was incubated. Thus the experiment was a factorial study conducted using a completely randomized experimental design with three replicates. The experiment was maintained on a benchtop at approximately 24°C. The diameter of mycelial growth was measured using two radii for each plate, for each day up to 10 days after transfer to the Petri plate. Measurements commenced three days after transfer and performed using a digital caliper. The entire experiment was repeated twice. Time course data were converted to area under the growth curve (AUGC) and analyzed using analysis of variance to investigate the sulfur effect on *A. euteiches* growth. All analyses were conducted using PROC GLIMMIX of the SAS statistical package.

The same isolates of *A. euteiches* used above were used as inoculum on different alfalfa cultivars planted on soilless growth medium amended with four different sulfur treatments. Three alfalfa cultivars were chosen according to resistance, WAPH-1 (expresses resistance to race 1, susceptible to race 2 of *A. euteiches)*, WAPH-5 (expresses resistance to race 1 and race 2 of *A. euteiches)*, and Vernal (is susceptible to all races of *A. euteiches).* ConeTainers (4 cm diameter x 7.5 cm height) with punctured bottoms were filled with soilless media of known mass to the top of the container. Ninety-eight ConeTainers were placed in a rack in a shallow flat, which was filled with water for irrigation. Before inoculating, the four sulfur treatments were applied by dissolving an exact amount of fertilizer in 20 mL deionized water to make 10, 20, 30, and 40 ppm concentrations. The sulfur treated water, including the no sulfur control, were incorporated evenly into the top 3 cm of media in each cone.

During the inoculations, each flat was designated to one specific *A. euteiches* race to avoid cross contamination, but within each tub the arrangement of ConeTainers with different alfalfa cultivars was randomized. Seeds of each cultivar were planted and flooded with *A. euteiches* mycelial fragments. One flat received no inoculum and was the negative control. The experiment was repeated, with three replicates per run. Incubation time, watering schedule, and a disease rating scale will be performed according to the protocol by Fitzpatrick *et al* (5). To confirm infection Koch's Postulates was completed by baiting the *A. euteiches* cultivars upon selective media as performed by Delwiche *et al* (4). Data were analyzed using analysis of variance to investigate the sulfur effect on *A. euteiches* growth. All analyses will be conducted using PROC GLIMMIX of the SAS statistical package.

Twelve alfalfa varieties were tested for resistance to *A. euteiches* races 1, 2, and, 3. Vernal was used as a susceptible check and WAPH5 as a resistant check. The Roundup Ready varieties tested included Dekalb DKA4118 RR, WL 356 HQ RR, Pioneer 54R04, Aphatron RR, WL 350RR LH, Dekalb DKA4416 RR, and Pioneer 54R02. Three conventional varieties were also included, which were WL 354 HQ, Legacy 449 Aph2, and Pioneer 55V50. Evaluation was carried out using the standardized *A. euteiches* resistance testing protocol. Briefly, thirty seeds of each variety were placed into a single cell of a greenhouse cell-pack. After seeding, plants were inoculated with mycelial fragments of each race of *A. euteiches*. Plants were bottom watered for seven days (depth of water maintained at 2.5 cm). Plants were then flooded and maintained for seven more days in the flooded conditions. Finally, plants were rated for proportion of plant survival. A survival rating of approximately 50% would be considered a "highly resistant reaction."

Results and Discussion

Sulfur source did not significantly impact the growth of *A. euteiches* (Fig. 1; *P*=0.09). Rate of sulfur source did not impact the growth of *A. euteiches* either (*P*=0.32). Sulfur did not have an inhibitory effect on *A. euteiches* in these experiments.

Significant interaction of *A. euteiches* race, alfalfa variety, and sulfur source were identified in experiments were plants were inoculated in ConeTainers (*P*=0.05). For all varieties, no difference in level of disease was identified in plants treated with sulfur compounds and inoculated with the less aggressive race 1 isolate, Larsen MF-1 (data not shown). For plants inoculated with the more aggressive race 2 isolate, Larsen NC-1, application of Ca_2SO_4 (calcium sulfate) was the most consistent treatment to reduce DSI across all alfalfa varieties (Fig. 2). However, DSI was not significantly different from the non-treated control in all cases. Follow-up experiments are being performed to investigate the role of Ca_2SO_4 (calcium sulfate) in Aphanomyces root rot control.

Roundup ready varieties inoculated with *A. euteiches* race 1 typically had better survival than the susceptible check Vernal (Fig. 3). However, the only Roundup Ready variety to perform as well as WAPH5 (resistant check) was Pioneer 54R02, which was also comparable to the best conventional cultivars, Legacy 449 Aph2 and Pioneer 55V50. Only the conventional alfalfa variety Pioneer 55V50 performed as well as WAPH5 when inoculated with *A. euteiches* race 2 (Fig. 4). Most of the roundup ready varieties did not have significantly better levels of survival compared to Vernal, with the exception of Dekalb DKA4416 RR. Inoculations performed using *A. euteiches* race 3 yielded similar results as the race 2 inoculations (Fig. 5). However, all conventional varieties had higher levels of survival than all Roundup Ready varieties with the exception of Dekalb DKA4416 RR and WL 354 HQ. Pioneer 55V50 was the best performing commercial cultivar in these trials, with levels of survival comparable to WAPH5 (resistant check). In the presence of *A. euteiches* races 2 and 3, Roundup Ready varieties tested in these experiments had levels of plant survival comparable to Vernal (susceptible check).

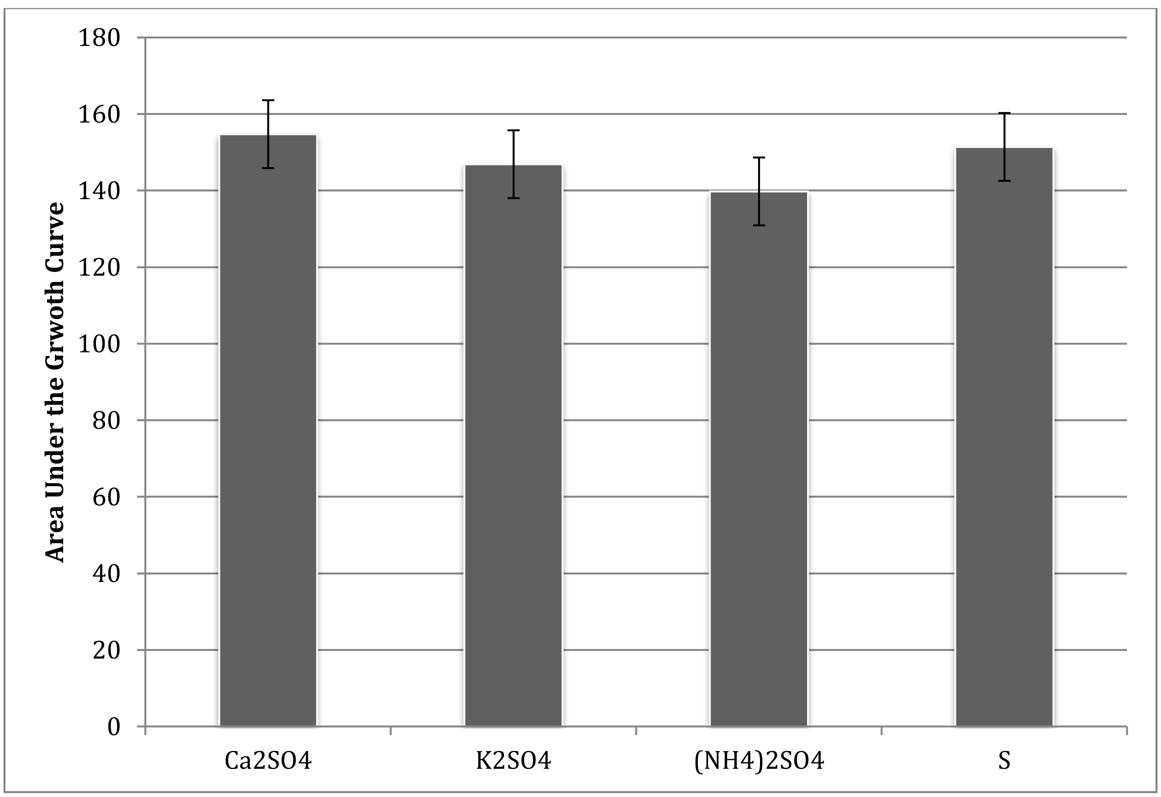

Figure 1. Area under the growth curve (AUGC) ratings for *A. euteiches* in culture in the presence of different sources of sulfur, which include K_2SO_4 (potassium sulfate), Ca_2SO_4 (calcium sulfate), $(NH_4)_2SO_4$ (ammonium sulfate), and S (elemental sulfur). Bars indicate 95% confidence intervals.

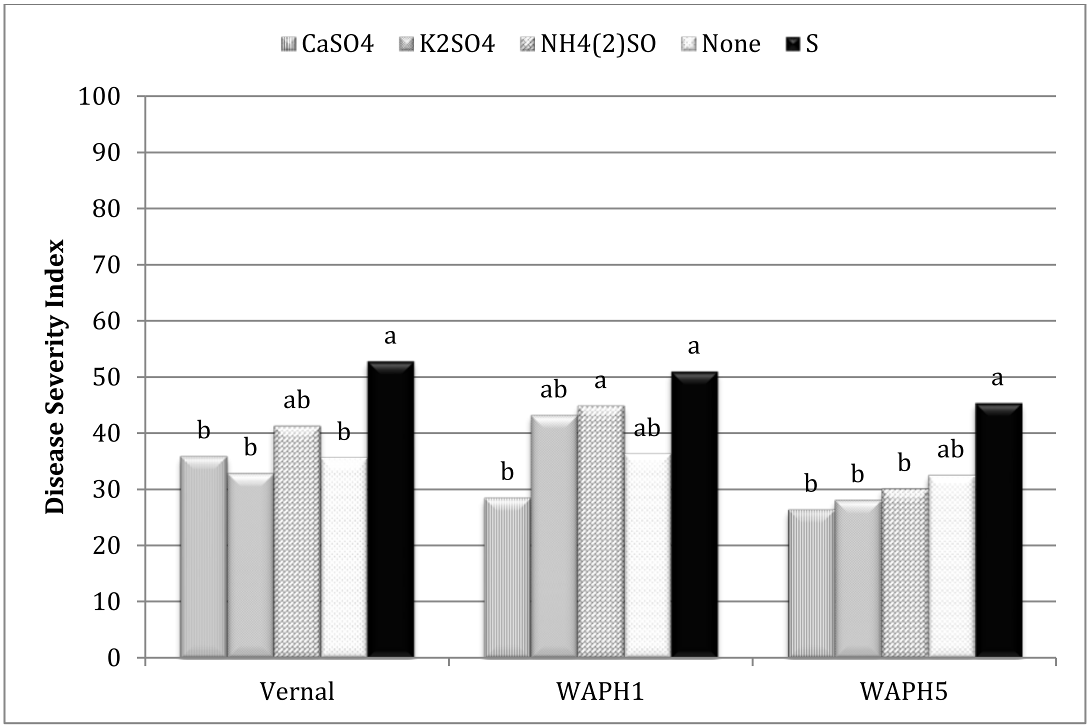

Figure 2. Disease severity index for three alfalfa cultivars inoculated with *A. euteiches* race 2 (Larsen NC-1) and fertilized with four sulfur-containing compounds, which include K_2SO_4 (potassium sulfate), Ca_2SO_4 (calcium sulfate), $(NH_4)_2SO_4$ (ammonium sulfate), and S (elemental sulfur). Bars with the same letter are not significantly different (α=0.05).

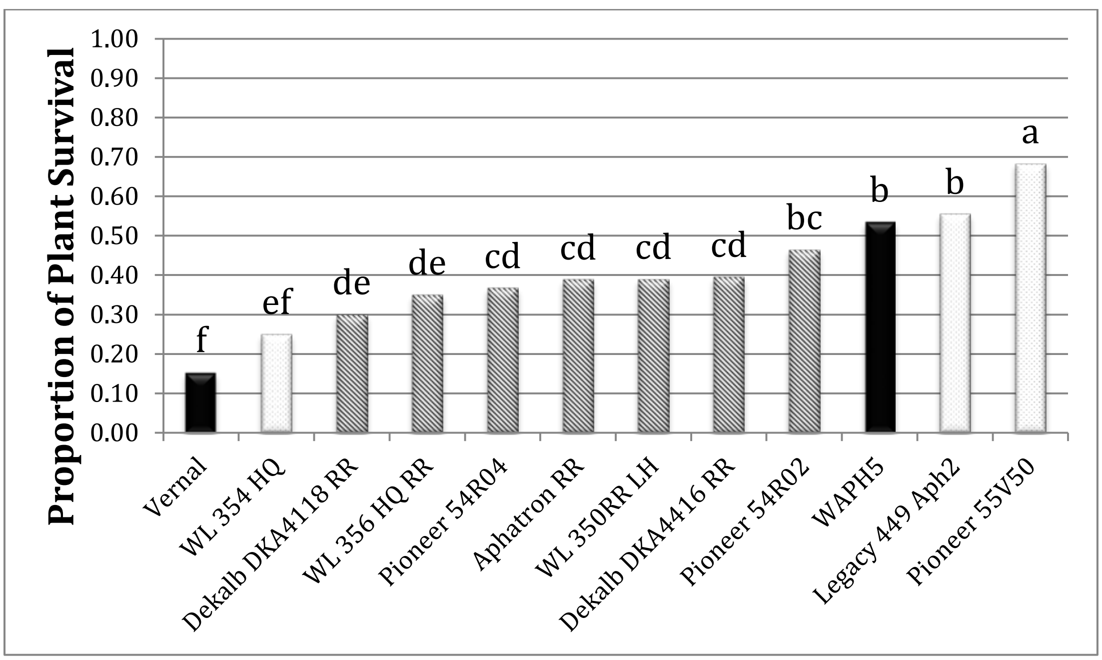

Figure 3. Proportion of alfalfa seedling survival after inoculation with *A. euteiches* race 1. Bars with the same letter are not significantly different (α=0.05). Solid bars indicate "check" varieties. Light bars indicate conventional varieties. Bars with diagonal hashes are Roundup Ready varieties.

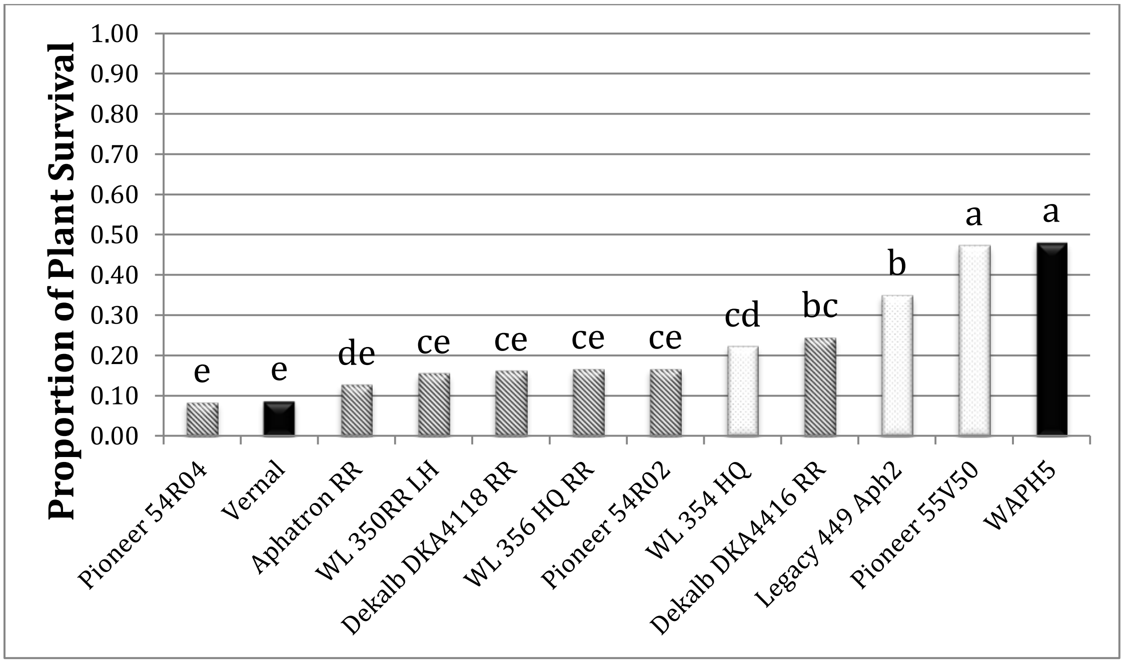

Figure 4. Proportion of alfalfa seedling survival after inoculation with *A. euteiches* race 2. Bars with the same letter are not significantly different (α=0.05). Solid bars indicate "check" varieties. Light bars indicate conventional varieties. Bars with diagonal hashes are Roundup Ready varieties.

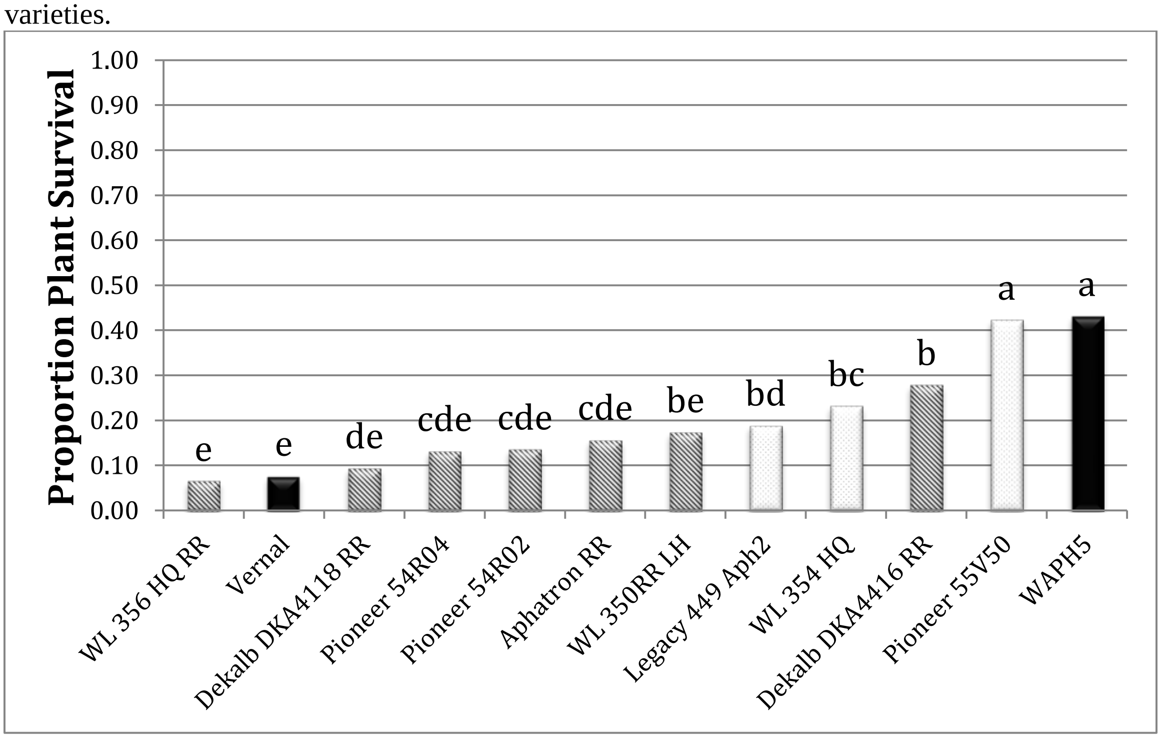

Figure 5. Proportion of alfalfa seedling survival after inoculation with *A. euteiches* race 3. Bars with the same letter are not significantly different (α=0.05). Solid bars indicate "check" varieties. Light bars indicate conventional varieties. Bars with diagonal hashes are Roundup Ready varieties.

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DO WEEDS REDUCE FORAGE QUALITY?

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NEONIC INSECTICIDES AND THE CURRENT STATE OF SOYBEAN APHID IN WISCONSIN

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THRIPS DISPERSAL AND SOYBEIN VEIN NECROSIS VIRUS (SVNV)
IN WISCONSIN SOYBEAN

Chris Bloomingdale[1/], Damon Smith[2/] and Russell L. Groves[3/]

Introduction

Soybean Vein Necrosis Virus (SVNV) is a *Tospovirus* that was first described in 2008 (Zhou et al., 2011) and first reported in Wisconsin in 2012 (Smith et al., 2013). SVNV symptoms include yellowing and clearing of the veins which eventually lead to necrosis of both the vein and leaf tissue. Soybean thrips, *Neohydatothrips variabilis* (Beach), have been identified as a principal vector of this virus (Zhou and Tzanetakis, 2013) making SVNV the first known virus to be transmitted by soybean thrips.

Since SVNV is new to Wisconsin, it is important to understand the timing of thrips movement and virus spread as well as the associated impacts the viral infection may have on soybean. The objective of this research was to establish field trials to investigate the species composition and timing of arrival of thrips in Wisconsin soybean fields, as this information might be important for developing management strategies to reduce the damage caused by SVNV.

Materials and Methods

Aerial thrips fauna were sampled weekly for twelve weeks (June 24, 2013, until September 12, 2013) using yellow sticky-panel traps (Seabright Laboratories, Emeryville, CA) to determine the timing of thrips flights, the periods of greatest thrips activity and predominant species of thrips in five research locations across Wisconsin. Specifically, trap transects were established alongside soybean variety trials in Chippewa Falls, Galesville, Lancaster and Fond du Lac, as well as another experimental soybean field at the Arlington Agricultural Research Station (AARS). After collection, all thrips were counted within ten quadrats on the card (approximately one third of the card's area). Fifty of the thrips found in this area were randomly chosen for speciation to estimate total thrips numbers and relative proportions of species present.

Disease incidence was recorded in fields near R5-R6 stage of development and symptomatic leaf samples were tested to confirm the presence of SVNV via nested polymerase chain reaction (PCR). Additionally, yield data were collected on symptomatic soybean breeding lines located at West Madison Agricultural Research Station to determine the effects of disease

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on soybean yield. This was achieved by marking symptomatic and asymptomatic plants at growth stage R6, hand harvesting pods from all plants marked and weighing and grading all pods and seeds.

Results

Logit-transformed proportions of total thrips counts showed peak capture periods during mid-July (week 3) and late August (week 9; Fig. 1). There was also a correlation between region of soybean field and thrips flights; thrips captures peaked earlier at locations on the west side of Wisconsin (Lancaster, Galesville and Chippewa Falls) versus eastern locations (Arlington and Fond du Lac; Fig. 2). PCR results confirmed SVNV associated symptom with the presence of SVNV at each location. Additionally, sampling was performed in commercial production fields by Wisconsin Department of Agriculture, Trade and Consumer Protection (Fig. 3), identifying other locations with disease. SVNV was identified in 12% of the fields sampled, a 100% increase in the number of positives found compared to 2012. Preliminary results do not show a strong correlation between SVNV severity and soybean yield loss in Wisconsin (data not shown).

Discussion and Future Objectives

Thrips sampling showed that a peak capture period in Wisconsin occurred during mid-July and late August 2013. This pattern of thrips captures suggests that there are two main thrips flights in Wisconsin. These data correspond to results reported from the southern U.S. (Nault et al., 2002). Additionally, there is a correlation between arrival of thrips and the region of the soybean fields, suggesting differences in thrips arrivals between the fields located in western Wisconsin and those located in eastern Wisconsin. Thrips peak catches for the eastern portion of Wisconsin lagged about 2 weeks behind those for the western part of the state in 2013. Larger populations of thrips were observed in the southwestern portion of Wisconsin than any other region.

Future objectives of this research are to continue identification of collected thrips to determine the thrips species composition in Wisconsin. Furthermore, insecticide trials, including seed treatment and foliar insecticide treatments, were implemented at the AARS in 2013, and we plan to evaluate the treatment effects of these products to control reproducing thrips populations in soybean. Finally, the impact of SVNV on soybean yield will be further investigated in the coming year to better understand the economic importance of this virus while determining which varieties of soybean are most resistant to the virus.

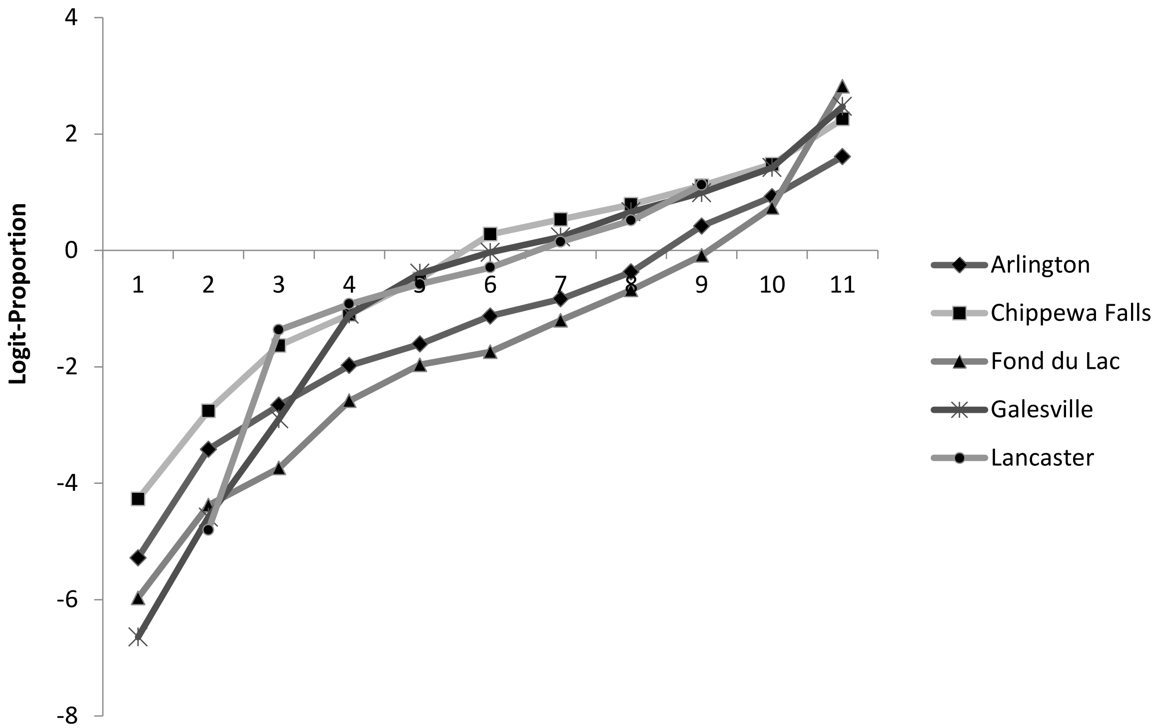

Figure 1. Logit-transformed proportions of total thrips at five sampling location in Wisconsin. Dates of sampling for week designations correspond to those in Figure 2.

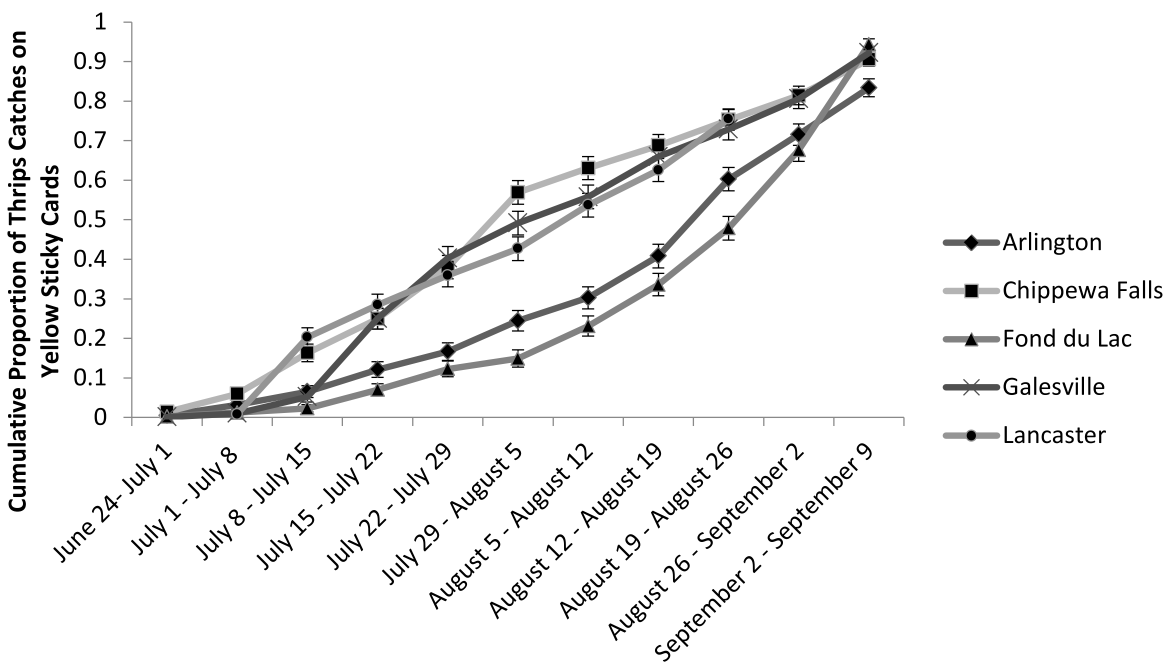

Figure 2. Cumulative proportion of thrips catches at each location sampled. Date ranges correspond to weeks one through eleven in Figure 1.

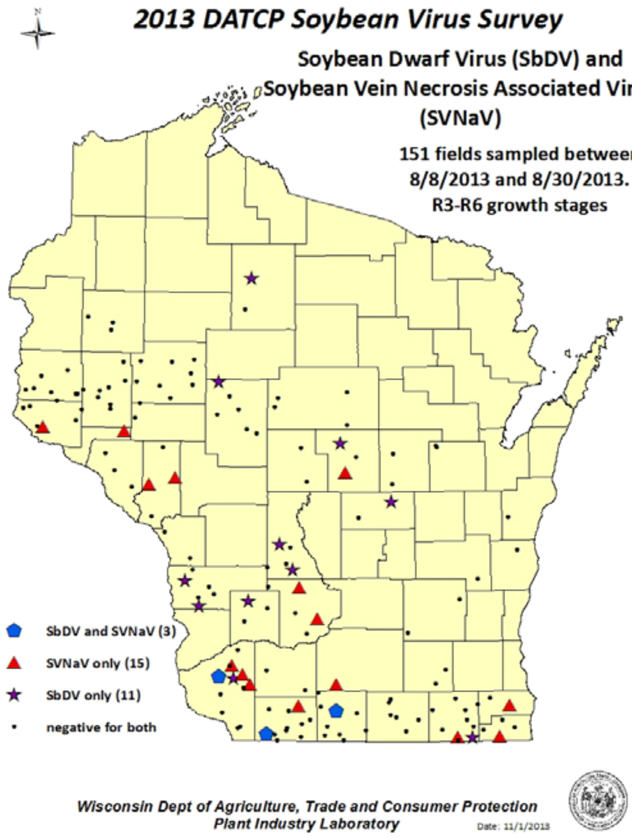

Figure 3. Map showing fields sampled for SVNV and SbDV. Fields positive for SVNV are denoted by triangles and pentagons. (Figure Courtesy of Anette Phibbs, Wisconsin DATCP)

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BUGS: THE MORE THINGS CHANGE, THE MORE THEY STAY THE SAME

Phil Pellitteri [1]

Insect – Scientific name- Origin- First US record,-First WI Record

ALAFALFA

Pea aphid- *Acyrthosiphon pisum*- Europe or Asia – first record 1878 US
Cow pea Aphid- *Aphis craccivora*- found worldwide- problem in WI in 2003
Spotted alfalfa aphid *Therioaphis maculata*- Middle East –New Mexico 1954 WI 1957
Alfalfa Plant bug –*Adelphocoris lineolatus* – Palaeartic- Iowa 1929
Alfalfa weevil- *Hypera postica* North Africa –Maryland 1951 WI 1966
Clover leaf weevil – *Hypera punctata*- Europe 1875 -
Clover Root Curcurlio- *Sitona* sp.- Europe
Alfalfa Blotch leafminer *Agromyza frontella*- Mass 1968 WI 1994

CORN

Corn leaf aphid *Rhopalosiphum maidis*- Asian?- worldwide
European Corn Borer- Ostrina nubalis- Europe – 1917 US -1938 WI
Western Bean Cutworm -*Richia albicosta* -WI 2005
Potato Stem Borer Europe –*Hydrecia micacea*- 1908 US -1970 WI
Western corn rootworm - *Diabroticaa virgifera* – Native -Colorado 1909
Northern corn rootworm –Native- *Diabrotica barberi*- Colorado

WHEAT

Cereal leaf beetle- *Oulema melanopus* Europe -1962 US- -1971 WI

SOYBEAN

Soybean aphid *Aphis glycines* -Asia – WI and US JULY 2000
Mexican Bean beetle-*Epilachna varivestis*, - 1970's WI
Japanese Beetle -*Popilia japonica* - Japan -New Jersey 1912- 1990's WI
Brown Marmorated Stink Bug – *Halyomorpha halys* -Asian US 1988-2011 WI

OTHER NOTABLES
Spotted wing Drosophila- *Drosophila suzuchi*i- 2008 US 2010 WI
European earwigs- *Forficula auricularia* Europe- 1907 US- WI 1970??
Multicolored Asian Lady beetle – *Harmonia axyrdis* – Asian/Japan-1988 US- 1993 WI

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WISCONSIN INSECT SURVEY RESULTS 2013 AND OUTLOOK FOR 2014

Krista L. Hamilton[1/]

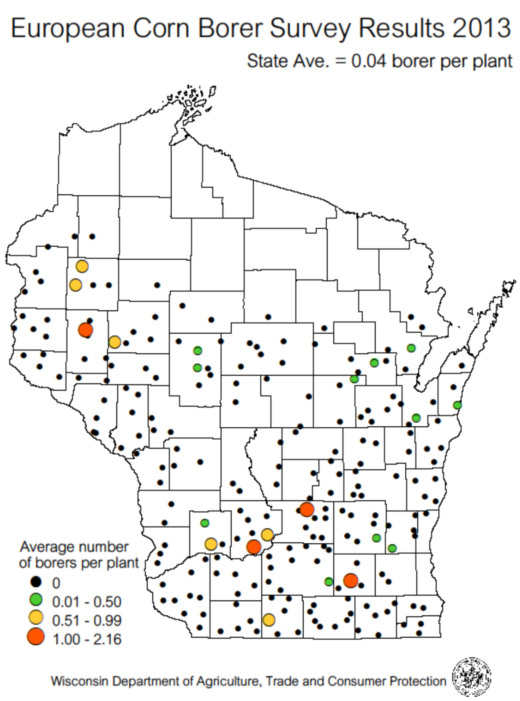
Black Cutworm

Moths began arriving in the state on April 15, first appearing near Janesville in Rock County. The first significant flight was registered in Dodge and Grant counties from May 6-7 and the primary cutting period was predicted to start by May 28. Spring planting delays and rampant weed infestations created very favorable outbreak conditions this year, but widespread cutworm problems failed to develop. The spring migration of 577 moths collected from April 16-June 5 was much smaller than last year's flight of 2,601 moths and damage to emerging corn was not as prevalent or severe as expected.

European Corn Borer

Larval surveys in the fall of 2013 found the second lowest population in 72 years, 0.04 borer per plant. The lowest state average recorded in the history of the Wisconsin European corn borer survey was 0.03 per plant in 2012. Minor population increases from 2012 were charted in the southwest, south-central, southeast, northwest and north-central agricultural districts, and decreases occurred in the west-central and northeast areas. District averages in the central and east-central regions remained unchanged at 0.01 borer per plant. Only 18% of the 229 fields sampled this fall showed evidence of infestation, while the other 82% had no signs of larval injury.

The near-historic low number of corn borers observed again this year reflects the increased prevalence of Bt corn, which comprised 66% of corn acreage in the state in 2013. Another exceptionally low overwintering population indicates the spring moth flight and subsequent first generation of larvae are unlikely to pose a significant early-season threat to the 2014 corn crop.



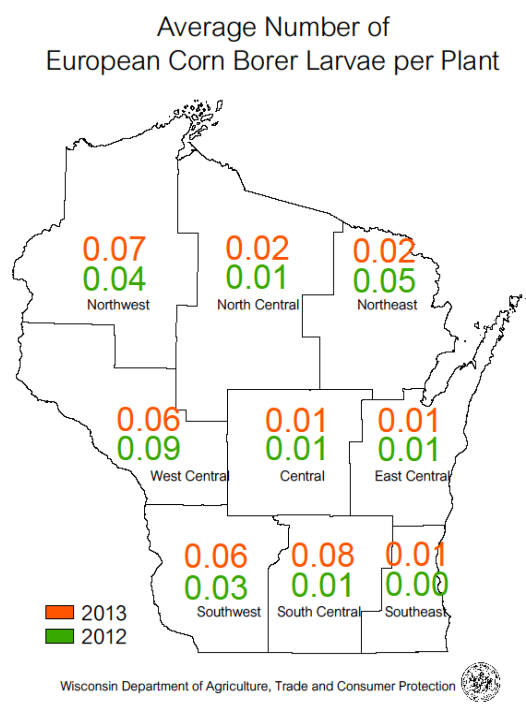


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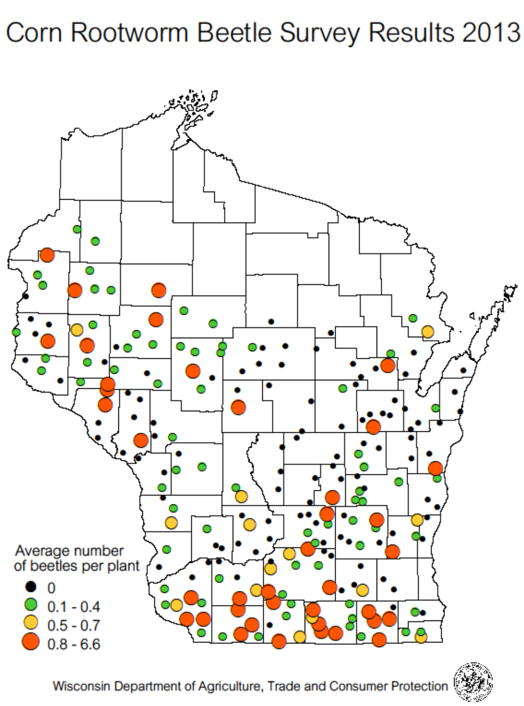
Table 1. European corn borer fall abundance survey results 2004-2013 (Average no. borers per plant).

District	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	10-Yr
NW	0.13	0.01	0.27	0.24	0.12	0.06	0.08	0.15	0.04	0.07	0.12
NC	0.20	0.36	0.16	0.35	0.18	0.10	0.02	0.07	0.01	0.02	0.15
NE	0.22	0.33	0.23	0.07	0.12	0.12	0.19	0.13	0.05	0.02	0.15
WC	0.05	0.24	0.42	0.52	0.04	0.10	0.08	0.12	0.09	0.06	0.17
C	0.06	0.44	0.51	0.42	0.11	0.06	0.06	0.05	0.01	0.01	0.17
EC	0.22	0.25	0.11	0.21	0.20	0.09	0.01	0.03	0.01	0.01	0.11
SW	0.10	0.49	0.20	0.28	0.05	0.06	0.12	0.03	0.03	0.06	0.14
SC	0.05	0.67	0.38	0.33	0.07	0.02	0.07	0.20	0.01	0.08	0.19
SE	0.02	0.35	0.16	0.12	0.04	0.00	0.00	0.01	0.00	0.01	0.07
State Ave.	**0.10**	**0.40**	**0.29**	**0.31**	**0.09**	**0.06**	**0.07**	**0.09**	**0.03**	**0.04**	**0.14**

Corn Rootworm

Development was delayed this season by dry soils during the summer drought of 2012, which caused oviposition to occur at a lower depth in the soil profile, as well as historically cold, wet spring weather. The first beetles appeared later than normal, around July 11, and populations peaked during the third and fourth weeks of August. The state average population of 0.5 beetle per plant was a decrease from the 2012 average of 0.6 per plant, indicating that beetle pressure was slightly lower in 2013. A few reports of heavy populations were received from the northwestern counties where the survey found an average of 0.7 per plant and about one-quarter of sampled fields had economic beetle counts above the 0.75 beetle per plant threshold. Averages across the northern and central counties were otherwise low.

Results of the annual beetle survey suggest a lower potential for root damage to non-Bt continuous corn in central, north-central and northeastern Wisconsin next spring. A higher risk of damage is likely for the areas represented by red symbols in the map below.



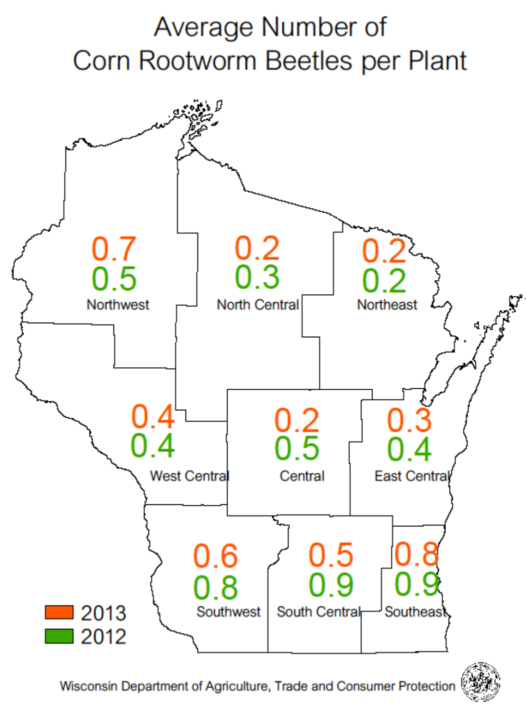


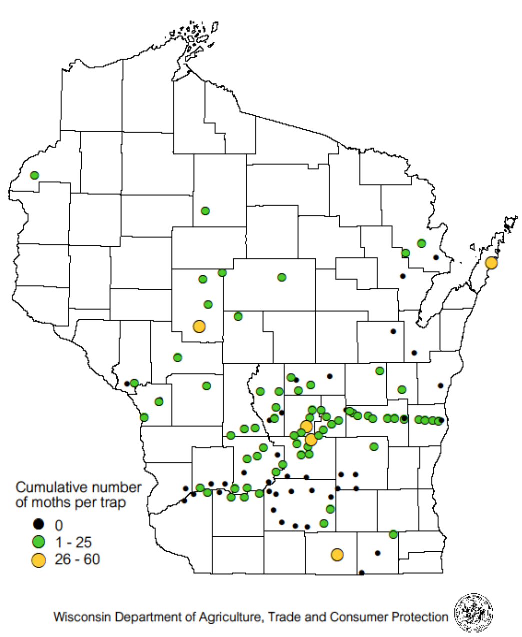
Table 2. Corn rootworm beetle survey results 2000-2013 (Average no. beetles per plant).

District	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	10-Yr
NW	0.9	0.4	0.1	0.4	0.5	0.4	0.3	0.1	0.5	0.7	0.4
NC	0.1	0.8	0.9	0.7	0.9	0.4	0.1	0.1	0.3	0.2	0.5
NE	0.1	0.3	1.8	0.5	0.6	0.6	0.1	0.3	0.6	0.2	0.5
WC	1.1	0.8	0.8	0.4	0.6	0.5	0.4	0.6	0.4	0.4	0.6
C	0.6	0.9	0.7	0.8	0.5	0.4	0.4	0.8	0.5	0.2	0.6
EC	1.5	1.1	2.2	1.4	1.0	0.6	0.3	0.5	0.4	0.3	0.9
SW	0.7	3.2	2.2	0.4	1.1	0.7	0.3	1.1	0.8	0.6	1.1
SC	0.6	1.9	1.7	2.2	1.5	1.1	0.3	1.4	0.9	0.5	1.2
SE	0.2	3.8	1.4	1.0	1.6	0.3	0.2	0.7	0.9	0.8	1.1
State Ave.	**0.7**	**1.6**	**1.4**	**1.0**	**1.0**	**0.6**	**0.3**	**0.7**	**0.6**	**0.5**	**0.8**

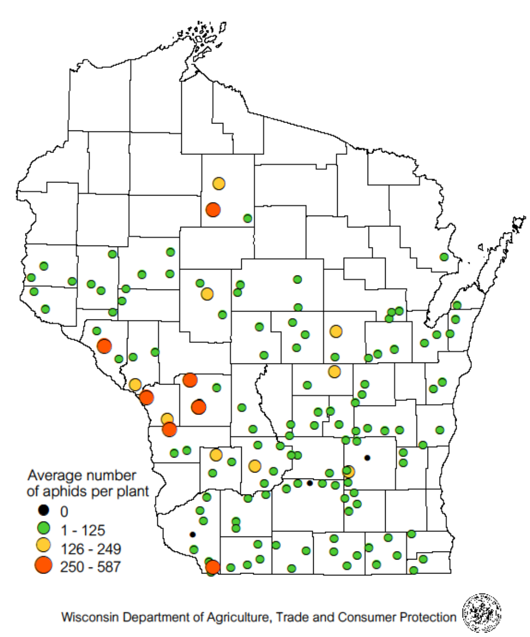
Western Bean Cutworm

Moth counts were the lowest in the nine-year history of western bean cutworm monitoring in Wisconsin. The 2013 trapping survey registered just 663 moths in 114 traps, or six per trap. This is considerably lower than in 2012 when a total of 3,290 moths were collected in 132 traps (25 per trap). The highest individual count for the eleven-week monitoring period was 60 moths near Montello in Marquette County. Possible explanations for the unprecedented decline are that larval populations were reduced by the 2012 drought or that high mortality occurred during the 2012-13 winter months. Moth numbers have consistently declined since 2010 when the annual survey found the state record of 10,807 moths in 136 traps, or 79 per trap.

Western Bean Cutworm Trap Counts 2013



Soybean Aphid Survey Results August 2013



Soybean Aphid

Densities during the second half of the annual survey were the highest in five years. Examination of 139 soybean fields, once in July and again in August, found a state average of 18 aphids per plant during the July survey and a substantially higher count of 55 per plant in August. For comparison, state average densities from 2010-2012 were extremely low at 7-16 aphids per plant and the state average in 2008 was 72 per plant. Approximately 6% of sites sampled from August 6-28 contained economic populations of 250-587 per plant, 22% of fields had moderate averages of 50-249 per plant, and 72% had counts of less than 49 per plant. Populations in 30% of fields decreased from July to August, suggesting that about one-third of the survey sites may have been treated for aphid control this season. This insect was the most economically important insect pest affecting soybeans in 2013, with populations reaching the highest levels since 2008.

Corn Earworm

Migrants first arrived during an early flight that started by May 29 and continued throughout July. Moth numbers fluctuated during this period, with a weekly high count of 154 registered from June 7-13 near Janesville. Larvae resulting from the early flight appeared in vegetative corn by June 27.

A subsequent and more destructive primary flight from early August to mid-September led to larger larval populations which required spray programs to prevent ear damage. Counts during the primary flight peaked from August 23-September 5 when the Fond du Lac County sites registered 309-613 moths per trap.

Although the cumulative seasonal capture of 6,568 moths in 2013 was 38% lower than 10,656 moths in 2012, late-season infestations were more widespread this year compared to last year when most of the moths arrived after sweet corn was well past the susceptible silking stage.

RESISTANCE TO BT CORN BY WESTERN CORN ROOTWORM IN THE U.S. CORN BELT

Eileen Cullen [1]

Abstract:

Transgenic Bt corn hybrids that produce insecticidal proteins from the bacterium *Bacillus thuringiensis* Berliner have become the standard insect management tactic across the U.S. Corn Belt. Widespread planting of Bt corn places intense selection pressure on target insects to develop resistance, and evolution of resistance threatens to erode benefits associated with Bt corn, such as reduced reliance on conventional insecticides. Recognizing the threat of resistance, the U.S. Environmental Protection Agency requires seed companies to include an insect resistance management (IRM) plan when registering a Bt trait. The goal of IRM plans is to delay Bt resistance in populations of target insects. One element of IRM is the presence of a non-Bt refuge to maintain Bt-susceptible individuals within a population, and growers are required to implement IRM on-farm by planting a refuge. Field-evolved resistance has not been detected for the European corn borer, *Ostrinia nubilalis* (Hubner), even though this species has been exposed to Bt proteins common in U.S. corn hybrids since 1996. The IRM situation is unfolding differently for Bt corn targeting the western corn rootworm, *Diabrotica virgifera virgifera* LeConte. In this article, we examine the scientific evidence for *D. v. virgifera* resistance to Bt rootworm traits and the cropping system practices that have contributed to the first reports of field-evolved resistance to a Bt toxin by *D. v. virgifera*. We explain why this issue has developed, and emphasize the necessity of an integrated pest management approach to address the issue.

The full article text is available Open Access at the Entomological Society of America's Journal of Integrated Pest Management:
http://www.ingentaconnect.com/content/esa/jipm/2013/00000004/00000003/art00003

Reference:

Cullen, E.M., Gray, M.E., Gasmann A.J., and Hibbard, B.E. 2013. Resistance to Bt Corn by Western Corn Rootworm (Coleoptera: Chrysomelidae) in the U.S. Corn Belt. Journal of Integrated Pest Management 4(3):D1-D6(6). DOI: http://dx.doi.org/10.1603/IPM13012

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Soil Applied Corn Rootworm Insecticides 101

Bryan Jensen[1/]

Introduction

Using soil insecticides for control of corn rootworm larvae have been a common practice on continuous corn since the 1950s. However, the development of Bt CRW hybrids has raised concerns regarding use, efficacy and resistance. Particularly with newer crop advisors that are unaccustomed with their use.

History

Corn rootworms have a history of insecticide resistance problems and good stewardship of currently labeled insecticides is recommended. The first confirmed case of western corn rootworm resistance was to the cyclodiene (Group 2a) insecticides in 1959. By the 1960s resistance to the cyclodienes was widespread and recommendations were adapted to include the carbamate (Group 1A) and organophosphate (Group 1B) insecticides.

These newer classes of insecticides are not known to have corn rootworm larval resistance problems. However, representatives of each class (carbofuran and isofenphos) were subject to enhanced microbial degradation and are no longer efficacious at controlling rootworm larvae. That is, the soil microbes used these pesticides as an energy source which reduced their concentration in the soil until they were no longer effective. Repeated use also conditioned the soil for even faster breakdown by microbes.

An alternative method of control which targeted adult beetles during the egg laying period did lead to insecticide resistance of carbaryl (Group 1A) and methy-parathion (Group 1B). Targeting adults was developed as an effort to reduce egg laying and hopefully reduce damage from subsequent larval generations. This approach requires accurate identification of both species, ability to distinguish between sexes, determine if females are gravid (have eggs present) while using all this information to determine the proper timing of a single foliar insecticide.

Research and development during the 1980-mid 1990s saw an abundance of insecticide research and develops which included new active ingredients, placements, formulations and delivery methods. However, genetically modified corn hybrids significantly slowed down development of insecticide discovery and research. Development of resistance to Bt hybrids has renewed interested in using soil insecticides for control of corn rootworms.

Discussion

Several rules of thumb exist for providing consistent control from the currently labeled corn rootworm insecticides:

(1) **Chose products wisely**. Refer to university research data and field performance history to select products that consistently offer acceptable performance (nodal root ratings < 0.5 to 0.75). Soil applied insecticides do not control 100% of the larvae. In some years, high populations may overwhelm all rootworm control methods.

[1/] Integrated Pest Management Program, Univ. of Wisconsin-Madison.

(2) **Follow labeled instructions for rates, placement, etc**. Granular insecticides have a use rate based on oz/1000 row feet but also have limitations on the amount that can be used per acre. For example, a commonly used soil insecticide has a use rate of 6 to 8 oz/1000 row feed but also has a limit of 8.7 lb/acre. The latter label requirement limits row spacing to no less than 30 inches.

Research is not always clear on the best placement (T-band vs. in-furrow) of granular insecticides. However, labels may dictate the placement based on whether you are trying to control rootworm and/or white grubs, seed corn maggot, wireworms, cutworms, etc. Label restriction may also require specific placement based on slope, tillage practices and potential threat to endangered resources.

(3) **Calibrate, calibrate, calibrate**. Calibrating soil applied granular insecticides is just as important as calibrating liquid sprayers. On boom sprayers, each nozzle should be calibrated. The same should hold true on each row of your corn planter. The calibration charts supplied on labels are only a starting point. If you walk behind a corn planter and each granular applicator is set at the same setting you can be sure the planter was not calibrated. Planting speed has a major effect on granular insecticide application rates. Know your planting speed and keep it consistent while calibrating and planting.

(4) **Rotate soil insecticides**. Existing labeled granular insecticides are not known to have resistance issues with corn rootworms. Keep it that way. Rotating modes of action is just as important as with other pesticides to avoid resistance.

(5) **Scout for beetles**. Monitoring beetle numbers during the egg laying period can be a helpful method to select a field(s) that do not warrant treatment and those fields where seed treatments should be efficacious. It will also assist with selecting fields where either soil applied insecticides or Bt hybrids are appropriate.

(6) **Validate insecticide performance**. Rootworms do cause lodging but not all lodging is a result of corn rootworm feeding. Compaction, stalk rot, stalk boring insects, inadequate stalk strength, wind and rain are all possible causes. Do not assume lodged corn is a result of rootworm feeding. Dig corn plants (lodged or not), give them a through washing and rate them for damage after larval feeding is complete (late July or early August) to confirm performance.

(7) **Seed treatments**. Clothianadin and thiamethoxam are two active ingredients labeled for larval control. They also have the same mode of action. High rates of these neonicotinoid (Group 4A) seed treatments can be effective on low to moderate corn rootworm populations. Using under a high population scenario may result in unreliable control.

(8) **Organophosphate insecticide and ALS herbicide interaction**. Organophosate insecticides can have significant phytotoxic effects on corn if used before or after an ALS-inhibiting herbicide. Consult the label on all organophosphate insecticides, regardless of formulation, for specific use requirements. Some labels will strictly prohibit their use while others will give guidelines for safer use.

(9) **Nematicidal properties**. Do not assume insecticides will control or even suppress corn nematodes. Avicta Complete Corn (with additional thiamethoxam) and Counter are two insecticide/nematicides labeled for corn rootworm and corn nematodes.

HARVEST 2013 GRAIN QUALITY

Bob Marlow [1/]

{This page provided for note taking}

[1/] The Andersons.

WHAT'S NEW IN THE FEED INGREDIENT INDUSTRY

Ryan Moe [1/]

{This page provided for note taking}

[1/] Land O'Lakes.

GRAIN ELEVATOR AND FEED MILL ASSET VALUATIONS – WHAT IS MY BUSINESS WORTH?

Timothy P. Muehler [1/]

OVERVIEW - Methodologies to Value the Company

There are three basic Approaches to value a Company: 1) the Asset approach; 2) the Income approach; and 3) the Market approach

Asset based approach

The Most appropriate valuation approach for Companies that are considered holding entities (for example, real estate or Companies with high asset values and modest earnings) is the Asset Approach. This approach requires the adjustment of the Company's book value of its assets and liabilities to their Fair Market Value. Often times, it is necessary to get formal appraisals of equipment, land and other assets the Company holds.

The Asset approach is often the correct method for an operating entity if the company has modest or negative earnings and a significant net asset value. This is most often the case for Grain Elevator and Feed Mill operations that have been in existence for many years if not decades. This is because a business owner requires a return on its investment in the fixed assets. As an example, if a company has net asset value of $5 million and the owner requires a return on its assets of 10%, it would be necessary for the Company to earn $500,000 JUST TO PROVIDE A RETURN ON THE INVESTMENT IN THE ASSETS. Unless the Company earns more than $500,000 (in this example) the return on the assets will be insufficient to cover the asset investment and there will be no earnings available to generate Goodwill (also known as Blue Sky). The Income approach discussion below addresses this issue in more detail. In the agricultural environment, because there is often very significant net asset value in the Company, and the earnings are relatively modest in comparison, there is often NO goodwill or blue sky in this type of business.

Income based approach

There are two general income approaches to valuing Companies – The Capitalized Earnings approach which looks at historical earnings, and the Discounted Cash Flow approach which looks at future earnings to arrive at business value.

Capitalized Earnings (historical earnings) - This approach involves looking back historically for indication of future performance.

Discounted Cash Flow (DCF) - The DCF approach involve the use of forward looking requiring forecasts to value the Company. This approach is typically used when historical earnings are not representative of future expectations. In order to use this approach, you need

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to have the ability to accurately forecast future earnings. Forecasts are typically management's responsibility.

Market based approach – Used for Operating entities

The Market based approach looks to actual transactions in the existing Company or the marketplace to serve as a proxy for the value of the Subject Company. It is often very difficult to use this method for Grain Elevators and Feed Mills due to the lack of "comparable" transactions. Issues to address in this approach include:

- i. Prior transactions of subject company ownership interests
    1. How old is the prior transaction?
    2. Arms' length?
- ii. Prior transactions of similar companies
    1. Synergies?
    2. Reason for transaction?
    3. Availability of data?
    4. Age of transaction?
    5. Comparability of transaction?
- iii. Information from publicly traded guideline companies
    1. Concept is that you find comparable companies and use their P/E or other pricing multiples as proxies for your subject company's multiple
    2. Need to adjust these multiples for differences in Size; Growth outlook; etc.
    3. Usually for valuing larger companies
    4. Requires enough COMPARABLE data to be relevant
        - a. Garbage in, Garbage out
        - b. Probably most misused approach by casual valuators
        - c. Adjustment for differences in size, e.g., can be as high as 50% or more

CONCLUSION: BECAUSE OF THE LARGE NET ASSET VALUES IN MOST OF THESE MATURE COMPANIES, FOR MOST FEED MILLS OR GRAIN ELEVATORS, THE ASSET APPROACH WILL BE USED TO DETERMINE THE FAIR MARKET VALUE OF THE OVERALL BUSINESS.

Key Valuation Drivers – How can the business owner increase the value of the business?

There are several key drives of value for all businesses, including Grain Elevators and Feed Mills. By knowing what these drivers are and how they impact value, it is possible to focus management's long-term decisions on these drivers to enhance value of the Company down the road.

1. Earnings

- i. It is important to choose an earnings stream that is relevant to your company/industry. Heavy investments in hard assets; or very high or very low debt levels can dictate which earnings stream is appropriate.

1. Net Income (includes consideration of interest expense, income taxes, and non-cash items such as depreciation and amortization)
2. EBITDA (Earnings Before Interest Taxes Depreciation and Amortization)
3. EBIT (Earnings Before Interest and Taxes)
4. Cash Flow (eliminates non-cash items such as Depreciation)

ii. Whatever earnings stream is used, it must match the multiples applied to those earnings arrived at from market data.

b. Multiple

i. Public Company/Transactional data

1. Need to be sure they are truly comparable
2. Must be applied correctly, each database has different items that need to be added to the calculated value (such as cash, fixed assets, etc.) **THIS IS OFTEN DONE INCORRECTLY AND CAN RESULT IN HUGE SWINGS/ERRORS IN VALUE.**
3. Is a company 50x larger than yours really comparable?
4. If the "comparable" company is diversified into many areas and your company is in one niche, is that a comparable company?

ii. BuM (Build-up Method) Valuator builds up the risk rate using empirical data

Risk Free Rate	4%	4% (Treasuries)
Equity Risk Premium	5%	5% (SBBI)
Size Premium	6%	6% (SBBI)
Specific Risk (JUDGMENT)	5%	5% (Valuator)
Discount Rate (for DCF)	20%	20%
LESS Growth Rate	(3%)	(8%) (Valuator)
Capitalization Rate	17%	12%
Multiple (1/Cap. Rate)	5.9	8.3

c. Growth – One of the biggest value drivers in a valuation

i. Can dramatically impact value

ii. Looking at LONG TERM –

- Should it be at least equal to inflation?
- Can it be double digit?
- What happens if growth is not expected to be constant?
- What is the impact on value?

Multiple (1/Cap. Rate)	5.9	8.3
o Times Cash Flow	$100,000	$100,000
o Calculated Value	$590,000	$830,000

- **In this case, a difference of 5% in growth resulted in a 40% difference in value!!!**

d. Risk (this adjustment has similar impact to value as Growth in many cases)

i. Chosen by Valuator, based on company analysis such factors as:

1. **Client concentration**
2. Volatile Niche
3. Poor Capitalization

4. **Competition**
5. Thin Management

AS A BUSINESS OWNER, YOU CAN CONTROL THE VALUE DRIVERS THAT IMPACT THE VALUE OF YOUR BUSINESS. A LONG-TERM PLAN FOCUSED ON THE KEY VALUE DRIVES AND BUSINESS RISKS WILL HAVE DRAMATIC IMPACT ON VALUE OF THE COMPANY IN THE EYES OF A BUYER.

What is the appropriate Income/revenue definition to us for valuing the Company?

- i. **Revenue** Multiple?
    1. What if the subject company is losing money? You get the same value for a profitable company as a company losing money under this approach.
- ii. **Earnings**? - There are many different "earnings" metrics.
    1. Are you using "Cash Flow"; "EBIT"; "EBITDA", each one requires a different multiple. For example, applying the same multiple to EBIT and EBITDA will result in a much higher value under the EBITDA calculation than the EBIT calculation, due to the addback of depreciation and amortization, which is often significant.
    2. Do you adjust Earnings for market based expenses such as:
        - a. Officer's Compensation - are the officer's over paid/underpaid? If so, the net income reflected is not market earnings. What would an outside owner have to pay to replicate the skills/tasks provided by the officers?
        - b. Rent
            - i. If the company is leasing from a related party, this rent expense could be higher than market rates, thereby lowering the income, and thus the value.
        - c. Other
            - i. What do you do about non-operating assets? Is that cash in the business needed for operations, or can it be distributed without impacting earnings? This can have an impact on the value of the company under an earnings method. Non-operating assets are added to the value of the company calculated under the income methods.
    3. Do you reduce earnings for income taxes (C-Corp or S-Corp)?
        - a. In valuing a pass through entity, we will typically impute taxes against the net income, even though the entity itself doesn't pay taxes. This will lower the value of the company as compared to not tax imputing. If the agreement is silent on this issue, different appraisers may do this differently.
    4. If using historical data, what weighting do you give each year?

a. Use most recent year?
    i. What if that year is a mountain or a valley? In today's economy, the reliance on the most recent year or even the last 3 years will result in a lower value for the company than is likely warranted, due to lower earnings and often times lower multiples.

    TYPICALLY, A POSITIVE TREND IN EARNINGS WILL CREATE A HIGHER VALUE THAN SPORADIC EARNINGS, OR A NEGATIVE TREND.

b. 5 most recent years?
    i. Weight them equally or other method?
    ii. How do you consider <u>anomalies</u>?
    iii. How do you consider cyclicality within the industry?
    iv. Does the formula require an adjustment for <u>non-recurring items</u>? For example, what if you have a capital gain in the most recent year of $500,000; do you remove that item from earnings? If not, and your multiple is 5, your value is $2,500,000 higher than it probably should be.

5. Does your valuation require a reduction of the debt, or consideration of the equity of the company?
    a. This goes to the issue of comparing apples to apples.
    b. When valuing "invested capital" the value figure includes the debt.
    c. When valuing equity, the debt is removed. Depending on the level and nature of the company's debt, this distinction can be dramatic.

    THIS IS ONE OF THE MOST MISUNDERSTOOD CONCEPTS IN VALUATION. IF YOU ARE USING <u>PRE</u>-DEBT EARNINGS, YOU MUST DEDUCT LONG-TERM DEBT FROM THE CALCULATED VALUE.

Other issues that impact value of the business and cash in the hands of the seller.

1. Is there excess cash or other non-operating assets that can be removed prior to sale without impacting value? If so, you can "clean up the balance sheet" by removing these assets.
2. Do your key people have non-compete agreements? The absence of non-compete agreements for key employees and management can often be a deal breaker. You must have these in place prior to marketing the business or risk losing value in the Company. You give the employees all the leverage if you ask them to sign these after marketing the business.
3. Tax Planning

    The gross sale price is not as relevant as the after-tax proceeds
    Consult your tax advisor regarding:
    - Stock sale versus asset sale

    - Stock sale usually favors the Seller, all other things being equal
    - Buyer may prefer asset purchase to allow for new basis in assets and resulting depreciation expense
- Allocation of asset values – often a key area of disagreement
- Tax impact of non-competes; consulting agreements; etc.

Conclusion

Many Grain Elevators and Feed Mills will be valued based upon the Net Asset Value method, which requires the assets and liabilities to be adjusted to their fair market value.

In the case of a highly profitable Elevator or Mill, there is a possibility that Goodwill exists due to its earnings. In those cases, the management of these key value drivers of the business can pay off dramatically for the seller in the form of a higher sale price.

A PRACTICAL SUSTAINABILITY ASSESSMENT PROGRAM:

PROCESSING VEGETABLE RESULTS

Paul Mitchell [1/]

{This page provided for note taking}

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EVALUATION OF POTENTIAL NEW HERBICIDES IN GARDEN BEETS

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

Weed management options in garden beets have become limited in recent years, particularly after the introduction of glyphosate-resistant sugar beets and subsequent loss of herbicide registrations. The primary objective of this project was to evaluate registered and non-registered herbicides as part of pre- and post-emergent programs in an effort to achieve season-long weed control. Studies were conducted in 2013 at two locations (Arlington and Plover, WI). A total of 12 weed management programs were evaluated. Four garden beet varieties were included: 'Ruby Queen', 'Detroit Supreme', 'Red Ace' and 'Red Titan'. This study will be repeated in the 2014 growing season at both locations.

Plover Location Results:

Weed control was outstanding across all herbicide programs. Common lambsquarters, redroot pigweed, common purslane, wild buckwheat, wild proso millet and large crabgrass control throughout the season were almost always between 95 and 100%. In fact, season-long weed control likely would have been adequate with just the pre-emergent and 2-leaf herbicide application timings, with the 4- and 6-leaf herbicide applications available to control escaped or newly-germinated weeds if necessary. In particular, Dual Magnum plus Ethotron applied pre-emergence followed by Ethotron and UpBeet at the 2-leaf beet growth stage resulted in excellent weed control and minimal crop injury across varieties. Garden beet injury was variable by treatment and variety and there were no strong trends among registered herbicide programs. Of the herbicides not currently registered in garden beets (Chateau, Zidua, Curbit and Firstrate), only Zidua was worthy of further investigation. Injury was unacceptable with Curbit, and Chateau and Firstrate applied post-emergence eliminated the crop.

Arlington Location Results:

Treatments at the Arlington location were similar with the exception that Dual Magnum rates were generally increased to correspond to the heavier soil and the Upbeet rates were increased to provide additional velvetleaf control that was expected at this location. Nearly all treatments provided exceptional season long weed control. As in the Plover location, it again appeared that many of the treatments would have been satisfactory with just the pre-emergent and 2-leaf herbicide timings. Injury was greatest after the 2-leaf timing across all treatments, but there was very little variability in injury among varieties within a treatment. Overall, 'Ruby Queen' had the greatest correlation between injury and yield loss across all treatments.

While this study will be repeated in 2014 under a different set of environmental conditions and with varying weed spectrum and density, the 2013 results suggest that acceptable weed control without compromising crop yield are both still possible with existing herbicide tools. In fact, herbicides applied pre-emergence and at the 2-leaf beet growth stage may be adequate and still allow for another salvage herbicide treatment if scouting suggests the need.

Herbicides not registered for use on garden beets were included in this study. Always read and follow the herbicide label prior to use.

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PREDICTING SOYBEAN APHID FLIGHTS AND INFLUENCE ON NON-PERSISTENT VIRUS TRANSMISSION

Russ Groves and Ken Frost [1/]

{This page provided for note taking}

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DISTRIBUTION & CHARACTER OF CUCURBIT DOWNY MILDEW AND POTATO AND TOMATO LATE BLIGHT IN 2013

Amanda J. Gevens[1]
{with contributions from Anna Seidl[2] and Amilcar Sanchez Perez[3]}

Introduction

On vegetable and potato crops, the water molds, or fungus-like, oomycetous plant pathogens, which threaten the greatest crop losses include *Pseudoperonospora cubensis* (causal agent of downy mildew on cucumbers), and *Phytophthora infestans* (causal agent of late blight on potatoes and tomatoes). Downy mildew and late blight can both be aerially dispersed over long distances and genotypes identified in the region are not known to be soilborne at this time (1, 2). Initial inoculum and infection occurs as the result of movement of spores in the air from diseased fields to healthy, infected seed or transplants, or by overwintering plant tissues harboring the pathogen from the previous year (e.g. volunteers, cull piles, compost piles). In Wisconsin in 2013, both diseases were detected in vegetable crops.

Results and Discussion

Cucurbit downy mildew caused by the fungus-like pathogen *Pseudoperonospora cubensis* has become more prevalent in the Midwestern & Great Lakes states and throughout the U.S. over the past 8 years. Growers of cucurbits (cucumber, squash, melon, pumpkin) in the Midwestern U.S. states, may recall rare occurrences of late season downy mildew on squash or watermelon crops over the last four decades. Whether there has been a change in the pathogen population by way of a genetic mutation or sexual recombinations, or introduction of an invasive and aggressive cucumber strain, or if changes in environmental conditions have promoted increased virulence is unknown. North Carolina State University researchers determined that recent eastern U.S. populations of cucurbit downy mildew were much more diverse in host range and pathogenicity than was previously known, with *Cucumis* species (cucumber, melon) having greater susceptibility to most pathogen isolates than *Cucurbita* species (squash, pumpkin). Recent identification of the presence of mating pairs in U.S. cucurbit downy mildew populations strongly suggests a source of genotypic and phenotypic variation.

Since 2005, the Midwestern U.S. has seen cucumber as the first cucurbit crop infected with downy mildew with symptoms detected as early as mid-June. Here in Wisconsin, we have seen sporadic and low incidence of downy mildew on cucumber, in particular, in recent years. Few other cucurbits have been noted with downy mildew symptoms. In mid-August 2013, melon and squash cultivars were diagnosed with downy mildew on just a single farm in Jefferson County. The disease did not decimate all of their cucurbit crops, but rather was evident through profuse sporulation on leaf undersides and some necrosis of leaves. No noted progress or spread occurred from this single site. Typically, when environmental conditions favor downy mildews, the disease can be a continual challenge until harvest or frost.

Cucurbit crops in the Midwest have typically not needed routine application of fungicides for downy mildew control. For ~40 years, varietal resistance in commercial cucumber and some melon varieties, conferred by the recessive *dm1* downy mildew resistance gene, was effective in controlling disease.

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[3]Graduate Research Assistant, Plant Pathology Department, University of Wisconsin-Madison

Pumpkin, squash, and watermelon crops were without this resistance and would sporadically become infected with downy mildew late in the production season. It had been standard recommendation that pumpkins in northern states were to be planted and harvested early to avoid risk of downy mildew because the pathogen could make its way north on late season air currents. The strain(s) of the downy mildew pathogen that have recently made their way to our region are not adequately controlled by *dm1* resistance that held up for decades.

Downy mildew, like other members of the water molds, is favored by warm temperatures (65-85°F) and wet field conditions. In 2010, areas of Wisconsin received over 30 inches of rainfall from May to October, the highest quantity of precipitation recorded over the production season since 1895. Conducive weather coupled with presence of the pathogen resulted in downy mildew in multiple cucumber producing areas of the state.

While downy mildew does not cause fruit infection on cucurbits, the pathogen can defoliate plants leaving fruit at risk for sunscald and secondary infection. Foliar symptoms include pale green-yellow angular (squared off within veins) lesions on leaf surfaces with corresponding and distinctive fuzzy brown growth on leaf undersides (Figure 1). The fuzzy growth is the pathogen producing thousands of new sporangia (spores) which can become airborne and further spread the pathogen within field and beyond at a rate of approximately 6 miles/day. Early infections can be tricky to identify, as they may mimic a nitrogen deficiency, angular leaf spot, or even virus symptoms. The pathogen is an obligate parasite, requiring living plants to remain viable. The pathogen cannot overwinter in the soil on its own, as production of persistent soilborne spores (oospores) have not been found here in Wisconsin.

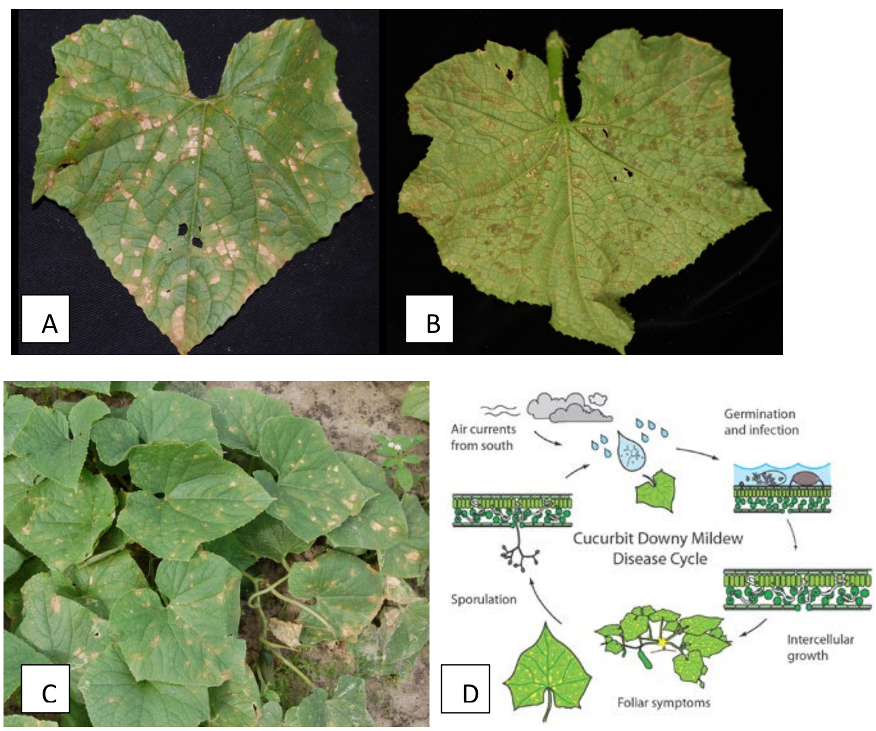

Figure 1. Symptoms of downy mildew on cucumber. A) Mature, angular, necrotic downy mildew lesions on cucumber leaf surface. B) Fuzzy, brown, pathogen sporulation on leaf underside. C) Cucumber downy mildew in the field. D) Cucurbit downy mildew diseaes cycle.

Management Currently, with mid-season risk of spore movement and lack of commercially available and durable varietal resistance in cucurbits, fungicide applications are essential for protection of yield and quality. The selection of fungicides, timing of application, and thoroughness of application are critical for effective disease control. Fungicides should be applied prior to or at first sign of infection to best control cucurbit downy mildew. Based on field research in multiple states including Michigan and North Carolina, effective fungicides for downy mildew control include zoxamide+mancozeb, fluopicolide, propamocarb hydrochloride, cyazofamid, famoxadone+cymoxanil, and ametoctradin+dimethomorph. The effective control program for cucumber established at Michigan State University by Dr. Mary Hausbeck, which I recommend to producers in Wisconsin, specifies a 7-day spray interval of the previously listed materials tank-mixed with either mancozeb or chlorothalonil when initiated **before** downy mildew is found in the field. Fungicides should be alternated so as to manage the potential development of fungicide resistance. Sprays are tightened up to a 5-day interval when initiated **after** disease is found in the field. For cucurbits other than cucumber, the program above is modified to expand the spray intervals from 7 to 10-day **before** disease, and 7-day **after** disease is found in the field. Downy mildew can be well controlled in cucurbit crops with use of effective fungicides, however, this adds a significant increase to the cost of production and success is contingent upon careful attention to regional extension vegetable disease reports and careful field scouting to appropriately time fungicide application.

To aid in tracking cucurbit downy mildew in your county and beyond, the website: http://cdm.ipmpipe.org/ offers forecasting of the disease based on confirmed reports across the U.S. The ipmPIPE (or **i**ntegrated **p**est **m**anagement **P**est **I**nformation **P**latform for **E**xtension and Education) cucurbit downy mildew website provides a publicly accessible site for sharing of cucurbit downy mildew detections, as well as symptom descriptions and management recommendations by region. The site is maintained by researchers at North Carolina State University with collaboration from researchers across the U.S., including Wisconsin. With the multitude of tasks that growers have to manage in the field, office, and marketplace, I recommend use of the CDM ipmPIPE Alert System (link on left side bar of website) which sends you an email or text message when downy mildew is reported within a selected geographic radius around your farm. Also, consider e-mail list serve membership to the University of Wisconsin Extension Vegetable Crop Update newsletter each week through the growing season for downy mildew status reports. Newsletters may be sent out by your grower association or can be directly accessed each week at our UW-Vegetable Pathology website: http://www.plantpath.wisc.edu/wivegdis/.

Research is ongoing in the U.S. and worldwide to better understand the pathogenicity, host resistance, and spread of cucurbit downy mildew. Advances in resistance breeding will greatly aid in improved disease control and sustainability of cucurbit production in Midwestern states and worldwide.

Tomato and potato late blight was confirmed in 15 Wisconsin counties in 2013 from both tomato and/or potato. For all but 2 samples (that were US-8), the pathogen genotype was US-23 (Table 1 & Figure 2). Nationally, the US-23 genotype predominated disease outbreaks, with few determinations of US-7, US-8, and at least one novel type. By production season's end, most of the late blight samples coming in through our lab from Wisconsin were from home garden tomatoes (Table 1). Given the understood nature of the pathogen in state at this time, the early hard frosts should have aided in our late season late blight control as dead plants=dead pathogen.

Late blight is the most limiting disease to potato production worldwide and has been recognized as a significant agricultural concern since the Irish potato famine in the late 1840s (2,3). In addition, recent strains or genotypes of the pathogen have also been problematic on tomato – a crop with less significant acreage in Wisconsin than potato – but a crop with great distribution around the state. Two mating types are needed to produce sexual, persistent soil-borne oospores. The population is largely clonal outside its center of origin in the Toluca Valley of Mexico, relying on production of asexual sporangia for persistence. Nationally, US-1 (A1) was the predominant clonal lineage until the late 1980s-early 1990s, when US-8 appeared. US-8 was the opposite mating type (A2) and was insensitive to mefenoxam, a fungicide with exceptional activity against oomycetes, but with a specific mode of action that effectively selects for insensitivity.

Table 1. Characterization of late blight from Wisconsin in 2013.

County	Host	Genotype	Date of 1st Confirmation in County
Adams	Potato	US-23	28 Jun
Juneau	Potato	US-23	29 Jun
Sauk	Tomato	US-23	2 Jul
Dunn	Potato	US-23	29 Jul
Portage	Potato	US-8/US-23	29 Jul/6 Aug
Brown	Potato+Tomato	US-23	6 Aug
Langlade	Potato	US-23	6 Aug
Racine	Tomato	US-23	8 Aug
Waushara	Potato	US-23	8 Aug
Milwaukee	Tomato	US-23	22 Aug
Forest	Tomato	US-23	28 Aug
Marinette	Tomato	US-23	10 Sep
Oconto	Tomato	US-23	10 Sep
Walworth	Tomato	US-23	10 Sep
Waukesha	Tomato	US-23	20 Sep
Polk	Tomato	US-23	3 Oct

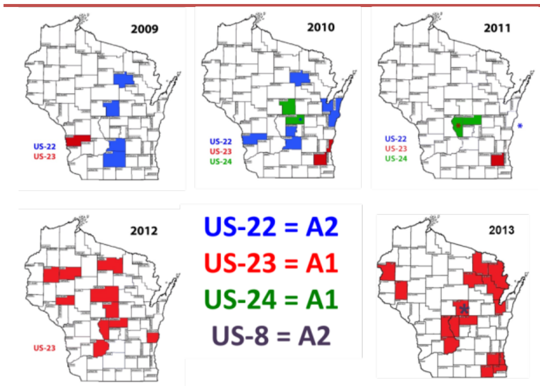

Figure 2. Distribution and character of late blight detected in Wisconsin during production seasons of 2009 to 2013.

Leaf symptoms appear as pale green, water-soaked spots that often begin at the leaf edges or tips where water from rain and dew accumulates. Lesions can be circular or irregular and bordered by pale yellow to green blending into healthy tissue. They enlarge rapidly (expanding ¼ to ½ inch per day) turning brown to black over time. When relative humidity is in excess of 90% leaf lesions are often surrounded by cottony white mold on the lower leaf surface (Figure 3). This white, cottony growth distinguishes late blight from several other foliar diseases of potatoes and tomatoes. Infected stems and petioles turn brown to black and may also be covered with white masses of sporangia. Stem lesions frequently appear first at the junction between the stem and leaf, or at the cluster of leaves at the top of the stem. Entire vines may be killed very rapidly. A characteristic odor similar to that produced by green tissue after a severe frost can be detected. Visit the UW-Vegetable Pathology website http://www.plantpath.wisc.edu/wivegdis/ for additional late blight photos and links to other late blight information and identification resources.

After 2002, Wisconsin growers enjoyed a 6-year respite from this disease, until it appeared in 2009, and in each of the subsequent years including 2013. In these years, isolates were collected from potato and tomato from across the state. Allozyme genotype was resolved using cellulose acetate electrophoresis (3). This revealed 3 banding patterns which profiled US-22, US-23, and US-24. All isolates of US-22 and US-23 were sensitive to mefenoxam, while isolates of US-24 showed partial insensitivity. US-22 isolates were of the A2 mating type, and US-23 and US-24 isolates were of the A1 mating type. In 2013, we also detected US-8, an older genotype with resistance to mefenoxam and an A2 mating type status.

While possible under laboratory conditions, to date, opposite mating types have not been identified in the same field within the same production year in Wisconsin. Oospores have not been identified in late blight infected plant tissues in samples submitted for diagnostic services. Ongoing studies are designed to better understand the overwintering and germination potential of oospore. Constant monitoring and managing of late blight through use of varietal resistance and well-timed and –selected fungicides is essential in order to efficiently and effectively control late blight and maintain geographical separation of mating types.

***Management Considerations for fungicide programs to manage late blight*:** There is not one recommended fungicide program for all late blight susceptible potato fields in Wisconsin. Fungicide selections may vary based on type of inoculum introduction, proximity to infected fields, crop stage, late blight strain, and other diseases that may be in need of management. This article provides general guidance to assist in development of your fungicide program.

Under high late blight pressure, fungicide programs with Revus Top, Forum, Curzate 60DF, Ranman, Tanos, Gavel, Previcur Flex, or Omega should be used. Mefenoxam containing fungicides such as Ridomil Gold SL can also be highly effective in controlling late blight caused by the pathogen strain US-23. This strain was identified in most WI cases in 2013. Zampro is a newly registered late blight fungicide offering a novel mode of action fungicide in an effective pre-mix for late blight control. Brief comments on each of these fungicides are listed below.

Revus Top contains mandipropamid (Group 40) for late blight and difenoconazole (Group 3) for early blight; excellent protectant on leaf blight; rainfast; translaminar and contact activity.

Forum contains dimethomorph (Group 40) for late blight; can be applied after vine kill; good protectant on leaf blight; good antisporulant; rainfast; translaminar activity.

Curzate 60DF contains cymoxanil (Group 27) for late blight; locally systemic; excellent curative activity; good protectant on leaf blight; rainfast in 2 hours.

Ranman contains cyazofamid (Group 21) for late blight; excellent protectant for leaf and tuber blight; rainfast; contact activity.

Tanos contains cymoxanil (Group 27) for late blight and famoxadone (Group 11) for early blight; excellent curative activity; good protectant on leaf blight; rainfast; translaminar and contact activity.

Gavel (zoxamide, Group 22+mancozeb, Group M3) is best used as a protectant and has been reported to reduce tuber blight; excellent protectant on leaf blight; rainfast; contact activity.

Previcur Flex contains propamocarb hydrochloride (Group 28); good protectant on leaf, new growth, and stem blight; good curative and antisporulant activity; excellent rainfast activity; systemic and contact activity.

Omega is a broad spectrum fungicide (fluazinam, Group 29) and especially effective at controlling the tuber phase of late blight (with added benefit of white mold control); excellent protectant on leaf blight; good protection against tuber blight; rainfast; contact activity. Has special label for powdery scab in WI as of 2011.

Ridomil Gold SL contain mefenoxam (Group 4); excellent systemic movement in plant; curative activity; excellent control of stem, leaf, and tuber late blight; rainfast; can only be effective if you are controlling a sensitive strain such as US-23, US-22.

Zampro contains ametoctradin (Group 45) and dimethomorph (Group 40) both with activity on late blight; good preventative disease control; systemic and protective activity.

In Wisconsin, the QoI inhibitors Headline (pyraclostrobin, Group 11), Quadris (azoxystrobin, 11), and Reason (fenamidone, 11) have offered good late blight control at high label rates under moderate late blight pressure and should be used in a manner which mitigates pathogen resistance development - in tank-mix with protectant fungicides such as mancozeb or chlorothalonil-based products and do not apply in consecutive applications.

Headline, Quadris, Reason, Revus Top, and Tanos, also provide good control of early blight in most potato fields in Wisconsin. There are fields/areas where the early blight pathogen population may have some resistance to the QoI fungicide group (11), but generally, this group of fungicides is still effective.

Phosphorous acid formulations such as Crop-phite, Fosphite, Phostrol, Prophyt, and Rampart can increase tuber protection to late blight and pink rot. However, rates must be high and multiple applications must be made for significant tuber protection. Post-harvest treatments can aid in storage late blight development and progress.

Mancozeb used as a tank-mix partner in the final fungicide applications can provide some additional tuber late blight production. Research conducted in Washington and published in 2006 by Porter, Cummings, and Johnson indicated that soil application of mancozeb greatly reduced the incidence of tuber blight when compared to other fungicides. Additionally, in our early blight fungicide trial work at the Hancock Research Station we have often seen yield increases when we use mancozeb as the base protectant tank-mix partner in our final 2 applications.

In years when weather conditions do not favor severe late blight, programs based on chlorothalonil formulations and EBDCs can be adequate to reduce risk of late blight. The addition of TPTH 80WP to any of the protectant programs can enhance disease control particularly towards the end of the growing season. Our current weather conditions, while very hot, can promote disease development due to periods of rainfall, high humidity, and moderate overnight temperatures.

Timing and frequency of fungicide applications are critical elements in an effective disease control program. As in previous years, our program offers Blitecast information which indicates timing for initial preventative fungicide applications for late blight control. Blitecast uses accumulated environmental conditions from crop emergence to determine risk thresholds and has been very reliable in recent years in pre-empting late blight epidemics. Five to seven day applications are needed to protect the crop under conditions of rapid growth and high disease pressure. Once late blight has been detected in WI, protectant programs should be maintained in areas near affected fields until the end of the growing season to limit late season infection and the tuber phase of the disease.

In fields with late blight ‘hot spots,’ crop destruction is recommended to limit disease development and production of inoculum. A conservative approach to reducing spread from a hot spot includes destruction of 30 rows on either side of the newest lesions at the border of the late blight locus and 100 feet along the row (either side) are killed with Reglone or with Gramoxone (generic). Although harsh, trials at MSU have shown that the latent period between infection and symptom development is about seven days and although not visible, plants within this area are already infected. Fields with very few lesions across a broad acreage, must be intensively managed and consideration for early vine kill and harvest should be made to reduce overall risk.

Listing of 2013 WI potato late blight fungicides:
http://www.plantpath.wisc.edu/wivegdis/pdf/2013/Potato%20Late%20Blight%20Fungicides%202013.pdf

The 2013 A3422 Commercial Vegetable Production in Wisconsin guide is available for purchase or download through the UW Extension Learning Store website (updated annually):
http://learningstore.uwex.edu/Commercial-Vegetable-Production-in-Wisconsin2013-P540.aspx

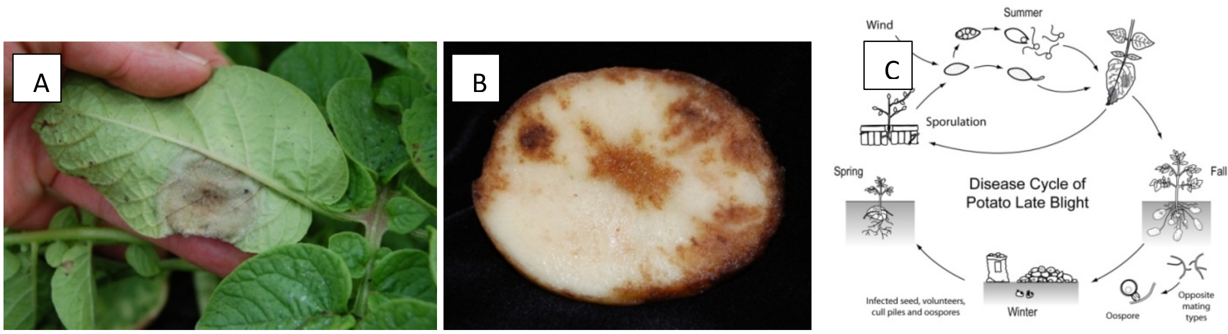

Figure 3. Potato late blight symptoms and disease cycle. A) Lesion on potato leaf displaying pathogen sporulation on underside. B) Internal late blight symptoms on potato tuber. C) Potato late blight disease cycle.

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FROM THE GROUND UP: GROUNDWATER, SURFACE WATER RUNOFF, AND AIR AS PATHOGEN ROUTES FOR FOOD CONTAMINATION

Mark A. Borchardt[1]

Foodborne infectious disease transmission of 31 pathogen types is estimated to account for 9.4 million illnesses, 56,000 hospitalizations, and 1,300 deaths in the United States annually (Scallan et al. 2011). The economic costs from foodborne illness in the United States are more than $50 billion per year (Scharff 2012). The Food Safety Modernization Act of 2011 recognizes agricultural water is a source of pathogen contamination of fresh produce and monitoring strategies are being proposed to assess the sanitary quality of water used for food production and processing. Nonetheless, one lesson learned from foodborne outbreaks the past several years is that the events and pathogen movement routes leading to contamination are often surprising. Food producers need to be constantly vigilant for previously unanticipated contamination routes.

This presentation tells three stories about three studies, highlighting the potential for human pathogens to travel unusual routes and end up in surprising places. Insofar as these routes and places intersect with food, foodborne illness can result.

Attendees are reminded of three summary points:

Groundwater – Contrary to conventional wisdom, municipal drinking water from non-disinfected groundwater sources is not pathogen-free and cannot be assumed to be sufficiently sanitary for food processing.

Surface Runoff – Pathogen types and concentrations are highly variable in runoff from manure-applied fields, and pathogen genomes in these fields can survive for many months.

Air – During spray irrigation of dairy manure, under cool windy conditions, pathogens can be detected at distances greater than 500 feet downwind of the irrigation site. However, under hot, sunny, low-wind conditions, pathogen detections downwind are sporadic.

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NITROGEN FERTILIZATION DECISIONS: CAN WE DO BETTER?

James J. Camberato[1/]

Overview of Presentation

Nitrogen (N) fertilization recommendations for corn in several states in the Midwest (including WI and IN) are based on the results of many N response trials conducted over a number of years, locations, soil types, and hybrids. The maximum return to N (MRTN) is calculated based on the yield response to applied N derived from the analysis of these trials and the price of grain and N fertilizer (Sawyer and Nafziger, 2006). The recommended fertilizer rate represents the point at which no further profit is realized by the application of additional N. All states using the MRTN approach consider crop rotation an important factor in determining the N recommendation and several include soil type, soil productivity, or region of the state as well (http://extension.agron.iastate.edu/soilfertility/nrate.aspx).

Although the MRTN recommended N rate is likely to be the most profitable over a similar set of future environmental conditions, soil types, and hybrids, there can be considerable deviation from the recommended N rate in any given situation. For example, the frequency distribution of economic optimum N rate for 41 individual N response trials is shown for the east and central regions of Indiana (Figure 1, left panel) considering a grain cost of $4.50 and a N cost of $0.55 per pound of N ($900 per ton anhydrous ammonia or $310 per ton 28% urea ammonium nitrate solution). The average optimum N rate was 195 pounds per acre under these conditions. The range in optimum N rates for individual locations was about 50 to 250 pounds of N per acre. Only 55% of the trials had optimum N rates between 170 and 225 pounds per acre (20 pounds per acre below, and 30 pounds per acre above, the average economic optimum N rate).

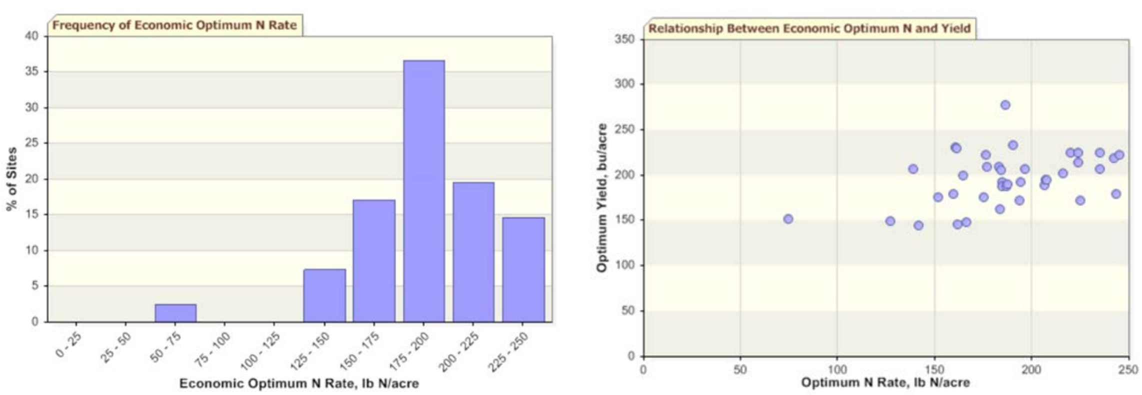

Fig. 1. The frequency distribution of economic optimum nitrogen (N) rate for 41 N response trials conducted in east and central Indiana from 2006 through 2011 [calculated with $4.50 per bushel corn and $0.55 per pound nitrogen ($900 per ton anhydrous ammonia or $310 per ton 28% urea ammonium nitrate solution)] is shown in the left panel. The average economic optimum N rate for the 41 N response trials is 195 pounds of N per acre. The weak relationship between optimum N rate and yield at the optimum N rate is shown in the right panel.

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There are many factors that may result in the optimum N rate for an individual location varying from the average optimum N rate. Variation in grain yield (perhaps arising from differences in hybrid, plant population, weather patterns, management, etc.) is the most commonly suggested factor altering the crop N requirement and therefore the optimum N rate, even though each of the states using the MRTN approach shows little relationship between optimum N rate and yield attained at the optimum N rate (Fig. 1 right panel, IN for example). Another factor perhaps affecting the optimum N rate at an individual location may be abnormally high or low precipitation causing more or less than average nitrate leaching or denitrification, especially when N fertilizer or manure is applied in the previous fall or winter before corn planting. Soil moisture and temperature conditions can also affect the mineralization of soil and manure organic N altering their contribution to the corn crop, thereby increasing or decreasing the amount of N that must be added to attain the optimum N rate in any given year. In truth there are many other factors and interactions of factors that may affect the optimum N rate in any given situation.

Adaptive management is a recently coined term used to describe an approach for identifying an optimum N rate for a specific soil/management system or in a particular season that is more accurate than an average N rate recommendation such as that obtained from the MRTN approach. Preplant or pre-sidedress soil nitrate, tissue N concentration, sensor-derived crop greenness and biomass, and end-of-season stalk nitrate are measurements that can be used for making season-to-season or in-season adjustments of N rate decisions. Computer modeling that predicts crop development and soil N transformations is another method for addressing soil, management, and weather effects on crop N demand and soil N availability to arrive at a season-specific N rate recommendation. Conducting N response trials is yet another approach to assessing management- and field-specific optimum N rates.

The results of studies evaluating the end-of-season cornstalk nitrate test (Brouder, 2003) and the Cornell developed Adapt-N computer model (Moebius-Clune et al., 2011) as tools for adaptive N management will be discussed in this presentation.

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CORN STOVER REMOVAL AND SOIL FERTILITY

Matt Ruark [1/]

Introduction

With cellulosic ethanol production on its way to becoming a reality, the effects of stover removal on the landscape have not been fully examined and efficient agricultural management practices for biofuel production systems have not been developed. The current UW recommendations (e.g., UWEX A2809) do not recommend changes to nutrient management plans based on biomass removal (i.e., when corn is grown for silage). Data sets which evaluate the short- or long-term effects of biomass removal on optimum N fertilization rates for continuous corn in Wisconsin do not exist. Long-term field research (30+ years) in Wisconsin has shown that continuous corn rotations maintain and often increase corn yields and NUE over time when N is fertilized at UW recommended rates (Bundy et al., 2011); SOC and soil N supplying capability also have been shown to increase. These results indicate that with proper N fertilization and stover additions to the soil, the capacity of the soil to supply N for crop production can be maintained. An increase in biomass removal may jeopardize the sustainability of these agricultural systems. Future research in this area should focus how stover removal affects optimum N fertilization rates. However, the quantity of studies which evaluate the value of crop residue related to N fertilization rates are lacking.

Management of crop residue has been studied over the past several decades, although the effects on SOC and corn yield have not been consistent. Blanco-Canqui and Lal (2007) determined that biomass removal did not result in a decrease in SOC or corn yield after three years. Barber (1979) also reported that stover removal did not affect the corn yields, but did report a significant decrease in SOC after 11 years of stover removal. In contrast, Wilhelm et al. (1986) reported that continual removal of corn stover lead to a significant reduction in corn yields after only 3 years. Moebius-Clune et al. (2008) determined that after 32-years of annual stover removal from no-till, continuous corn systems, SOC was significantly reduced, but potentially mineralizable N pools remained unchanged. Although the authors did not report yields, they concluded that stover removal from the systems can be a sustainable management practice. It is clear that the short-term and long-term effects of stover removal need to be considered across different soils and climates, as well as in conjunction with other management practices.

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Materials and Methods

A three-year study was conducted on three Experiment Stations in Wisconsin: Arlington, Lancaster, and Marshfield. The experimental design was a randomized complete block, split-plot design. The main plot factor was stover removal rate and the treatments included: (i) no removal, (ii) a low rate of removal, and (iii) a high rate of removal. The system evaluated here is a two-pass system. Corn was harvested and then a flail chopper was used to cut and collect corn stover. The rates of stover removal were determined by the capacity of the flail chopper. When the blades on the flail chopper were set as low to the ground as possible, the amount of stover removed was determined to be ~50% on a dry weight basis (high rate). The low rate of removal was ~25% and was collected by setting the blade on the flail chopper to its highest setting. The split plot factor was N rate and the treatments were 0, 50, 100, 150, 200, and 250 lb/ac of N applied pre-plant as urea. The urea was lightly incorporated into the soil prior to planting.

Starter fertilizer containing of P and K will be applied 0.05 m (2 inches) below and 0.05 m (2 inches) to the side of the seed. Tillage operations will be consistent across all treatments and sites and will include fall chisel and disk after stover removal. Soil samples (8 inches) were taken in the fall of each year and analyzed for pH, organic matter, soil test P, and soil test K by the UW Soil and Plant Analysis Laboratory.

Preliminary Results

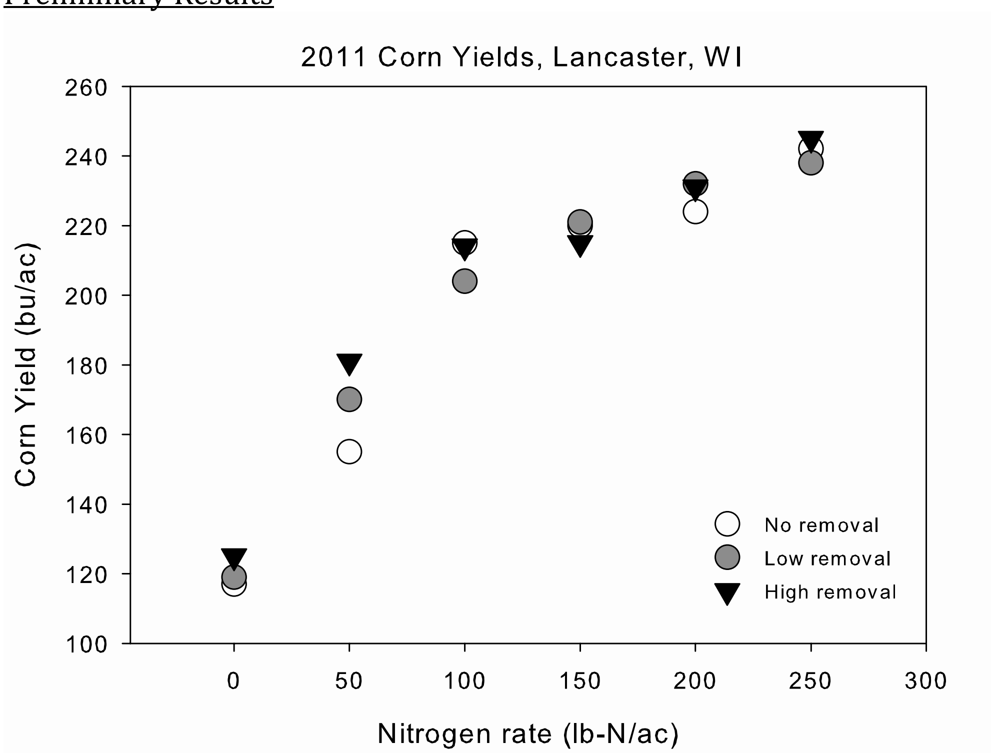

Figure 1. 2011 corn yields in Lancaster, WI for three removal rates of stover.

Preliminary analysis of yield results indicates that there was not a clear effect of stover removal across all sites and across years. For example, at Lancaster in 2011, there was no difference between stover removal rates (Fig. 1). But in 2012, no removal had higher N rates compared to the low removal rate at 200 and 250 lb/ac N rates. However, the high removal rate had a similar to the no removal at the 250 lb/ac N rate, confounding our interpretation. No clear effects of stover removal were determined at Arlington or Marshfield.

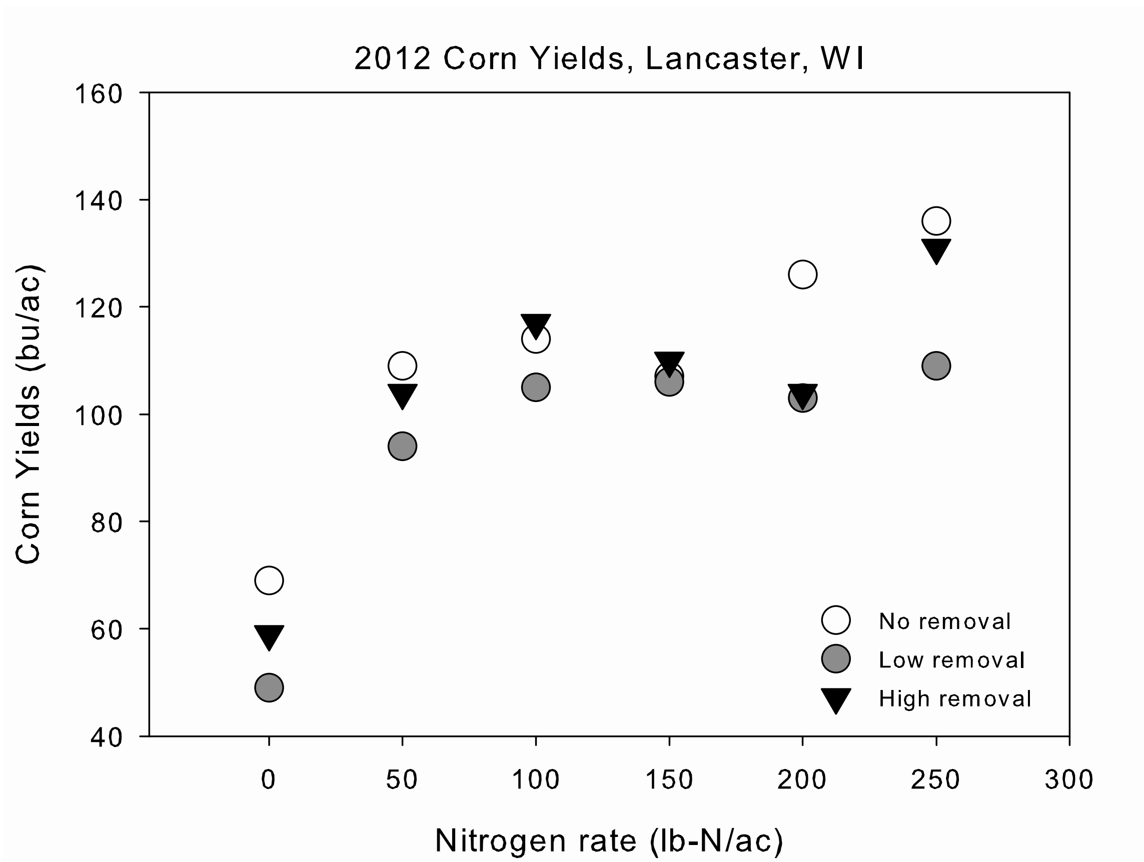

Figure 2. 2012 corn yields in Lancaster, WI for three removal rates of stover.

Table 1. Routine soil analyses from selected N rate plots from each stover removal treatment. Soil samples were collected at the end of 3 years of stover removal in fall of 2012.

Site†	Stover treatment	N rate	pH	OM	P	K
		lb/ac		%	ppm	ppm
ARL	No removal	0	6.9	3.3	73	144
		150	6.8	3.6	82	157
	Low removal	0	7.2	3.4	78	138
		150	7.0	3.8	102	132
	High removal	0	7.1	3.6	97	129
		150	7.0	3.1	72	140
LAN	No removal	0	7.2	2.2	25	91
		150	7.1	2.2	20	89
	Low removal	0	7.2	2.1	18	82
		150	7.0	2.1	20	90
	High removal	0	7.3	2.1	18	86
		150	7.0	2.1	20	87
MAR	No removal	0	6.6	2.9	53	106
		150	6.5	3.0	43	94
	Low removal	0	6.7	2.8	45	102
		150	6.7	2.9	40	104
	High removal	0	6.7	2.8	45	90
		150	6.3	2.9	48	83

† ARL = Arlington; LAN = Lancaster; MAR = Marshfield.

<u>Preliminary Conclusions</u>

- There is no clear effect of stover removal on corn yield at Arlington, Lancaster, or Marshfield after three consecutive years of stover removal.
- No clear negative effects of some stover removal on pH, OM, soil test P or soil test K.
- Further analysis must be conducted to evaluate trends in production and soil fertility over time.
- Short-term removal of stover, in amounts not exceeding 50% of stover biomass will not result in reductions in productivity or meaningful reductions in soil fertility on these Wisconsin soils.

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NUTRIENT MANAGEMENT – PANEL

Pat Murphy, Sara Walling, and Andrew Craig [1/]

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IMPLEMENTING ON-FARM RESEARCH: IT'S EASIER THAN YOU THINK?

James J. Camberato[1/]

Overview

Agricultural production advances occur incessantly. Constant development and marketing of a myriad of crop genetics, equipment, fertilizers, pesticides, and management practices require evaluation via research to enable the wise adoption of beneficial products and practices. Research conducted on farmer's fields by farmers themselves or in cooperation with industry or university partners is a useful approach to comparing the new to the old and facilitate decisions to embrace change. Field-scale research is more realistic and believable to farmers and the agricultural industry thus encourages the adoption of proven products and practices. Better yet, a well-designed field-scale research study is superior to traditional small plot research in detecting grain yield differences!

On-farm research is most applicable to fairly simple agronomic questions with six or fewer treatments due to field area limitations arising from the large treatment plot sizes dictated by commercial planters, applicators, and combines. Randomization and replication (at least three per treatment and preferably four or more) are necessary to reduce the probability of introducing systematic bias into the results and allow statistical analysis. Statistics enable the researcher to distinguish between random variation and true treatment effects.

Precision agriculture technologies have made it easier than ever to conduct research at the field scale. Aerial photography, digital soil maps, and GPS allow candidate fields for research to be evaluated remotely for suitability and proper experimental design. The plot layout and treatment applications can be designated with prescription maps and verified with as-applied maps to minimize errors. Guidance systems allow the application of all replications of one treatment to be applied without flagging or cleaning out the fertilizer tank or planter box. A properly calibrated yield monitor can be utilized to accurately measure yield and quantify the treatment effects and without slowing harvest. In some situations GIS software can be used to evaluate treatment effects within soil types or management zones and increase the amount and applicability of the information obtained from the research.

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THE REAL STORY BEHIND SDS-GLYPHOSATE INTERACTIONS

Kiersten A. Wise[1]

In recent years, producers have become concerned about the potential impact of long-term use of glyphosate in field crops. One concern is the reported claim that glyphosate applications weaken the soybean plant, making it more susceptible to organisms that cause disease. In fact, a link between glyphosate use of glyphosate and the increase in the important soybean disease sudden death syndrome, or SDS has been proposed. Results from multi-year and multi-state research trials designed to determine the impact of glyphosate and other herbicides will be presented, and optimum management practices to manage SDS will be discussed.

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RELATIONSHIP BETWEEN SDS AND SCN IN COMMERCIAL SOYBEAN FIELDS IN WISCONSIN[1]

David Marburger[2], John Gaska[2], Shawn Conley[2], Paul Esker[3], Ann MacGuidwin[4], and Damon Smith[4]

Introduction

Soybean Cyst Nematode (SCN) is an economically important disease of soybean in Wisconsin. It was first discovered in the southeastern part of the state in 1981 and now is found in over 90% of the state's soybean acres (Fig. 1). It is caused by the soybean cyst nematode, a non-segmented roundworm that inhabits the soil. More recently, another economically important disease of soybean, Sudden Death Syndrome (SDS), was first found in southeastern WI in 2006. A fungus found in the soil called *Fusarium virguliforme* is the causal agent of SDS.

Soybean Cyst Nematode (SCN)

In high-yielding fields or during years when soil moisture is plentiful, profoundly visible symptoms of SCN are rarely seen. Subtle symptoms include uneven plant height, a delay in canopy closure, or early maturity. Severely infected plants may be stunted with yellow foliage, and canopy closure might be delayed or not occur in affected areas. Management of SCN should include sampling soil and confirming the presence of the nematode. For a detailed description about sampling for SCN in WI, see the pamphlet titled "Soybean Cyst Nematode Sampling and Testing in Wisconsin". Management should include an integrated plan where crop rotation and resistant cultivars should be used. Rotating to non-hosts of SCN can help reduce SCN populations in soil. Cultivars resistant to SCN should be planted when numbers of SCN are above suggested thresholds, and sources of resistance (e.g., Peking vs. PI 88788) should be alternated in fields with high populations. When SCN numbers are below threshold, rotating with resistant and susceptible varieties can slow increase in populations of SCN that can overcome common types of resistance available in commercial soybean cultivars. Cultural practices such as managing weeds, providing adequate fertility, amending soil pH to 6.5 and improving soil moisture through tillage and supplemental irrigation can reduce plant stress and help plants deal with SCN populations.

Sudden Death Syndrome (SDS)

Symptoms of sudden death syndrome are expressed as yellowing and necrosis between the veins of leaflets. Veins of symptomatic leaves will remain green. Leaflets will eventually curl or shrivel and drop off with only the petiole remaining. Management of SDS includes a combination of strategies. Most importantly, SDS-resistant cultivars should be chosen whenever possible. If SDS and SCN are both problems in a field, choosing a variety with the best

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resistance/tolerance to both will be beneficial. Planting into cool, wet soils typically seen early in the season can favor infection by the SDS fungus. Delaying planting can reduce the risk of infection, but remember that yield loss will occur from delaying planting too long. Improving soil drainage and reducing compaction can help reduce levels of SDS. Crop rotation can be useful to manage other disease of soybean; however, research has demonstrated that crop rotation does not significantly reduce levels of the SDS fungus in the soil. Even after several years of planting corn in a field, the SDS fungus can survive on corn plants and corn kernels can harbor the pathogen. In addition, the SDS fungus can survive in soil for long periods of time as specialized, thick-walled spores. For more information about SDS, consult the Wisconsin Farm Fact Sheet XGT1015 titled "Sudden Death Syndrome of Soybean."

Cross Relationships

The relationship between these two diseases has been studied for almost 30 years and has yielded inconsistent results. Studies have shown positive associations between SCN and SDS foliar symptom development, where more severe SDS symptoms occur when SCN is present (McLean and Lawrence, 1993; Melgar et al., 1994; Roy et al., 1989; Sherm et al., 1998; Xing and Westphal, 2006). However, other studies report weak or no association between SDS symptom development in the presence of SCN (Gao et al., 2006; Roy et al., 1993; Sherm et al., 1998). The relationship between the actual presence of the SDS fungus in the soil as it relates the presence of SCN has been under- studied.

More research is needed to not only understand the relationship between SDS and SCN but also specifically between the two causal agents of these diseases. In WI, we have the unique opportunity to address this relationship. Until recently, the distribution of the SDS fungus throughout WI was not well understood, while the range of SCN was well documented in the state. We conducted a study to determine the presence of both causal agents, SCN and SDS fungus, from commercial soybean fields in WI and to determine if establishment of these two causal agents in production soybean fields is correlated.

Sample Collection Program

This study was possible through the checkoff-funded Wisconsin Soybean Marketing Board (WSMB) SCN soil testing program which offers free testing to WI growers. Soil samples that were voluntarily submitted during the 2011 and 2012 growing seasons were tested for SCN by wet-seiving methods and for the SDS fungus using DNA based detection methods.

WI Results

Sample submission totals are presented in Table 1 for 2011 and 2012. In 2011, 56 of 135 (41.5%) samples were positive for SCN while 10 of 135 (7.4%) samples were positive for the SDS fungus. In 2012, 64 of 318 (20.1%) samples tested positive for SCN while 13 of 318 (4.1%) tested positive for the SDS fungus.

Table 1. Number of samples received, samples where either pathogen was detected, and population densities for SCN and SDS fungus in soil samples collected from soybean fields in Wisconsin counties, 2011 and 2012.

		SCN		***F. virguliforme* (SDS fungus)**	
Year	**#Samples**	**#Detected**	**Population range**	**#Detected**	**Population range**
			Eggs/100 cc soil		Spores/g soil
2011	135	56	0-10,050	10	0-401,252
2012	318	64	0-37,200	13	0-11,226

Wisconsin counties testing positive for SCN in 2011 and 2012 were representative of the confirmed SCN-positive region of the state (Figure 1,2, and 3). Soil samples where both SCN and the SDS fungus were found in the same sample occurred infrequently (data not shown), and counties where both SCN and the SDS fungus were found were not common. Our results also show the SDS fungus was found in counties farther west and north of the area where Bernstein and colleagues first found the pathogen.

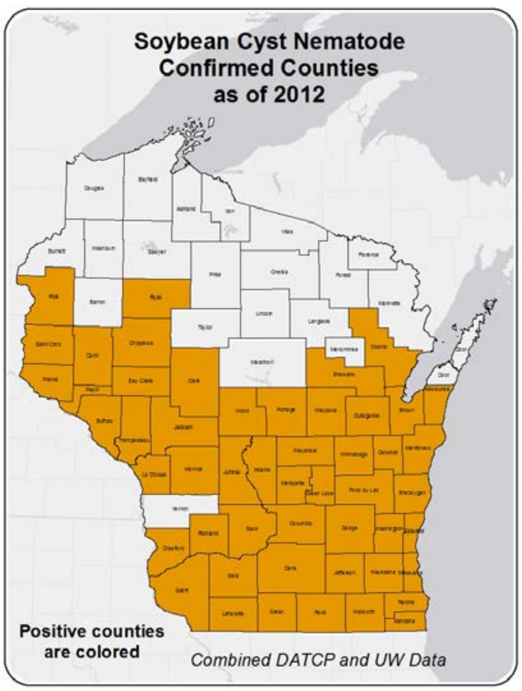

Figure 1. Wisconsin counties where SCN is confirmed as of 2013. DATCP and UW data.

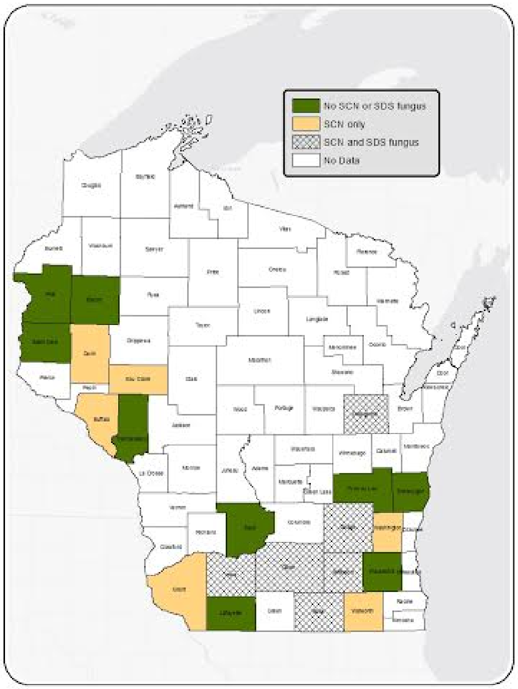

Figure 2. Wisconsin counties where soil samples were submitted from soybean fields that tested positive for SCN (light gray shading), both SCN and the SDS fungus (crosshatch shading), did not test positive for either pathogen (dark gray shading), or were not sampled (white) in 2011.

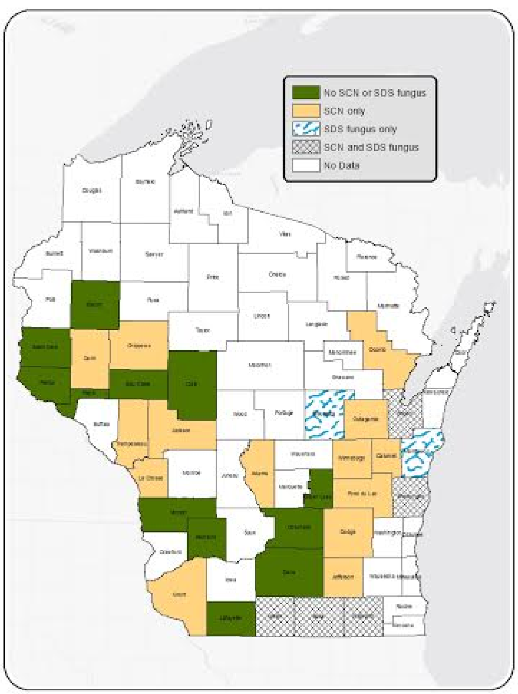

Figure 3. Wisconsin counties where soil samples were submitted from soybean fields that tested positive for SCN (light gray shading), the SDS fungus (gray squiggly lines), both SCN and SDS fungus (crosshatch shading), did not test positive for either pathogen (dark gray shading) or were not sampled (white) in 2012.

Conclusions and Recommendations

Our study found a negative correlation between SCN and the SDS fungus, indicating that as the probability of finding the SDS fungus in a soil sample increases, the probability of finding SCN in the same soil sample decreases. As the odds of detecting the SDS fungus in soil approach 100%, the likelihood of finding SCN in Wisconsin soybean fields is estimated at just 60%. This negative correlation suggests that SCN and the SDS fungus do not rely on each other to colonize fields. Therefore, fields with heavy SCN pressure are not at greater risk for colonization by the SDS fungus. However, in the infrequent case where SCN and the SDS fungus do occur together, symptoms of disease and damage by both pathogens can be synergistic. Therefore, disease management practices for both pathogens should be implemented in these fields.

Growers should continue to test their soils for SCN. If SCN is found, management practices discussed above should be implemented to reduce the effect of SCN and to ensure continued profitable soybean production.

The WSMB offers a free testing program for SCN. Sample kits can be requested by emailing to freescntest@mailplus.wisc.edu. More information is available at www.coolbean.info and http://fyi.uwex.edu/fieldcroppathology/

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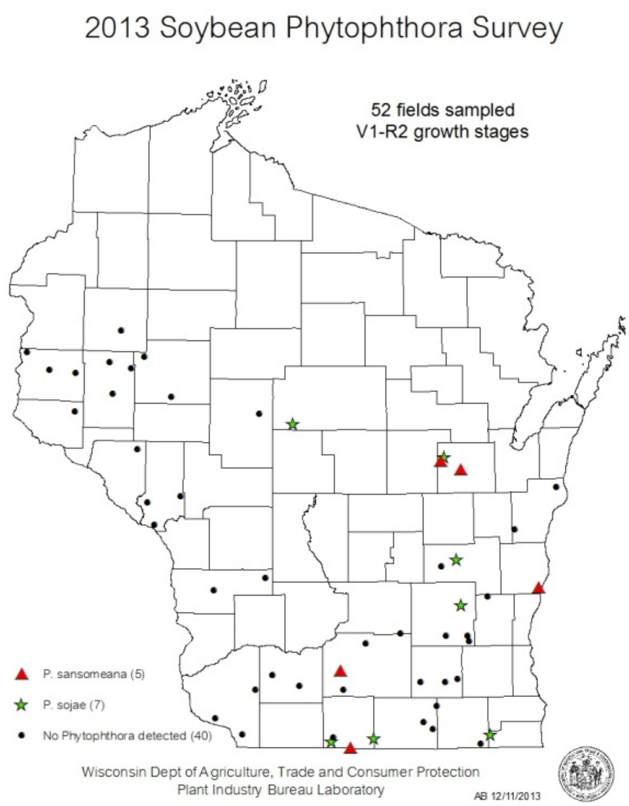
2013 WISCONSIN CROP DISEASE SURVEY RESULTS

Adrian Barta[1], Anette Phibbs, and Susan Lueloff[2]

Phytophthora sansomeana

Continuing survey work for soybean seedling root rots again found *Phytophthora sansomeana* along with the endemic *Phytophthora sojae*. *P. sansomeana* was first detected in Wisconsin in 2012; results from the 2013 survey of 50 randomly-selected soybean fields and two corn fields showed soybean roots from four soybean fields and corn roots from one corn field were infected. Survey staff re-sampled the three fields in 2013 that tested positive for *P. sansomeana* in 2012, including two fields that had been rotated to corn. Felds were sampled between June 17 and July 18. While the significance of this *P. sansomeana* find is being investigated, it is the host range that raises concern about this organism. With both corn and soybeans being susceptible to infection (though the development of disease on corn has not been documented in Wisconsin to date), the potential for increases in inoculum is significant, given the widespread use of corn/soybean rotations.



Soybean Dwarf Virus (SbDV)

Soybean Dwarf Virus (SbDV) is an aphid-vectored luteovirus which causes widespread economic damage in Japan. The first reported detection of SbDV in the United States was made in California in 1983 from clover, the first report on soybeans came from Virginia in 2000, and the first find on soybeans in Wisconsin was made in 2003. Subsequent annual surveys of soybean viruses in the state have shown an upward trend in the percentage of samples testing positive for SbDV.

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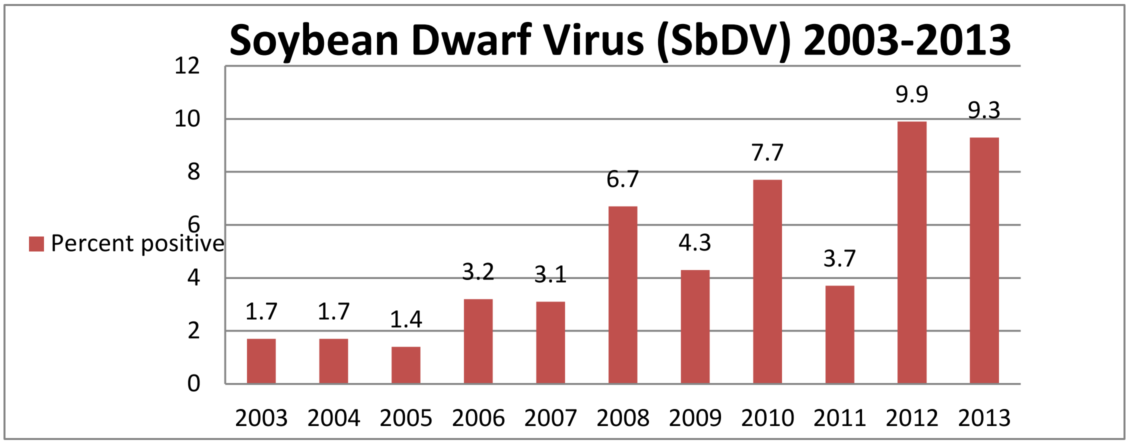
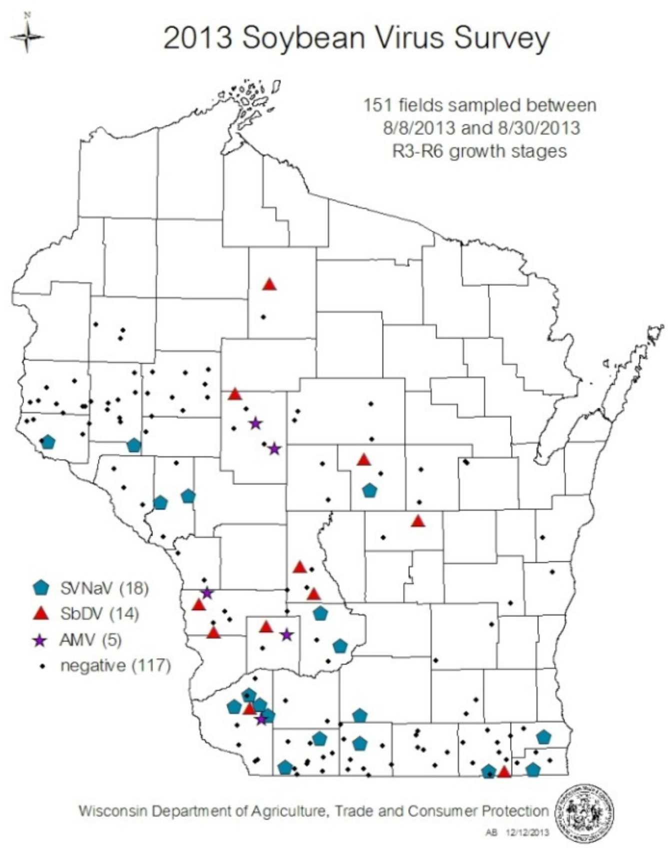
[2] WI DATCP Plant Industry Laboratory

Nucleic acid based testing shows that the dwarfing strain is the most prominent SbDV strain in Wisconsin, only a few yellowing strain have been reported. Symptoms have not been observed during our surveys.



The vector relationship of SbDV remains uncertain. Soybean aphid (*Aphis glycines*) is generally not considered to be an efficient vector of SbDV. Though transmission of the virus to soybean by *A. glycines* may simply be a function of large numbers, DATCP data on SbDV incidence and aphid pressure do not appear to be well correlated.

Other known vectors of SbDV include the clover aphid (*Neararctica bakerii*) and the pea aphid (*Acyrthosiphon pisum*), neither of which are known to colonize soybeans, and the foxglove aphid, *Aulacorthum solani*, which is not known to occur in Wisconsin.



The virus is common in red and white clover, according to DATCP surveys from 2004 to 2006 up to 66% of red clover samples were infected with SbDV.

Soybean Vein Necrosis-associated Virus

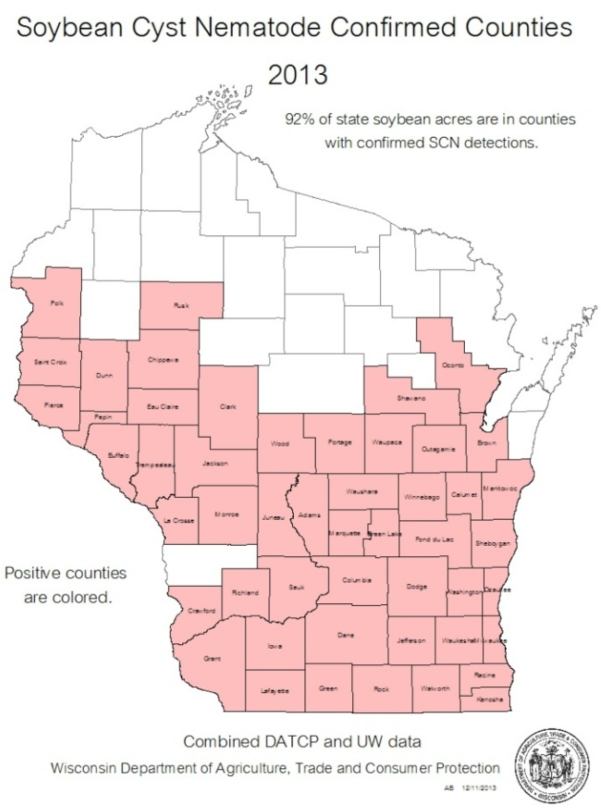
Soybean Vein Necrosis-associated Virus (SVNaV) was first identified in Tennessee in 2008, and was detected in Wisconsin in 2012, when it was identified by UW researchers and was found in 35.4% (97 of 274) of soybean virus survey samples gathered and tested by DATCP. In 2013, the virus was identified in 11.9% (18 of 151) of soybean leaf samples tested. This makes it the most common virus detected on soybeans but much needs to be determined about this new virus. DATCP is collaborating with Prof. Damon Smith UW-Madison on further research. The disease has been widely reported throughout the Midwest in the last two years. This tospovirus is probably vectored by thrips.

Soybean vein necrosis-associated virus   Damon Smith UW-Madison

Soybean Cyst Nematode

No new counties were added to the soybean cyst nematode map in 2013. The current counties where soybean cyst is known to occur include 92% of the state's soybean acres, **so growers are urged to test for the presence of this pest in all counties.**

Canada has proposed deregulating the soybean cyst nematode, which would reduce the need for current information on occurrence in Wisconsin for nursery growers and other exporters. With the substantial majority of soybean acreage in counties where the nematode has been detected and with deregulation by our state's number one trade partner nation, it is likely that DATCP will no longer conduct detection surveys for this nematode in the future



PRE- AND POST-TASSEL FUNGICIDES IN FIELD CORN: WHAT THE DATA TELLS US

Kiersten A. Wise[1]

Fungicides are commonly promoted in corn for foliar disease management, as well as for additional physiological benefits that may enhance yield, even in the absence of disease. The fungicide market has expanded rapidly since 2007, and now there are many questions on which products to use and what application timings and methods will best enhance yields. In this talk, we will examine research data from Midwestern states to determine optimum application timings of fungicides in corn, as well as product efficacy against specific diseases, and the economic breakdowns for fungicide use. Attendees will learn what to consistently expect from fungicide applications in corn, and receive information on optimum placement of fungicides in their specific production systems.

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WHITE MOLD MANAGEMENT IN 2013: WAS IT PRODUCT OR TIMING?

Damon L. Smith [1/]

Introduction

Sclerotinia stem rot (SSR) or white mold of soybean is caused by the fungus *Sclerotinia sclerotiorum* (Grau and Hartman, 1999). In the temperate north central soybean production areas of the United States, SSR can be a significant yield limiting disease. In seven growing seasons between 1996 and 2009, yield losses as a result of SSR where greater than 10 million bushels (270 million kg) per year (Peltier et al., 2012). Yield can be reduced 2-5 bushels per acre (133-333 kg/ha) for every 10% increment increase in SSR incidence in soybeans at the R7 growth stage (Peltier et al., 2012). These impacts on yield are significant and make SSR one of the most important diseases of soybean in the North Central U.S.

Sclerotinia sclerotiorum survives in soil as specialized long-term survival structures called sclerotia. Sclerotia can survive for many years in soil; therefore it is difficult to use crop rotation to control SSR. Each sclerotium can produce one to several mushroom-like structures called apothecia (Grau and Hartman, 1999; Peltier et al., 2012). Spores (ascospores) are borne on apothecia. When weather conditions are conducive, spores are released from apothecia. In soybean, infection occurs via flowers during bloom. Incidence of SSR can be sporadic from one year to the next, and one field to another, because of specific environmental requirements necessary for infection. In years where flowering coincides with canopy temperatures less than 28°C (82°F) and extended periods of daily surface wetness (16 hr or more per day) SSR incidence and severity can be high (Grau and Hartman, 1999). The sporadic nature of the disease results because these weather conditions must be present at the time of soybean flowering, if they are absent, then SSR is unlikely to occur. Occasionally, secondary spread of SSR can occur via plant-to-plant contact (Grau and Hartman, 1999). Sclerotinia stem rot incidence is often greater in fields with high yield potential resulting in a dense canopy and in situations where plants are in narrow rows and at high population. In these instances, canopy humidity and wetness can be high thereby promoting increased incidence of SSR.

Management of SSR includes the use of cultural practices such as reduced tillage, crop rotation, canopy management, irrigation management, weed control, and chemical control (Peltier et al., 2012). Chemical control of SSR can be variable. Fungicides labeled for use on soybean for management of SSR have only limited mobility in the plant. This means that they might only move a short distance into plant tissue or move upwards in the transpiration stream. None of the compounds will move downward in plants (Mueller and Bradley, 2008). Because of the limited mobility of these fungicides, thorough application coverage is critical in achieving good control of SSR. Lack of good coverage is often a cause for inconsistent control using fungicides. Timing of application of fungicides is also critical in achieving good control of SSR with fungicides. Fungicides should be applied between the R1 and R3 growth stages of soybean. Research has demonstrated that better control is often achieved when fungicide is applied at R1 (Peltier et al., 2012). A fungicide trial was established in 2013 to examine product efficacy and also timing of application of products.

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Methods

The trial was established at the Arlington Agricultural Research Station located in Arlington, WI. The soybean cultivar '24RR19' was chosen for this study. Soybeans were planted on June 3, 2013 in a field with a Plano silt loam soil (2 to 6 percent slopes). The experimental design was a randomized complete block with four replicates. Plots consisted of 6 15-in. spaced rows, 21 ft long and 7.5 ft wide with 4-ft alleys between plots. Standard soybean production practices as described by the University of Wisconsin Cooperative Extension Service were followed. Treatments consisted of a non-treated control, 20 fungicide treatments, and one herbicide treatment. Pesticides were applied using a CO_2 pressurized backpack sprayer equipped with 8001 TurboJet flat fan nozzles calibrated to deliver 20 GPA. Pesticides were applied at growth stages R1, R3, or both. Natural sources of pathogen inoculum were relied upon for disease. Plots were mist-irrigated for 5-10 minutes every hour between 8pm and 12am each day during growth stages R1 to R4. Disease was evaluated at growth stage R7 using the Sclerotinia stem rot severity index (DSI). DSI was determined by rating 30 arbitrarily selected plants in each plot and scoring plants on a 0-3 scale: 0 = no infection; 1 = infection on branches; 2 = infection on mainstem with little effect on pod fill; 3 = infection on mainstem resulting in death or poor pod fill. The scores of the 30 plants were totaled and divided by 0.9. Yield was determined by harvesting the center 4 rows of each plot using a small-plot combine. All disease and yield data were analyzed using a mixed model analysis of variance (α=0.05).

Results and Discussion

Weather was very wet at planting and then turned hot and dry. During flowering weather was cool and humid, which resulted in high levels of Sclerotinia Stem rot. Plots treated with Aproach Prima 2.34SC at 6.8 fl.oz. (R1 growth stage), Domark 40 ME at 5.0 fl.oz. (R1 growth stage), Proline 480 SC 5.0 fl.oz. (R1 growth stage), Incognito 4.5FL at 20.0 fl.oz. (R1 growth stage), Priaxor 4.17SC at 4.0 fl.oz. (R3 growth stage), and Endura 70WG at 6.0 fl.oz. (R1 growth stage) followed by Priaxor 4.17SC 4.0 fl.oz. (R3 growth stage) had levels of Sclerotinia stem rot comparable to the non-treated check (Table 1). These treatments also typically resulted in the lowest yields in the trial with the exception of the Endura 70WG and Priaxor 4.17SC treatment. Lowest levels of Sclerotinia stem rot were recorded in plots treated with Cobra 2EC at 6.0 fl.oz. at R1. However, yield in these plots was not comparable to the highest yielding plots which were treated with Endura 70WG at 8.0 oz. (R1 growth stage). Plots treated with two applications of fungicide or one application of Aproach 2.08SC at 9.0 fl.oz. (R1 or R3 growth stage) or one application of Proline 480SC at 3.0 fl.oz. (R1 growth stage) resulted in variable levels of Sclerotinia stem rot, which in some cases was significantly higher than plots treated with Cobra 2EC. However, these plots yielded as well as plots treated with Endura 70WG at 8.0 oz.

Further analysis was performed to investigate timing of fungicide application (R1 vs. R3 application) when using the fungicides Aproach 2.08SC and Priaxor 4.17SC. Pooled disease and yield means for these two fungicides were compared for the two timings using CONTRAST statements. DSI was 23 points lower when fungicide was used at R1 vs. R3 (P=0.06). This difference in DSI did not translate to any discernable difference in yield. Despite this, fungicide use to control Sclerotinia stem rot should be targeted as early during the flowering period as possible. By targeting the R1 timing, even a slight delay in application (due to weather or other issue delaying application) will be useful until the R3 growth stage. After the R3 growth stage, the expected efficacy of any fungicide on Sclerotinia stem rot will be greatly reduced.

Table 1. Sclerotinia stem rot ratings and yield of soybeans treated with various fungicides or an herbicide.

Treatment and Rate/Acre (Crop Growth Stage at Application)	Sclerotinia Stem Rot DSI †	Yield (bu/a)
Non-treated Check	77.5 ac ‡	56.0 g[y]
Aproach Prima 2.34SC 6.8 fl.oz. + Induce 90SL 0.25% v/v (R3)	85.6 a	58.0 fg
Domark 40ME 5.0 fl.oz. + Induce 90SL 0.25% v/v (R1)	67.0 acf	58.0 fg
Proline 480SC 5.0 fl.oz. (R1)	74.5 acd	58.7 eg
Incognito 4.5FL 20.0 fl.oz. + Induce 90SL 0.25% v/v (R1)	81.4 ab	62.3 dg
Priaxor 4.17SC 4.0 fl.oz. + Induce 90SL 0.25% v/v (R3)	74.2 acd	63.7 bg
Domark 40ME 5.0 fl.oz. + Induce 90SL 0.25% v/v (R3)	43.1 cgh	63.9 bg
Priaxor 4.17SC 4.0 fl.oz. + Induce 90SL 0.25% v/v (R1)	38.1 dfgh	66.1 bcg
Endura 70WG 6.0 oz. + Induce 90SL 0.25% v/v (R1)	29.7 fgh	66.6 bcg
Cobra 2EC 6.0 fl.oz. + Induce 90SL 0.25% v/v (R1)	6.4 h	67.4 bcdef
Aproach 2.08SC 9.0 fl.oz. + Induce 90SL 0.25% v/v (R1)	37.0 dfgh	67.6 abdef
Aproach 2.08SC 9.0 fl.oz. + Induce 90SL 0.25% v/v (R1) Aproach Prima 2.34SC 6.8 fl.oz. + Induce 90SL 0.25% v/v (R3)	65.8 acef	68.1 abdef
Proline 480SC 3.0 fl.oz. + Induce 90SL 0.25% v/v (R1)	33.2 fgh	69.0 abde
Aproach 2.08SC 9.0 fl.oz. + Induce 90SL 0.25% v/v (R3)	42.0 cgh	70.1 abd
Aproach 2.08SC 6.0 fl.oz. +Induce 90SL 0.25% v/v (R1, R3)	45.0 bcg	71.4 abd
Proline 480SC 3.0 fl.oz. (R1) Stratego YLD 500SC 4.65 fl.oz. (R3)	40.3 cgh	72.4 abd
Aproach Prima 2.34SC 6.8 fl.oz. + Induce 90SL 0.25% v/v (R1, R3)	42.5 cgh	73.1 abd
Aproach 2.08SC 9.0 fl.oz. +Induce 90SL 0.25% v/v (R1, R3)	28.1 egh	73.9 ab
Proline 480SC 3.0 fl.oz. (R1) Stratego YLD 500SC 4.0 fl.oz. + Induce 90SL 0.25% v/v (R3)	25.3 gh	74.0 ab
Proline 480SC 5.0 fl.oz. (R1) Stratego YLD 500SC 4.65 fl.oz. + Induce 90SL 0.25% v/v (R3)	47.2 bcg	74.3 ab
Endura 70WG 6.0 oz. + Induce 90SL 0.25% v/v (R1) Priaxor 4.17SC 4.0 fl.oz. + Induce 90SL 0.25% v/v (R3)	48.7 ag	76.2 ac
Endura 70WG 8.0 oz. + Induce 90SL 0.25% v/v (R1)	38.6 dfgh	78.3 a
LSD (α=0.05)	37.9	10.8

†Sclerotinia stem rot DSI was generated by rating 30 arbitrarily selected plants in each plot and scoring plants with on a 0-3 scale: 0 = no infection; 1 = infection on branches; 2 = infection on mainstem with little effect on pod fill; 3 = infection on mainstem resulting in death or poor pod fill. The scores of the 30 plants were totaled and divided by 0.9.

‡Means followed by the same letter are not significantly different based on Fisher's Least Significant Difference (LSD; α=0.05).

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ISSUES AND HAPPENINGS AT THE CHICAGO BOARD OF TRADE

CME Group

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USDA CROP REPORTING PROCESS –

WHERE DO THE NUMBERS COME FROM?

Greg Bussler [1/]

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COMMODITY MARKETING UPDATES –

GRAIN MARKETS, TRANSPORTATION, ETC.

Brian Rydlund [1/]

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[1/] CMS Hedging.

DISCOVERY FARMS: DOCUMENTING MANAGEMENT IN WATERSHEDS

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WISCONSIN'S NUTRIENT REDUCTION STRATEGY FOR WATER QUALITY: OVERVIEW AND IMPLICATIONS

Ken Genskow[1]

Wisconsin has a long history of collaboration and partnerships around issues of nutrients and water quality. Over the course of 2012-2013, Wisconsin developed a statewide "Nutrient Reduction Strategy" document in response to a request from USEPA to all states in the Mississippi River Basin. Although based on multi-state interest in reducing nutrients to the Gulf of Mexico, Wisconsin's strategy includes information for the Great Lakes and also Wisconsin's groundwater. The strategy document was developed through DNR leadership in partnership with University of Wisconsin, Wisconsin's federal, state and local conservation agencies, and others. It was reviewed by agency staff, agency leadership, broader stakeholder interests, as well as the Natural Resources Board and the ATCP Board.

The Nutrient Reduction Strategy:

- Primarily is a new compilation and synthesis of existing but fragmented information, with new analysis of nitrogen and phosphorus data
- Identifies many existing and additional opportunities for coordination and public engagement
- Commits Wisconsin to annual reporting, via website and some type of forum

This presentation and discussion provides an overview of the strategy and highlights relevant components for agriculture and those working with agricultural producers.

<u>For more information:</u>
Wisconsin NRS Website: http://dnr.wi.gov/topic/SurfaceWater/nutrientstrategy.html
Hypoxia Task Force: http://water.epa.gov/type/watersheds/named/msbasin/index.cfm

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SOCIAL MEDIA IN AGRICULTURE

Don Stanley [1/]

ABSTRACT

Whether or not we like it or we use it, it is clear social media has transformed our world. Social media has created dramatic shifts in how people seek information, how they share information, how they learn, how they socialize, and how they interact with organizations and businesses alike. In this session, we will provide a broad overview of the tools most commonly used today, discuss how they are used by consumers and organizations alike and then share best practices for getting started or improve your use of social media.

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MONITORING FOR MANURE MANAGEMENT

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AGRICULTURAL MARKET UPDATE

Brenda Boetel [1/]

Agricultural markets have experienced significant volatility in recent years. In late 2013, corn and soybean prices retreated from 2012s historically high prices. Livestock prices were up in 2013 but the level of increase varied. 2014 will likely see lower corn, soybean, and hog prices, while cattle prices increase. The 2014 price outlook will be discussed, and factors that producers need to consider throughout the year will be mentioned.

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IMPLEMENTS OF HUSBANDRY

Michael Klingenberg [1/]

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THE IMPACT OF SOIL HEALTH ON CROP PRODUCTION

Francisco J. Arriaga [1/]

Soil health can be defined as the capacity of a specific soil to function in a natural or managed system to sustain plant and animal productivity, maintain environmental quality, and promote plant and animal health (SSSA, 2013). Soil organic matter (SOM) is a key component in soil health as it affects soil chemical, physical, and biological properties. It is commonly accepted that SOM enhances fertility, improves physical properties (such as, infiltration and water retention), and enhances overall soil health. Although improvements in crop varieties/hybrids and innovation in fertilizers continue to boost average yields, proper soil health is important for sustaining productivity. Crop and soil management are key to increasing SOM and improving soil health (Fig. 1).

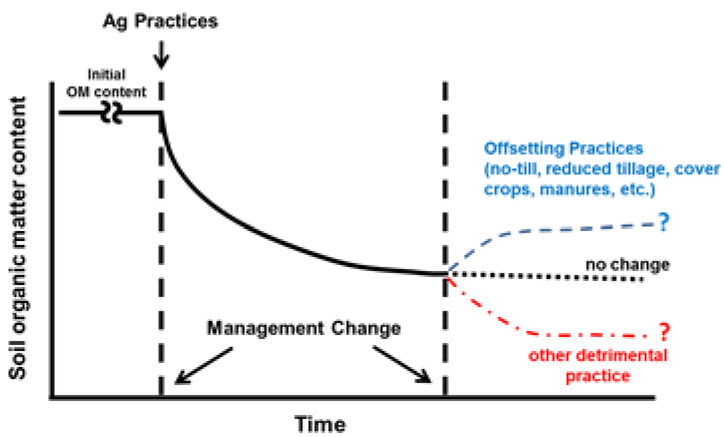

Figure 1. Agricultural production practices have reduced the naturally high organic matter (OM) content of soils under native natural systems. Although a new OM “equilibrium” is reached after years of repeated practices, changes in management practices can increase or further decrease soil OM. (figure adapted from National Academy of Sciences, 2009).

Most soil management practices needed for crop production have a tendency to reduce SOM. For example, microbial activity increases tremendously after a tillage operation due to the air and oxygen that is incorporated into the soil. Microbes in the soil feed on SOM, and subsequently, large amounts of CO_2 are released from the soil after a tillage operation. Additionally, tillage operations physically destroy soil aggregates. Aggregates in the soil are essential for proper gas exchange (i.e. aeration), infiltration, water retention, and water recharge of the soil profile. A slake test can be used to demonstrate the impact of soil management practices on aggregate stability (Fig. 2). Soil aggregation and structure in properly managed soils are significantly better, and as a result, water infiltration and soil water retention are increased. Greater infiltration means less runoff, lower erosion potential, and more water in the soil profile

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for crops use. The amount of water a soil can store increases with increasing SOM content, and this increase can potentially provide additional days of water for plant use, depending on the soil type, crop, weather conditions, and crop growth stage.

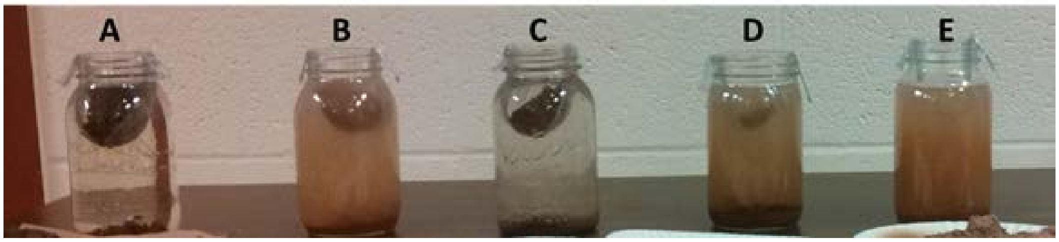

Figure 2. Slake test to demonstrate the impact of management on soil aggregate stability. (A) old woods; (B) Kewaunee B horizon; (C) hay four years followed by one year of corn; (D) corn silage for 2 years; (E) corn silage for 2 years. Photo courtesy of F. Arriaga, 2012.

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CROP ROTATION AND COVER CROPPING IMPACTS ON SOIL HEALTH

Erin M. Silva[1]

Discussion related to the benefits of the integration of cover crops and improvement of soil health as part of crop management practices has increased over the past several years. A recent survey conducted by the Conservation Technology Information Center reported that 2012 harvested yields from corn fields following a cover crop were 9.6% greater than side-by-side fields with no cover crops, and soybean yields improved 11.6% following cover crops. Yield differences were even greater in regions most impacted by the 2012 drought, with corn yielding 11% greater and soybeans yielded 14.3% greater than those grown in fields with no cover crops.

This same survey identified improved soil health as one of the key motivations for farmers integrating cover crops into their production systems. The USDA Natural Resources Conservation Service lists several recommendations for farmers to improve their soil health, including reducing tillage, diversifying species through crop rotation and integration of cover crops, maintaining living plantings in the soil as long as possible with crops and cover crops, and keeping the soil surface covered with residue year round.

The term "soil health" describes an overall assessment rather than a single soil characteristic; several indicators provide an estimation of the health of the soil. Examples of indicators include levels of soil organic matter, soil physical properties such as soil structure, bulk density, water holding capacity, compaction, and porosity; soil chemical properties such as pH, electrical conductivity, and concentrations of plant available nutrients; and soil biological properties such as microbial biomass C and N, potentially mineralizable N, soil microbial respiration, and other microbial activity measures.

Data from several long-term agricultural systems trials illustrate the beneficial impacts of crop diversity in the production system on soil health, which may be accomplished through rotation and cover cropping practices. Data from the Wisconsin Integrated Cropping Systems Trial (WICST) indicates that increasing the level of perenniality and decreasing the amount of tillage in management strategies allows for systems to trend towards less loss of soil organic carbon over time. In plots of the Oregon Long-Term Soil Quality Project (Schutter et al., 2001), greater numbers of fungal and bacterial markers were detected in cover cropped soils versus those managed in winter fallow. The Morrow plots, the University of Illinois

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long-term plots studying the effects of crop rotations since 1876, showed a higher rate of soil carbon decline under continuous corn as compared to the more diverse corn-oats-meadow crop rotation (Van Bavel and Schaller, 1950). In a shorter-term study, microbial biomass was shown to increase in soils managed with cover crops (Buyer et al., 2010).

The impacts of crop rotation and cover cropping strategies on soil health will depend on soil type, region, precipitation, and other environmental factors. However, research continues across the U.S. to further understand best management practices for the integration of diversity into cropping systems.

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