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The assistance provided by Carol Duffy and Geoff Siemering in preparation of this document is appreciated.

THESE PROCEEDINGS ARE AVAILABLE ONLINE IN A SEARCHABLE FORMAT AT:
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2015 Wisconsin Agri-Business Association Distinguished Service Awards

Distinguished Organization Award
Premier Cooperative
{For Exemplary Industry Professionalism}

Education Award
Matt Ruark, UW-Madison, Dept. of Soil Science
{For Leadership & Commitment to Educational Excellence}

Outstanding Service to Industry
Paul Vassalotti, Retiring from BASF
{For Dedication & Support to WABA and Its Members}

Friend of WABA Award
Secretary Ben Brancel
{Wisconsin Department of Agriculture, Trade & Consumer Protection}

Board Member Service Award
Tim Bauer, Deer Creek Seed
{For Full-Term Board of Director Service}

President's Service Award
Erik Huschitt, Badger State Ethanol
{For Dedication, Service, & Leadership}

2014 – 2015
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UW-River Falls

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Leroy Butler [1/]

Maria Eugenia de Sanchez [2/]

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[1/] Member Green Bay Packer Hall of Fame and Inventor of the Lambeau Leap.

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FIXING TILE BLOWOUTS: WHAT YOU NEED TO KNOW!

Eric Cooley[1]

Tile blowouts in Wisconsin are increasing in prevalence as older clay and concrete tile drainage systems continue to age. The gradual expansion of tile lines to an existing system, without proper resizing or venting, has only exacerbated this problem. Sinkholes caused by tile blowouts can introduce soil and nutrients into the tile drainage system and increase the potential for nutrient loss and tile blockage (Fig. 1).

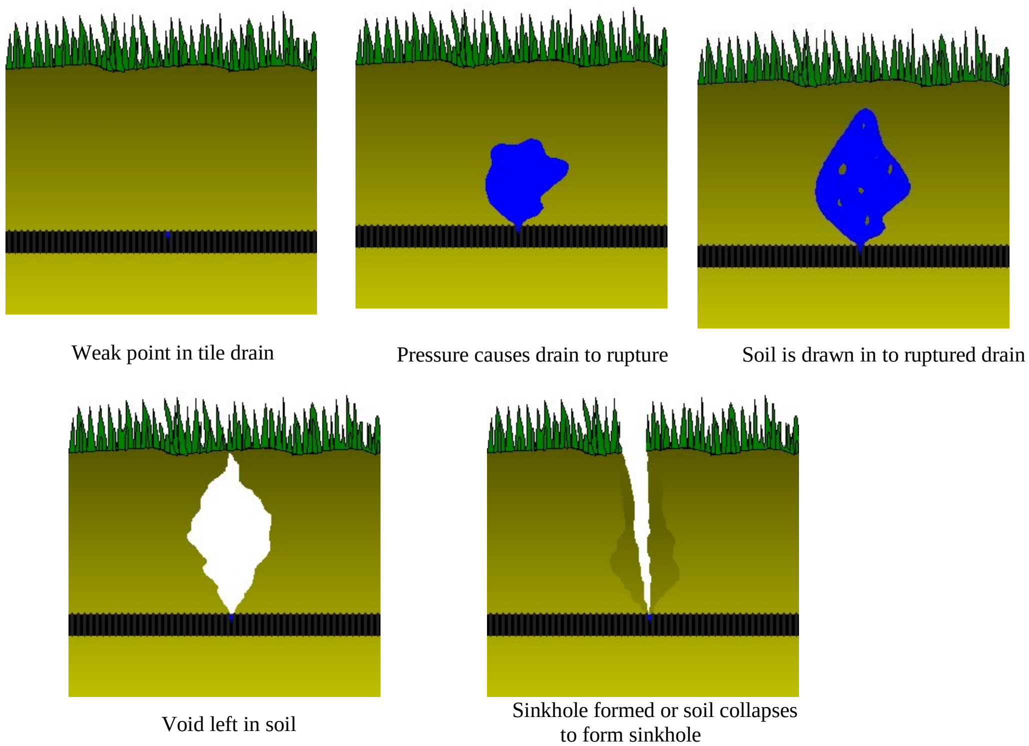

Figure 1: The sequence of steps forming a sinkhole from a tile blowout

Blowouts result from excessively high flow velocity or pressure inside the tile, causing it to crack or burst. Blowouts will often create a sinkhole when the surrounding material is drawn into the tile and transported downstream.

Tile blowout/sinkhole development in agricultural landscapes can occur from a variety of means:

- collapse of clay or concrete tiles from degradation over time
- inadequate venting
- expansion of tile system without adequately resizing main or sub-mains
- outlet blockages
- improper joint connections or junctions between old/new tile lines
- contact of deep tillage equipment with shallow tile lines
- animal burrows

The identification of sinkhole development is most easily performed in the late stages of spring snowmelt or following subsequent spring rain events when tile flow is generally high and when soils typically have reduced surface cover. Sinkholes range in size from a few inches to several feet and can be hard to find. Sinkholes can be observed during high flow periods by water upwelling or going into the ground and during lower flow periods by the hole left in the ground (Fig. 2). In some instances, a "sucking" noise can be heard as air and water are drawn into the sinkhole. Inspection of tile systems for sinkholes can be expedited by accurate maps identifying tile line locations and the use of GPS technology.

Figure 2: Sinkholes caused by tile blowout

Blowouts/sinkholes in tile systems should be repaired promptly by knowledgeable individuals. The direct pathways from the soil surface to the tile system created by these features can result in large amounts of sediment, debris, manure, fertilizer, or chemicals entering tiles. University of Wisconsin Discovery Farms (uwdiscoveryfarms.org) tile drainage research has observed elevated soil and nutrient loss to tile systems from sinkholes. Improper repairs and quick fixes can result in on-going problems with blowout/sinkhole development and tile system blockages.

Farmers are allowed to fix their own tile sinkholes, but there are several questions to consider:

1. **Is the tile system within a drainage district that is governed by county drainage boards?** If so, the local drainage board needs to be contacted prior to tile system maintenance. Cost-sharing for the tile system repair might be available through the drainage board. To determine if your tile system resides in a drainage district, visit the Wisconsin Department of Agriculture, Trade and Consumer Protection Drainage District Program at: http://datcp.wi.gov/Environment/Drainage_Programs for a web map and additional information.

2. **Is the location of the sinkhole within a designated wetland?** Contact your local United States Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS) field office for wetland determination. USDA benefits may be affected with non-compliance of rules: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_020717.pdf
3. **What caused the sinkhole to develop?** The cause of sinkhole formation is critical to prevent future formation of other sinkholes. Tile age degradation, improper venting or

undersized tile mains are common issues that will result in persistent development of sinkholes. If tile system issues are not remedied in conjunction with the tile sinkhole, the problems will persist.

Always contact Digger's Hotline -- (800) 242-8511 -- prior to excavation for tile repairs.

References

Cooley, E.T., Ruark, M.D., & Panuska, J.C. (2013). Tile drainage in Wisconsin: Managing Tile-Drained Landscapes to Prevent Nutrient Loss: GWQ064. http://learningstore.uwex.edu/Assets/pdfs/GWQ064.pdf.

Panuska, J.C., Ruark, M.D., & Cooley, E.T. (2009). Tile drainage in Wisconsin: Maintaining tile drainage systems. University of Wisconsin-Extension publication: GWQ056. http://learningstore.uwex.edu/Assets/pdfs/GWQ056.pdf.

Ruark, M.D., Panuska, J.C., Cooley, E.T., & Pagel, J. (2009). Tile drainage in Wisconsin: Understanding and locating tile drainage systems. University of Wisconsin Extension publication: GWQ054. http://learningstore.uwex.edu/Assets/pdfs/GWQ054.pdf.

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CROP RESIDUE MANAGEMENT: TRASH OR TREASURE?

Francisco J. Arriaga [1/]

Crop residues provide several benefits to the soil and crop production systems. Minerals and nutrients in crop tissue are released as residue decomposes, aiding in the recycling and better utilization of nutrients by subsequent crops. During decomposition, carbon in the residue is transformed into different soil organic matter forms. These different fractions of soil organic matter play important roles in soil fertility, soil water relations, and soil biology.

Management of crop residues is of importance for various reasons, including nutrient recycling, soil carbon build-up, erosion prevention, soil temperature and moisture regulation, and equipment interference, among others. The relative importance of these factors depends on the goals in mind, type of residue, crop in a rotation, climate, and soil type. For this reason, it is difficult to generalize crop residue management practices. However, a universal benefit of crop residues is their value on reducing soil erosion. Residues left on the soil surface help protect soil particles from raindrop impact and detachment, which eventually leads to erosion. Additionally, reducing soil particle detachment also helps in decreasing crust and surface seal formation, both of which hinder seed germination and water infiltration. Surface residue cover of 30% or greater can reduce erosion by 50% or more, with greater amounts of residue cover having a larger impact. Further, residues on the soil surface can help reduce crop water use by acting as a mulch and reduce plant canopy temperature during hot periods of the growing season. One concern with residues on the soil surface is slower warm-up of the soil in the spring and sluggish early plant growth, but typically as the crop develops and air temperatures increase as the growing season progresses, crop development catches up.

It is important to note that residue management should begin at harvest and continue with other field operations. Residue spreaders on combines should distribute residue biomass evenly across the field to avoid uneven emergence and planter interferences the following planting season. Additionally, newer headers have capabilities to chop and size residue, which can be beneficial for aiding decomposition and better residue mass flow through planting and tillage equipment.

While some tillage can help size and incorporate crop residues, excessive tillage will bury a great portion of the residue leaving the soil surface bare. Excessive or aggressive tillage can create crust issues, destroy soil aggregation, and inhibit water infiltration and redistribution within the soil profile. On the other hand, proper tillage will leave enough residue cover on the soil surface to create a good seedbed. In some situations, no-tillage or direct seeding might be an option. It has been noted that decaying root systems and stalks that are partially buried can create pathways for water to flow more freely into the soil, which enhances recharge of the soil profile. Although strict no-tillage might not be practical in some conditions, it might be possible to manage crop residues on a rotational basis depending on the crop phase. In this manner, overall disruption of soil aggregates is reduced on a longer time period (for example, tilling after corn only in a corn-soybean-wheat rotation) while a proper seedbed is created and high residue amount concerns are addressed after crops such as corn.

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Crop residues are beneficial to the overall function of plant and soil systems in crop production. Although issues can arise when not properly managed, crop residues are valuable for crop productivity as they help build-up soil. As such, plant residues are resources and should not be treated as a waste material.

MANURE IRRIGATION: BENFITS AND CHALLENGES

R.A. Larson[1/]

Introduction

Manure production is an unavoidable by-product of livestock production facilities. In the United States, there are approximately 58,000 dairy farms (USDA-NASS, 2013a) with a total of 9.2 million dairy cows (USDA-NASS, 2013b) which represent a manure production value of nearly 183 million tons of manure per year (USEPA, 2012). Manure production, collection, and land application are a part of every dairy system. When land applied, manure can provide essential nutrients for crop production and promote soil health and fertility. However, during these processes the manure constituents (including pathogens) can be lost to the environment causing negative environmental impacts and potentially human health impacts.

Animal manure is a significant reservoir for pathogens, which include bacteria, viruses and parasites (Gessel et al., 2004; Gerba and Smith, 2005; Pepper et al., 2006; Pachepsky et al., 2011). The presence of these pathogens has led to gastrointestinal illness including diarrhea and other more serious health concerns when people are exposed to the pathogens. At agricultural facilities, we are aware of the potential impact from pathogens and take care in direct handling of manure, but we do not have data on the airborne concentrations and potential transport of these pathogens to the surrounding area.

Manure irrigation has received a lot of attention particularly within the last 2 years in Wisconsin as a method for application. Produers have increasingly been interested in the practice due to the management flexibilities, crop and potential water quality benefits, as well as reducing road use for manure application and reduced application costs. However, the public has significant concerns about the practice and the potential issues related to human and environmental health. This issue became front and center in Wisconsin due to the pressing issues being raised by a number of different stakeholders, UWEX responded by developing resources and a manure irrigation workgroup. Outputs of this workgroup include an evaluation of manure irrigation systems with an assessment of the potential environmental impacts.

Discussion

To use manure irrigation, two important areas of knowledge include (1) technology and operational requirements and (2) management practices to limit environment impacts. Technology and operational information for manure irrigation include:

- Selection of equipment based on producer needs
- Reduced total solids content through processing or settling
- Operational practices including system pressure and nozzle type
- Field location and manure transport options

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Management practices to limit environmental impacts include:

- Knowledge of siting to limit drift
- Understanding of weather limitations including maximum operating wind speeds
- Protection of groundwater through check valves on equipment
- Operational parameters that affect drift (e.g., droplet size)
- Operational parameters that impact pathogen inactivation (e.g., UV intensity)

References

Gerba, C.P., and J.E. Smith. 2005. Sources of pathogenic microorganisms and their fate during land application of wastes. J. Environ. Qual. 34:42-48.

Gessel, P.D., N.C. Hansen, S.M. Goyal, L.J. Johnston, and J. Webb. 2004. Persistence of zoonotic pathogens in surface soil treated with different rates of liquid pig manure. Appl. Soil Ecol. 25:237–243

Pachepsky, Y., D.R. Shelton, G.E.T. McLain, J. Patel, and R.E. Mandrell. 2011. Irrigation waters as a source of pathogenic microorganisms in produce: A review. Adv. Agron. 113:73-138.

Pepper, I.L., J.P. Brooks, and C.P. Gerbra. 2006. Pathogens in Biosolids. Adv. Agron. 90:1-40.

USDA-NASS. 2013a. Farms, land in farms, and livestock operations. 2012 Summary. Available at: http://usda.mannlib.cornell.edu/usda/nass/FarmLandIn//2010s/2013/FarmLandIn-02-19-2013.pdf

USDA-NASS. 2013b. Surveys. Milk production. Available at: http://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Milk_Production/index.asp

USEPA. 2012. Potential environmental impacts of animal feeding operations. In: Dairy production. Available at: http://www.epa.gov/oecaagct/ag101/printdairy.html#impact

IRRIGATION WATER MANAGEMENT

J. Panuska and S. Sanford[1/]

Water stress can adversely impact crop yield and quality making adequate root zone soil water availability essential to any crop production operation. Irrigation has become an important tool of choice by growers for drought risk management. The recommended approach to root zone soil water management includes the use of soil moisture tracking in combination with monitoring. Irrigation scheduling and rainfall forecasts can project soil moisture conditions into the near future (1-3 days) while monitoring can be used to ground truth scheduler predictions.

The Wisconsin Irrigation Scheduling Program (WISP) is an irrigation water management tool designed to help growers optimize crop water use efficiency by tracking the root zone water inputs and outputs. Using WISP's water balance predictions, along with soil moisture monitoring, a grower can plan irrigation timing and amount to take maximum advantage of natural rainfall while minimizing over-application of water. WISP uses the checkbook method to track water inputs (rainfall and irrigation) on a daily basis and losses through evapotranspiration (ET) and deep drainage.

Types of moisture monitoring systems include portable probes and sensors at fixed locations. Portable probes have the advantage that measurements can be taken at several locations, but require walking or driving to the desired location. Stationary probes are placed at several predetermined depths and can operate continuously. Stationary probes must be placed at locations considered to be representative of the management unit. Stationary probes need to be directly accessed in the field or they can continuously upload data for web access. Monitoring technologies range from relative inexpensive mechanical means to more costly electronic sensors. Common sensor technologies include: soil water tension, capacitance and time domain reflectively. The approximate cost, advantages and disadvantages of the various technologies will be presented and discussed.

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SUCCESS: PRODUCER IMPLEMENTED WATER QUALITY IMPROVEMENT IN THE DRIFTLESS AREA

Laura Ward Good [1/]

A project in southwestern Wisconsin has shown that producers' changes in management can lead to improvements in stream water quality. This project began in 2006 as a pilot to test the targeting ideas of the Wisconsin Buffer Initiative (WBI, CALS, 2005). This was a project with many partners in addition to producers: Dane, Green and Iowa County Land Conservation offices, University of Wisconsin, University of Wisconsin-Extension, The Nature Conservancy, The Natural Resources Conservation Service (NRCS), US Geological Survey, and private sector agronomists.

Two watersheds, both approximately 19 mi^2, with a similar mix of agriculture, grasslands and woods and similar soils and topography, were selected for the project. The WBI recommended focusing efforts on watersheds of about this size in order to see results relatively quickly. Both of the pair selected were in the upper 10% of the WBI ranking of Wisconsin most likely to benefit from conservation practices to reduce sediment and phosphorus from entering the stream (CALS, 2005). The streams at the outlets of the two watersheds have been monitored for flow, phosphorus and sediment since September 2006. One of the watersheds was picked for targeted conservation efforts, while the other was used as a reference. Having a nearby reference watershed without any special conservation efforts allows us to determine how the project itself affected water quality without having the results obscured by variations in weather and regional land management trends.

The project watershed was inventoried to locate areas that were contributing comparatively high amounts of sediment and nutrients to the stream. The tools used for identifying high loss areas were the Revised Universal Soil Loss Equation 2 (RUSLE2) and the Wisconsin Phosphorus Index in the SnapPlus nutrient management software (UW Soil Science, 2014). Dane County Land Conservation staff also used BARNY to rank barnyards by their potential phosphorus runoff. Using these inventories, the project identified ten operations estimated to be contributing the most total phosphorus in surface runoff to the streams.

Eight of the ten focus operations began working with the project in 2010, and one joined in later. They implemented a combination of in-field and off-field practices to reduce runoff phosphorus and sediment losses with cost-share funding from the NRCS and The Nature Conservancy. The main field management changes were no-till/reduced tillage and pasture/lot systems.

We kept track of cropland and pasture management throughout the project and maintained the SnapPlus databases from the inventory in order to estimate the effects of the project. Participating farmers cut their operations' estimated erosion and phosphorus delivery by half. We also observed that some land not identified as high runoff loss areas in the initial inventory became high loss areas due to management changes. Chief among these changes was conversion of Conservation Reserve Program (CRP) grasslands into tilled cropland. The reference watershed had similar land management trends with CRP conversion.

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In 2013, the first year after full implementation, there was a statistically significant reduction in phosphorus runoff event loads in the project stream compared to the reference stream. This project showed that it is possible to achieve water quality improvements in a relatively short time frame by focusing conservation efforts within watersheds of the WBI-recommended size. Through monitoring both a treatment and reference watershed with both watersheds subject to the same weather and land management trends, we were able to show that producers' management changes had a positive effect.

References

CALS. 2005. The Wisconsin Buffer Initiative. Report by the University of Wisconsin-Madison, College of Agricultural and Life Sciences. http://faculty.nelson.wisc.edu/nowak/reports/nrbFinalReport.pdf

UW Soil Science. 2014. SnapPlus: Wisconsin's Nutrient Management Planning Software. Available at snapplus.wisc.edu.

CORN AND SOYBEAN HERBICIDE TRAIT PIPELINE – PANEL

Daren Bohannan, Bayer CropScience
Johnathan Dierking, Monsanto
Jeff Laufenberg, Syngenta
Ryan Keller, Dow Agrosciences

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DOES ADJUVANT CHOICE REALLY MATTER?

Bryan G. Young[1/]

The Roundup Ready crop era and the robust activity of glyphosate has almost eliminated the need for an applicator to be knowledgeable about adjuvants. Arguably, glyphosate is the most forgiving herbicide when applied under less than optimal conditions or application methods. Glyphosate can be optimized with proper adjuvant selection, however, the lack of doing such can be offset by just applying progressively higher rates of glyphosate. Continued abuse of glyphosate in these applications eventually led to the evolution of glyphosate-resistant weed biotypes which has required the use of alternative herbicides to glyphosate.

The foliar-applied herbicides currently used to manage the most challenging weed species include the PPO-inhibitors (e.g., Sharpen, Flexstar, Cobra), HPPD-inhibitors (e.g. Callisto, Laudis), and glufosinate (Liberty). These herbicides must be optimized with proper adjuvant selection to provide consistent and complete weed control. Instead of the focus being on the built-in adjuvant system of glyphosate, we should look to identify adjuvant products that will help these alternative herbicides control the weeds that glyphosate won't. For the PPO- and HPPD-inhibiting herbicides, the use of oil-based activator adjuvants may be necessary and the inclusion of a drift control agent in the adjuvant product may be a negative for the non-systemic (contact) herbicides.

With the potential future commercialization of soybeans with resistance to 2,4-D and dicamba a significant change in the composition of the commercial adjuvant products will be required compared to the adjuvant products sold today. No longer will we have one adjuvant product that can cover all the acres we need to spray each week. Each individual herbicide combination will likely require the best adjuvant product or the consequence will be failed weed control with little opportunity for a rescue treatment if glyphosate no longer kills your target weeds.

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UNDERSTANDING SPRAY DRIFT: REDUCING YOUR RISK

Daniel Heider[1]

Spray drift has been a part of the agricultural landscape since the very beginning of pesticide application through sprayers. Although our ability to contain drift has improved, current application technologies are never fully able to eliminate drift. Applicator understanding of the forces involved in delivering pesticides through a sprayer is critical for proper sprayer management in drift prone conditions.

Understanding Drift

Pesticide application through spray nozzles results in droplets that as a result of surface tension are roughly spherical in shape. Droplet size is measured in microns with 1 micron = 1/1,000,000th of a meter. Small droplets, those less than 150 microns, are highly susceptible to off-site movement.

As the spray solution exits the elliptical orifice of a fan nozzle (most commonly used type today) it does so as a thin sheet of fluid moving at speeds up to 60 feet per second (49 mph). Droplets are formed at the edge of this sheet of fluid. Unless the spray particles are electrostatically charged or propelled with an air assist boom, the forces of gravity and air resistance take over quickly on the emerging droplets. Small droplets, which have less mass and greater surface area will fall much slower than larger droplets due to more friction with the surrounding air. Larger droplets which are capable of maintaining a downward velocity longer are more likely to be deposited on the intended target. How far can you "push" a droplet before gravity and air resistance completely take over? A 100 micron droplet moving at an initial velocity of 33 feet per second can only be "pushed" approximately 5 inches. A 500 micron droplet moving at the same initial velocity can be "pushed" roughly 5 times as far.

Air temperature and relative humidity at application can have a major effect on droplet size and hence drift potential during movement from the nozzle to intended target. As temperature increases and relative humidity decreases, the droplet will evaporate more quickly. As evaporation occurs, droplet diameter decreases, reducing its mass affecting both its flight time and velocity. At the other extreme of very high relative humidity, small droplets are able to maintain mass, increasing their longevity and therefore their drift distance before they evaporate. Temperature and humidity effects are greatest on small droplets and have little influence on the drift potential of 200 micron and larger sized droplets.

Managing Droplet Size

From the previous discussion it is apparent that larger spray droplets maintain velocity longer, and are less prone to drift. If that is the case, why not simply choose a nozzle which produces droplets so large that drift becomes nearly impossible? Obviously, at some point a droplet becomes so large that too few are being deposited for effective pest control. Systemic pesticides (those taken up by the plant and moved to the site of action) often perform reasonably well in larger droplets sizes. Contact pesticides however perform better in smaller droplets where coverage is essential.

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Nozzle selection is one of the most critical aspects in determining spray droplet size. The days of sprayers set up with one nozzle for all applications, all season long, are long behind us. Today we have many nozzle manufacturers producing quality products to meet application needs. When studying their charts of nozzles and data on droplet sizes keep the following aspects in mind.

Spray Pressure – It is common knowledge that increased spray pressures lead to small droplets. With fan nozzles, the spray solution emerges from the nozzle orifice in a thin sheet, with droplets forming at the edge of the sheet. Under higher pressures, the sheet of spray solution is thinner, resulting in smaller droplets being formed.

Nozzle Orifice – Choosing nozzles based on orifice sizing to meet your output needs at reasonable operating pressure will help control droplet size. Remember that the relationship between pressure and flow rate is not linear. If you need to double your output (gpa) you will need to increase your pressure (psi) by a factor of 4. As an applicator you need to be aware of the chosen orifice size. It is highly unlikely that you will be able to use the same nozzle to spray at 10 gpa in a rough ten acre field that you can comfortably spray at 10 mph and a smooth, level 150 acre field that you could spray at 18 mph.

Nozzle Spray Angle – Wider spray angle nozzles of the same orifice size and operated at the same pressure "stretch out" the same amount of spray solution into a wider sheet as it exits the nozzle. Because the volume is the same, the sheet is thinner and will break up into smaller droplets. Wider spray angles can however be operated lower to the target and still maintain proper overlap to offset some of the increased drift potential of the smaller droplets.

Role of Adjuvants

Pesticide labels will often dictate the addition of either activator adjuvants (those which enhance a pesticides performance) or special purpose adjuvants (which includes compatibility agents, drift control agents, etc.). Activator adjuvants like surfactants, crop oil concentrates and seed oil concentrates all function a bit differently, but also all reduce the surface tension of the spray solution. Reducing the surface tension is often referenced in helping the spray droplets to spread out over a greater surface area on the target. Reduced surface tension however also causes the sheet of water released from the nozzle to break into smaller droplets. Most nozzle testing is done with water only, so realize that your experience of droplet size produced may differ somewhat from nozzle manufacturer charts based on the composition of the spray solution.

Special purpose adjuvants include products like drift control additives. According to the Compendium of herbicide adjuvants, there are roughly 130 different drift control products available to choose from that fall into 3 classes:

Thickeners – these tend to be polyacrylamide or polyvinyl polymers which thicken the spray solution and increase droplet size.

Encapsulators – these products do not affect overall droplet size, but encapsulate the pesticide into droplets to help minimize evaporation losses during product delivery.

Spray Modifiers – these products tend to be vegetable oil based and intend to reduce the amount of fine driftable droplets without increasing the size of the larger droplets.

WEATHER TREND IMPACT ON U.S. SOYBEAN YIELD: REGIONAL AND IN-SEASON DIFFERENCES

‡S. Mourtzinis, J.E. Specht, L. Lindsey, W. Wiebold, J. Ross, E. Nafziger, H. Kandel, N. Mueller, P. Devillez, F. Arriaga, and S.P. Conley

This manuscript was recently accepted for publication in the Journal Nature Plants. Due to publication timing I am unable to provide a written synopsis on this manuscript prior to its official publication. Please go to http://www.nature.com/nplants/ to view this document.

TRAITS, INSECTICIDES, AND CROP ROTTION: CORN ROOTWORM MANAGEMENT UNDER TIGHT CROP BUDGETS

Ken Ostlie [1/]

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WISCONSIN INSECT SURVEY RESULTS 2014 AND OUTLOOK FOR 2015

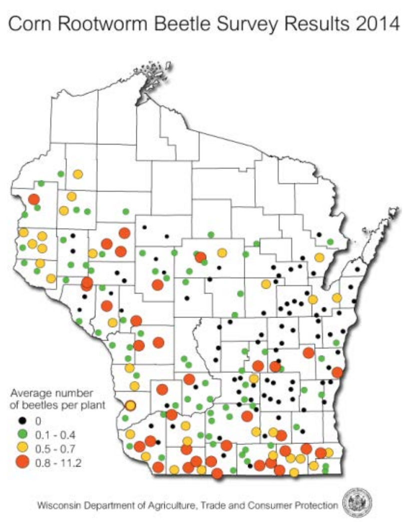
Krista L. Hamilton [1/]

Corn Rootworm

Results of the annual survey indicate adult corn rootworm populations decreased from 2013 across the eastern half of the state and increased in portions of western Wisconsin. Average counts in the six eastern and central crop districts (SC, SE, C, EC, NC, NE) were all well below the 0.75 beetle per plant economic threshold at 0.1-0.4 per plant, with the largest population decline from 0.8 to 0.4 beetle per plant observed in the southeast. The average in the northwest was also below-threshold at 0.5 beetle per plant.

By contrast, the survey found higher beetle populations than in 2013 in southwest and west-central Wisconsin, although part of the increase in the southwest was due to an exceptionally high count of 11.2 per plant in one Lafayette County field. Excluding this count, the district average would have been equivalent to the 2013 average at 0.6 beetle per plant. Economic populations of 0.75 or more beetles per plant were found in 36 of the 229 fields surveyed this season (16%), as compared to 18% last year and a five-year average of 25%. The statewide average of only 0.4 beetle per plant is the lowest since 2010 and the second lowest in the survey's history.

The general reduction in rootworm adults suggests that management practices such as crop rotation, soil insecticides, rootworm-resistant transgenic corn varieties, and natural controls, including low soil temperatures and heavy rain have recently kept numbers at lower levels. Nevertheless, this insect continues to be the most costly insect threat to corn production in Wisconsin.



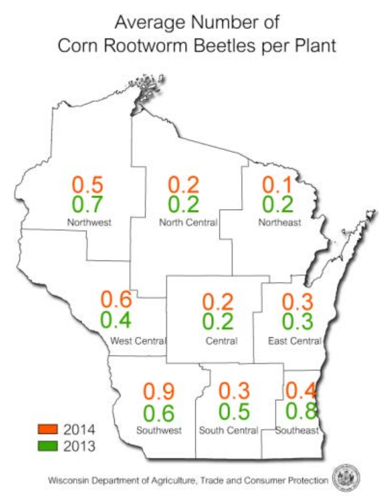


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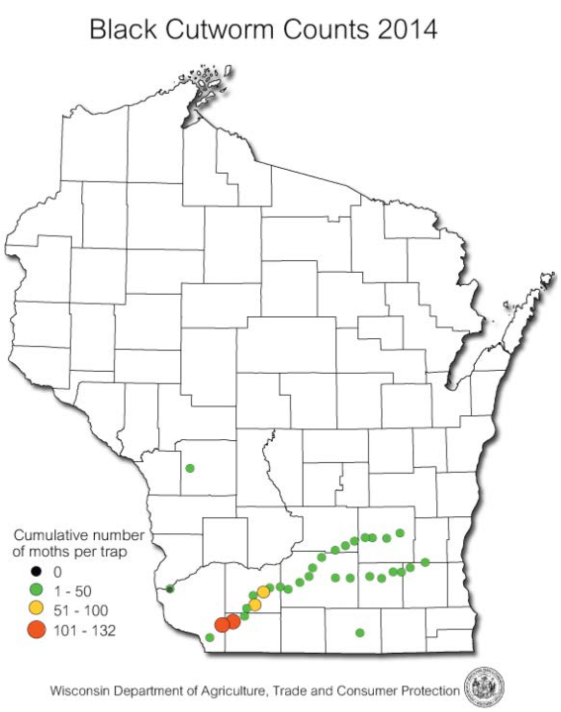
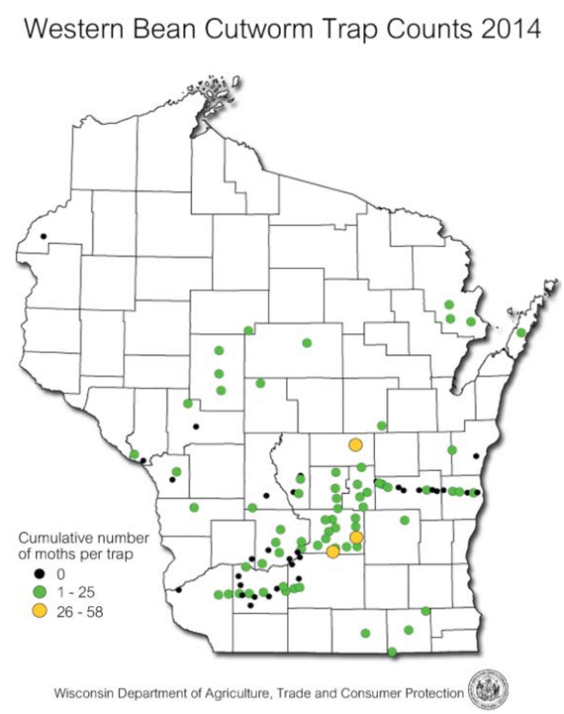
Table 1. Corn rootworm beetle survey results 2005-2014 (Average no. beetles per plant).

District	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	10-Yr
NW	0.4	0.1	0.4	0.5	0.4	0.3	0.1	0.5	0.7	0.5	0.4
NC	0.8	0.9	0.7	0.9	0.4	0.1	0.1	0.3	0.2	0.2	0.5
NE	0.3	1.8	0.5	0.6	0.6	0.1	0.3	0.6	0.2	0.1	0.5
WC	0.8	0.8	0.4	0.6	0.5	0.4	0.6	0.4	0.4	0.6	0.6
C	0.9	0.7	0.8	0.5	0.4	0.4	0.8	0.5	0.2	0.2	0.5
EC	1.1	2.2	1.4	1.0	0.6	0.3	0.5	0.4	0.3	0.3	0.8
SW	3.2	2.2	0.4	1.1	0.7	0.3	1.1	0.8	0.6	0.9	1.1
SC	1.9	1.7	2.2	1.5	1.1	0.3	1.4	0.9	0.5	0.3	1.2
SE	3.8	1.4	1.0	1.6	0.3	0.2	0.7	0.9	0.8	0.4	1.1
State Ave.	**1.6**	**1.4**	**1.0**	**1.0**	**0.6**	**0.3**	**0.7**	**0.6**	**0.5**	**0.4**	**0.7**

Black Cutworm

Migrants began arriving in the state by April 13. The first significant flight was registered near Platteville in Grant County from April 29-May 1 and the primary corn cutting window opened in southwestern Wisconsin on May 29. Spring planting delays and late weed control created very favorable outbreak conditions in June, but cutworm problems failed to materialize. Although the cumulative spring count of 1,068 moths in 34 traps indicated a markedly larger migration than last year's flight of 577 moths in 30 traps, economic damage to emerging corn was not observed this season.



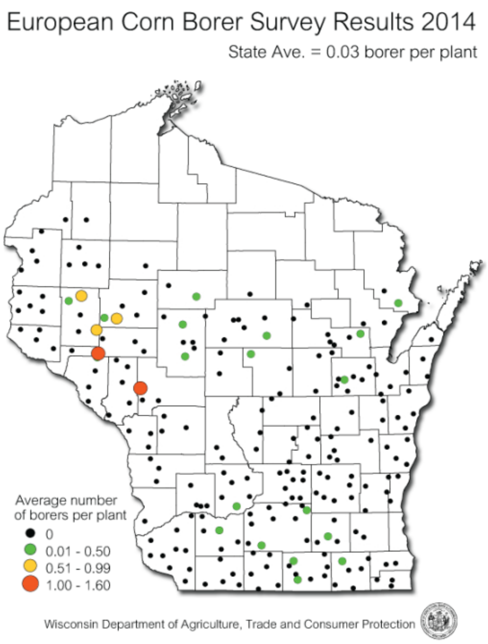


Western Bean Cutworm

The 2014 trapping survey documented the smallest flight in the 10-year history of the monitoring program, collecting only 521 moths in 108 traps (five per trap average). Most sites captured no more than 10 moths during the 10-week trapping period ending August 20. The season's highest cumulative count was just 58 moths near Pine River in Waushara County. Levels of this insect have shown a considerable decline since 2010 when pheromone traps collected the state record count of 10,807 moths in 136 traps (79 per trap average). Larval infestations have also been scarce and the western bean cutworm has not been a major pest of concern for most Wisconsin corn producers in the last four years.

European Corn Borer

Larval populations declined to an average of just 0.03 borer per plant this fall, tying 1998 as the lowest in the survey's 73-year history. Minor population reductions from 2013 were found in seven of the state's nine agricultural districts, while very slight increases were noted in the west-central and north-central areas. Eighty-four percent of the fields examined (193 of 229) showed no evidence of corn borer infestation. Based on the fall survey results, major change in the nearly decade-long low population trend is not expected for 2015.



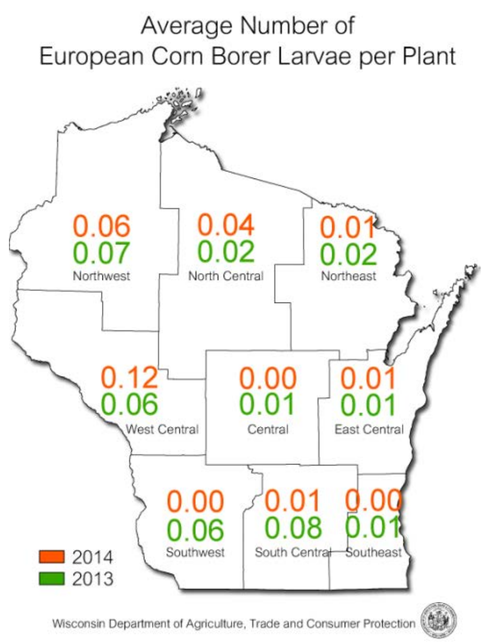


Table 2. European corn borer fall abundance survey results 2005-2014 (Average no. borers per plant).

District	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	10-Yr
NW	0.01	0.27	0.24	0.12	0.06	0.08	0.15	0.04	0.07	0.06	0.11
NC	0.36	0.16	0.35	0.18	0.10	0.02	0.07	0.01	0.02	0.04	0.13
NE	0.33	0.23	0.07	0.12	0.12	0.19	0.13	0.05	0.02	0.01	0.13
WC	0.24	0.42	0.52	0.04	0.10	0.08	0.12	0.09	0.06	0.12	0.18
C	0.06	0.44	0.51	0.42	0.11	0.06	0.06	0.05	0.01	0.00	0.17
EC	0.22	0.25	0.11	0.21	0.20	0.09	0.01	0.03	0.01	0.01	0.09
SW	0.10	0.49	0.20	0.28	0.05	0.06	0.12	0.03	0.03	0.00	0.13
SC	0.05	0.67	0.38	0.33	0.07	0.02	0.07	0.20	0.01	0.01	0.18
SE	0.02	0.35	0.16	0.12	0.04	0.00	0.00	0.01	0.00	0.00	0.07
State Ave.	**0.10**	**0.40**	**0.29**	**0.31**	**0.09**	**0.06**	**0.07**	**0.09**	**0.03**	**0.03**	**0.13**

Soybean Aphid

Densities increased to economically significant levels in about 20% of surveyed fields in late August, though most fields had low or moderate populations this season and control measures were generally not needed. The first aphids of the year were found on June 10 and densities remained extremely low through-out July at fewer than five aphids per plant. By mid-August, counts were still mostly below 20 per plant, although some isolated sites had developed economic populations above the 250 aphid-per-plant threshold. The average count of 118 aphids per plant documented in late August was a substantial increase over the average of only four per plant during the July portion of the survey and, as noted, approximately 20% of surveyed fields may have required treatment for aphid control this year. Biological controls (e.g., lady beetles, lace-wings, parasitic wasps and fungal pathogens), declining nutritional content of maturing soybeans, and other environmental factors reduced densities to very low levels by early September.

Japanese Beetle

Populations were down across the state in 2014 and treatment specifically for this defoliator was not justified for any soybean field sampled by DATCP. A few reports of moderate feeding damage were received from the west-central and northern counties where the Japanese beetle's range is still expanding and it remains a relatively recent pest. Beetle activity persisted through late September.

Alfalfa Weevil

Larval emergence was delayed 1-2 weeks by abnormally cool spring temperatures and counts were low throughout May and June, peaking at less than one larva per sweep from June 12-19. Significant populations did not develop in the first crop and weevil damage concerns were secondary to the excessive June rains which disrupted the alfalfa harvest. Low weevil pressure, cool weather and abundant precipitation all contributed to one of the most productive alfalfa crops in several years; 89% of the first crop rated as good to excellent when the harvest ended in late June.

Potato Leafhopper

Migrants first arrived from May 8-14 and were distributed in low numbers across the southern half of the state by early June. Nymphs appeared in second crop alfalfa during the week of June 11. Populations remained consistently low all season long, with representative counts averaging below 1.8 per sweep in all 534 alfalfa fields surveyed from May through August. Economic counts were not observed in 2014 and leafhopper control was seldom required.

ECONOMIC BENEFIT OF NEONICOTINOIDS IN THE U.S.

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SEED COMPANIES, DEALERS, EXTENSION, AND EPA: MAKING SENSE OF DIFFERING CORN ROOTWORM MANAGEMEN RECOMMENDATIONS

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DATCP ISSUES AND UPDATES

Robby Personette (Feed), Eric Hanson (Grain), and Dan Smith (Ag Development)

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THE FOOD SAFETY MODERNIZATION ACT AND WHAT IT MEANS TO YOU

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Overview

The Food Safety Modernization Act (FSMA) was signed into law on January 4, 2011, and provides the U.S. Food and Drug Administration (FDA) with sweeping new authorities and requirements. The law was a bi-partisan supported bill backed by the food and feed industries. It authorizes FDA to promulgate new rules for preventive controls, develop performance standards, create new administrative detention rules, provides authority for mandatory recall of adulterated products and provides authority for hiring more than 4,000 new field staff among other provisions. It remains unclear whether Congress will provide sufficient funding to fully implement the law, but FDA is proceeding with rulemaking to meet the court ordered deadlines that were established by court order. The animal food final rule must be published by August 2015.

The centerpiece of the law is the hazard identification, written food safety plan and preventive controls. These items are required of all feed, pet food and ingredient facilities that process, pack, manufacture or hold feed, unless they are exempt as a "farm," (facilities that feed their own animals on their own farms) or classified as a very small business. The food safety plan must be available for FDA to review and copy. It encompasses several areas and requires recordkeeping for two years. Basically, Congress requires FDA to do the following (quoted from the law):

> "The owner, operator, or agent in charge of a facility shall, in accordance with this section, evaluate the hazards that could affect food manufactured, processed, packed, or held by such facility, identify and implement preventive controls to significantly minimize or prevent the occurrence of such hazards and provide assurances that such food is not adulterated under section 402 or misbranded under section 403(w), monitor the performance of those controls, and maintain records of this monitoring as a matter of routine practice."

Regulations to implement this provision of the law were to be finalized by July 2012. FDA missed this deadline and was sued by food safety activists and is now under a court ordered mandate to finalize many of the FSMA regulations. This hazard analysis and preventive control regulation for animal food is due to be finalized by August 30, 2015.

Improving Feed Safety

The intent of FSMA is to better protect human and animal health by helping to ensure the safety and security of the food and feed supply. FDA embraces preventing food safety problems as the foundation of a modern food safety system and recognizes the need for a global approach to food and feed safety. Thus, FSMA is designed to take a proactive approach by promoting continuous improvement through audits vs. compliance to regulatory requirements through inspections.

FDA states that ensuring the safety of animal food involves: 1) the safety of the food consumed by animals and 2) the safety of humans handling the food, particularly pet food.

The agency indicates the gaps in the current system to ensure the safety of animal feed include a lack of federal regulations for Current Good Manufacturing Practices (CGMPs) to provide baseline requirements for non-medicated animal feed, pet food, raw materials and ingredients. In addition, the agency feels that there is a lack of federal regulation relating to hazard analysis and preventive controls for all animal feed and ingredients. FSMA provides requirements for these areas.

Manufacturers of animal feed, pet food, raw materials and ingredients will be responsible for ensuring the safety of their finished products. Each facility is responsible for identifying reasonably foreseeable hazards that may occur and determining the preventive controls necessary to minimize or eliminate the hazard. Manufacturers will establish CGMPs to ensure the proper design, monitoring and control of manufacturing processes are maintained. CGMPs provide an environment where hazards may be controlled more effectively.

FSMA requires facilities to create an animal food safety plan, which includes a hazard analysis and the development of preventive controls for reasonably foreseeable hazards. The food safety plan must include a supplier verification program, a recall plan, management of preventive controls, verification and validation activities for preventive controls, and a corrective action program. Records will be essential to demonstrate compliance.

The greatest risks for most feed manufacturing facilities come from outside of their facilities through raw materials and ingredients. Thus, an effective supplier verification program is critical to maintaining or improving the safety of animal food. Verification activities are required to ensure materials are obtained from approved suppliers and that reasonably foreseeable hazards are controlled.

While the FSMA requirements for animal food will not be final until August 30, 2015, facilities are developing programs and processes to ensure compliance with the new federal regulations. Based on the size of the facility, a business will have 1, 2 or 3 years to comply with the requirements from the final rule on CGMPs and hazard analysis and risk-based preventive controls for food for animals.

A facility that develops an effective quality and feed safety program to drive continuous improvement will reach compliance with the new FSMA requirements more efficiently and effectively. It is anticipated that facilities within the feed industry will seek third-party certifications to drive compliance with the new FSMA regulations and help gage their success with manufacturing safer animal food. Complete information on FSMA and its rules can be found at www.fda.gov/fsma.

The American Feed Industry Association developed feed safety programs that mirror the FSMA approach, in that it requires hazard analysis and development of preventive controls. The Safe Feed/Safe Food program can be utilized for feed and feeding ingredients. Separate programs for export to the European Union, pet food and pet food ingredients also have been developed and are based on either the EU HACCP approach or the global food safety initiative approach, which is also a HACCP program. More information about these programs can be found at www.safefeedsafefood.org.

OSHA 2015: WHAT YOU NEED TO KNOW

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LOW-DISTURBANCE MANURE APPLICATION METHODS IN A CORN SILAGE-RYE COVER CROP SYSTEM[1]

Bill Jokela[2], Jason Cavadini[3], and Mike Bertram[4]

Introduction

Manure can provide valuable nutrients, especially nitrogen, to high N-requiring crops such as corn. However, a large portion of manure N, about half in typical liquid dairy manure, is in the ammonium or urea form and can potentially be lost to the air as ammonia if the manure is not incorporated into the soil promptly (Jokela and Meisinger, 2008). Tillage is the most common method of incorporation, but tillage and, to a lesser extent, standard injection reduce crop residue cover, leaving the field more susceptible to erosion. Tillage may also be incompatible with management requirements to meet criteria in nutrient management plans. Corn production for silage is particularly problematic because whole-plant removal leaves minimal residue cover after harvest. Establishment of a cover crop such as winter rye after harvest can provide adequate residue cover, but timely seeding (preferably by mid-September) is critical. Farmers need a system that incorporates manure while still maintaining crop residue cover.

The overall objective of this study is to evaluate several relatively new methods for applying liquid dairy manure designed to maximize manure N availability while maintaining crop residue cover for erosion control in a silage corn system in the northern Corn Belt, specifically central Wisconsin.

Methods

Four novel manure application methods designed to inject or encourage infiltration of liquid manure were compared to conventional broadcast application either left on the surface or incorporated with a disk (Fig. 1.). Four pre-plant nitrogen fertilizer treatments (including zero N) provide a crop yield response curve to evaluate manure N availability of the various manure application methods. This resulted in the following ten treatments:

1) Low-disturbance sweep injection (Dietrich/DSI)
2) Manure/strip-till (Dietrich/DSI sweep injectors with paired disks designed to create a ridge for planting in the spring)
3) Coulter injection (Yetter Avenger) a narrow V-slot for manure followed by covering disks
4) Aerator/band application: rotary tine aerator (Gen-Till) with manure applied in bands over aerator slots to encourage manure infiltration
5) Broadcast manure with disk incorporation
6) Broadcast manure – surface (no incorporation)
7) Control: No manure or fertilizer N
8) Fertilizer N 60 lb/acre
9) Fertilizer N 120 lb/acre
10) Fertilizer N 180 lb/acre

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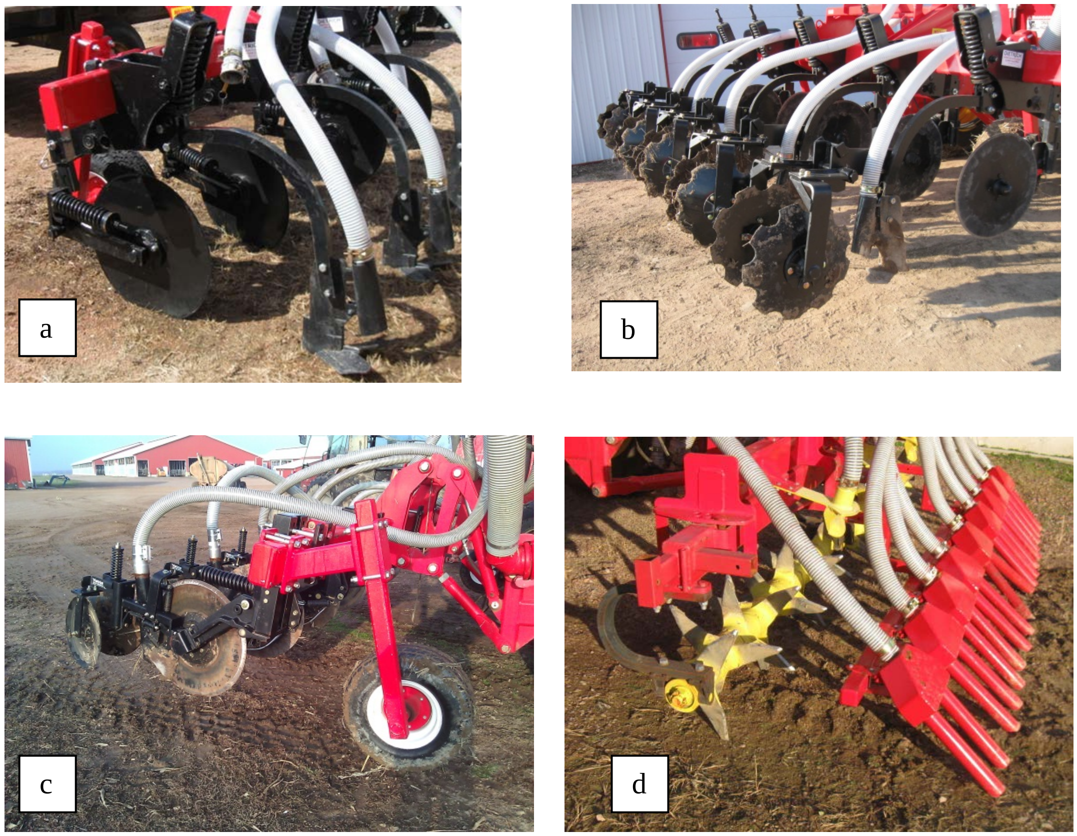


Figure 1. Manure application attachments: a) Dietrich/DSI slurry injector, b) DSI injector with paired disks for strip-till, c) Yetter Avenger coulter injector with covering disks, d) Aerator-band applicator.

This field trial was established on a Withee silt loam soil at the UW Marshfield Agricultural Research Station in Stratford, WI. Treatments were applied to plots 15 x 50 feet in size. Each treatment was replicated four times in a randomized complete block design. Blocks are separated by alleys 75 feet wide to allow adequate space for turning of the spreader and tractor. The experiment was established with limited measurements in the 2012 growing season (fall 2011 manure application) and continued on the same plots in 2013 and 2014.

Corn (a mid-season relative maturity hybrid) was planted in late May 2012 and 2014 and early June 2013, particularly late in 2013 because of unusually wet and cool conditions. Silage was harvested on 9/6/2012, 10/1/2013, and 9/30/14. Winter rye was seeded with a no-till drill by mid-September (Sept 13) in 2012 but an extended dry period delayed germination. In 2013, in anticipation of delayed silage harvest, rye was seeded manually to simulate aerial seeding on Sept 6, but growth was limited by cold weather and, perhaps, herbicide carry-over. Manure treatments were applied Nov 9, 2012, Nov 5, 2013, and Oct 21, 2014 for the following year's cropping season. Target manure rate was 8000 gal/acre, a rate estimated to supply about 80% of the corn N needs. Both application rate and manure nutrient content varied but on average manure supplied 190, 90, 80, and 200 lb/acre of total N, NH_4-N, P_2O_5, and K_2O. Starter fertilizer was applied each year with the planter (100 lb/acre of 9-11-30-6S) and potash was applied to all plots in May of

2013 (180 lb K_2O/acre) and 2014 (120 lb K_2O/acre). All treatments except manure/strip-till (#2) were field cultivated each spring before planting.

Soil samples for the pre-sidedress nitrate test (PSNT, 1-ft depth) were taken at 8- to 12-inch plant height. Ear leaf samples were collected at silking to assess nutrient status. At the same time an active canopy sensor (Crop Circle by Holland Scientific) was used to measure reflectance of three different wavelengths (670, 730, and 760 nm), from which three indexes -- NDVI, NDRE , and CCCI – were calculated. Silage yields were determined by harvesting the center two rows of each plot with a field-scale chopper and a wagon equipped with weigh cells. Surface residue cover was measured using photographs (2 per plot) and digital imagery analysis before and after fall manure application and the following spring to determine the effect of manure application method and associated tillage on residue cover. Ammonia emission from manure was measured using the dynamic chamber/equilibrium concentration technique during the three days immediately following manure application.

In 2014 a separate experiment was conducted on an area adjacent to the main trial to evaluate the effect of manure application method on loss of nutrients and eroded sediment in runoff using a portable rainfall simulator (Joerns, Inc., West Lafayette, IN). Selected manure treatments were applied in late October, followed two days later by rain simulation to generate runoff (1.6 inches of rain per hour for 30 minutes). Runoff was sampled and analyzed for suspended sediment, total and dissolved P, and total and dissolved N.

Preliminary Results

Because the project is still in progress no final conclusions can be made and interpretations of the data will be limited. Extreme weather conditions during these years created a further limitation in interpreting the results. In 2012 precipitation ranged from only one-third of 30-year norm in July to more than double the norm in October. 2013 was also a year of extremes with twice the norm for total precipitation during April, May, and October but about half the normal for August and September. Precipitation was above the long-term average in 2014 with almost twice the average in April, a third higher in May, and 60% above average in August. The growing season was also cooler than average with lower average temperatures most months and 196 fewer GDD units than the long-term average.

One indicator of the availability of N to the crop is the pre-sidedress nitrate soil test, or PSNT (Table 1). In 2012, while there were some treatment effects, all but the Control and Broadcast-Surface treatments were above the 21 ppm level for adequacy of N (Laboski and Peters, 2012). In 2013, however, all but the highest fertilizer N rates were well below the 21 ppm threshold, indicating a need for additional N. This likely reflects the excessive rainfall during April and May that created conditions for loss of N via leaching and/or denitrification. In 2014, all but the no N Control treatment were above the critical level. The Sweep Injected manure and the fertilizer N treatments had the highest levels.

The nutrient concentration of the leaf opposite and below the ear, or ear leaf, at 50% silk is another indicator of the nutrient status of the corn plant (Table 2). In 2012 N concentration was above the sufficiency level (2.5%) for most treatments, with the exception of the Broadcast-Surface, Control, and 60 lb N/acre treatments, indicating there was inadequate N applied or large N losses from those treatments. Nitrogen

Table 1. Pre-sidedress soil nitrate test (PSNT) concentrations. 2012-2014

Treatment	2012	2013	2014
		NO_3-N ppm	
Sweep Inject	36.2 abcd†	14.3 bcd	47.5 bc
Strip-Till Inject	39.0 abc	11.9 cde	24.6 d
Coulter Inject	23.4 def	8.1 cde	22.7 d
Aerator/Band	21.1 ef	7.2 de	21.0 d
Broadcast-Disk	31.0 bcde	12.5 cde	21.6 d
Broadcast-Surf	19.7 ef	6.3 e	22.6 d
Control	15.6 f	7.1 de	16.7 d
N 60 lbs/acre	28.4 cdef	15.2 bc	40.3 c
N 120 lbs/acre	45.5 a	20.7 ab	56.4 b
N 180 lbs/acre	43.5 ab	24.8 a	80.5 a
P-value	0.01	0.01	0.01
CV, %	35	46	34

† In each column, least square means followed by the same letter are not statistically different at P-value = 0.10 based on Duncan's Multiple Range Test.

Table 2 Nitrogen concentrations in ear leaf samples at silking. 2012-2014

	2012	2013‡	2014
Treatment		N concentration	
		%	
Sweep Inject	2.87 a†	1.77 b	2.36 ab
Strip-Till Inject	2.60 ab	1.56 bc	1.76 c
Coulter Inject	2.60 ab	1.54 bc	1.92 c
Aerator/Band	2.64 ab	1.45 cd	1.76 c
Broadcast-Disk	2.57 ab	1.43 cd	1.76 c
Broadcast-Surf	2.39 bc	1.23 d	1.67 c
Control	2.02 c	1.38 cd	1.24 d
N 60 lbs/acre	2.30 bc	1.63 bc	1.80 c
N 120 lbs/acre	2.82 a	2.09 a	2.27 b
N180 lbs/acre	2.66 ab	2.25 a	2.61 a
P-value	0.01	0.01	0.01
CV, %	10	8	9

† Within each column, values followed by the same letter are not significantly different at P = 0.05 based on Duncan's Multiple Range Test.
‡Reps 1, 2, and 4 only

concentrations in 2013 were all below the sufficiency level, probably a function of excessive rainfall and perhaps limited manure N release due to unusually cool spring temperatures. Ear leaf N concentrations for 2014 were lowest for the Control and highest for the sweep injection manure and highest fertilizer N treatments, which met or approached the sufficiency level. The general pattern was similar to that of PSNT results, though specific statistical effects varied. One or more of the indexes of canopy reflectance (NDVI, NDRE , and CCCI) showed good relationships with measured N concentration of ear leaf at silking. This suggests that canopy sensors could be a useful tool to indicate crop N status, assuming the crop can benefit from additional N late in the season and application equipment is available.

There were no significant effects of treatment on silage yields in 2012, but the no-N control had the lowest yield values (Table 3). Nitrogen uptake was affected by treatment, with the Control and Broadcast-Surface N lowest, providing further evidence of N loss (most likely ammonia-N) from surface-applied manure. The other manure treatments were statistically similar to those receiving N fertilizer. In 2014 yield and N uptake from treatments receiving injected or disk-incorporated manure were statistically similar to N fertilizer treatments; those manure and N treatments were approximately twice or more that of the no N Control. No data is shown for 2013. Unusually wet soil conditions at planting and through the spring, followed by an extended dry spell in late summer, led to poor stands and growth in substantial portions of the plot area. This led to extreme variability, which was compounded by problems with weighing equipment during silage harvest.

Ammonia emission was measured during the three days following manure application in 2013 using the dynamic chamber/equilibrium concentration method. Even though temperatures were low (maximum of 43 F) during the measurement period and there was a 0.6 inch rain during the first night, there was measurable ammonia emission, with the greatest amount from the surface-applied manure. Ammonia loss was reduced by about 85% by coulter injection and >95% by strip-till injection, with the aerator/band and disk incorporation intermediate (30 to 55% reduction). Results from 2014 showed generally similar patterns with dramatic reductions from the injected manure treatments and substantial, but lower, reductions from disk and aerator-band.

Crop residue cover (corn residue, rye, and weeds) in November before manure application was 30 to 40% in 2012 and averaged about 40% in 2013 (See Figure 4 for 2013-2014). Residue cover was reduced by all methods that involve soil disturbance, the most by disking and the least by coulter-injection. Note that manure cover is not included in the data shown in the figures. This explains the decrease in residue cover for the broadcast-surface treatment in 2013, for which no reduction would be expected. (Residue covered with manure was not visible and not counted.) Residue cover the following spring (pre-tillage 2014) increased to levels close to the fall pre-manure amounts (with the exception of the Broadcast-Disk treatment), primarily due to growth of the rye cover crop. Following spring field cultivation and planting (post-plant), residue cover was reduced to 10 to 15% in all treatments except Strip-till Injection (25%), which is the only treatment that was not spring-tilled.

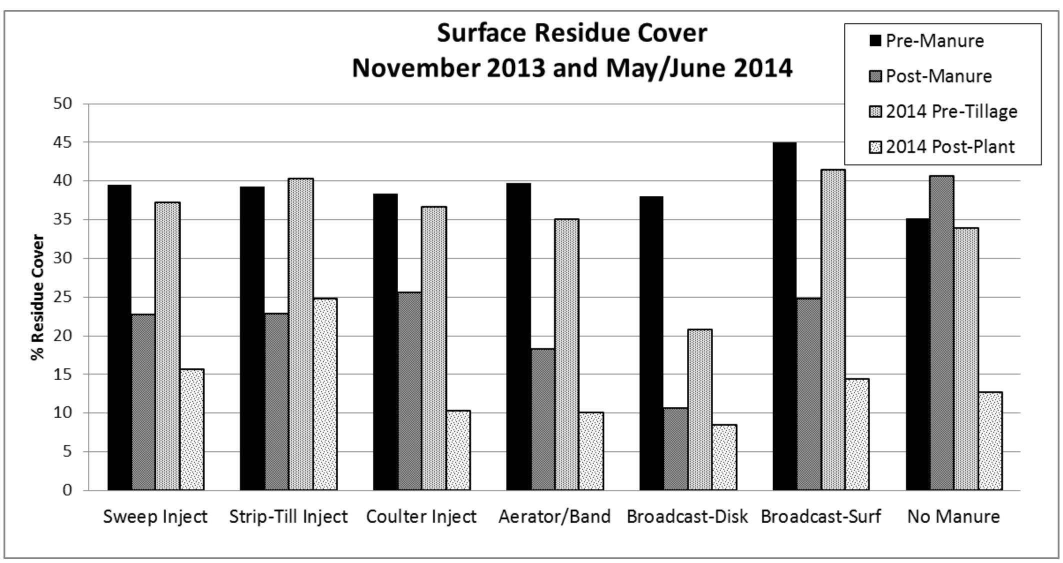
Preliminary results from the rain simulation-runoff experiment show the highest runoff losses of total and dissolved P from surface-applied manure, as would be expected. Total P loss was reduced by approximately 35% by the aerator band method, 70% by disk incorporation, and almost 90% by strip-till injection, which was not statistically different from the control treatment that received no manure. Results for dissolved P losses followed a similar pattern but with even greater reductions from injected or incorporated manure.

Table 3. Silage yield and N uptake for 2012 and 2014.

Treatment	2012 Yield	2012 N uptake	2014 Yield	2014 N uptake
	Ton DM/a	lb/a	Ton DM/a	lb/a
Sweep Inject	6.55	172 a	8.34 a	189 a
Strip-Till Inject	6.50	158 ab	6.70 ab	140 abc
Coulter Inject	6.93	154 ab	5.43 bcd	120 bcd
Aerator/Band	6.68	151 ab	4.26 bcd	88 cde
Broadcast-Disk	6.34	150 ab	5.24 bcd	111 bcde
Broadcast-Surf	6.47	126 bc	3.57 cd	70 de
Control	5.88	102 c	2.91 d	49 e
N 60 lbs/acre	6.05	145 ab	6.46 ab	134 abcd
N 120 lbs/acre	6.27	174 a	5.99 abc	136 abc
N180 lbs/acre	6.19	169 a	6.67 ab	165 ab
P-value	NS	0.01	0.01	0.01
CV, %	8	14	26	30

† In each column, means followed by the same letter are not statistically different at P-value = 0.05 based on Duncan's Multiple Range Test. NS = nonsignificant.
‡Silage yield not reported for 2013 (See text for explanation.)

Figure 2. Surface residue cover pre-and post-manure application in November 2013 and pre-tillage and post-planting in May/June 2014.



Preliminary Conclusions

- Manure N availability, as indicated by the PSNT, ear leaf N concentration at silking, and silage N uptake, was generally highest from injected or disk-incorporated manure and lowest from surface broadcast manure. The best manure treatments were similar to fertilizer N treatments (specific N rate depending on year and indicator).
- Differences in manure N availability reflect losses from ammonia volatilization, as indicated by similar differences in measured ammonia emission – surface broadcast highest, injected lowest, and others intermediate. Ammonia emission was a function of the amount of manure left on the surface.
- Silage yields followed a similar pattern, but differences were less pronounced and sometimes lacked statistical significance.
- Residue cover was reduced by all methods that involve soil disturbance, the most by disking and the least by coulter-injection. Cover increased by spring due to growth of rye cover crop, approaching pre-manure application levels, except for disk incorporation; but cover in all treatments except strip-till (no spring tillage) was greatly reduced by spring field cultivation.
- Preliminary results for phosphorus runoff losses shortly after manure application reflected the degree of manure incorporation, with greatest loss from surface broadcast and the least from injection.
- Overall, preliminary results from this study show that the low-disturbance manure application methods can greatly reduce ammonia-N emission and nutrient runoff losses and improve manure N availability compared to surface application; and that they maintain residue cover better than disk incorporation of manure.

References

Jokela, W.E., and J.J. Meisinger. 2008. Ammonia emissions from field-applied manure: management for environmental and economic benefits. Proc. 2008 Wisconsin Fertilizer, Aglime, and Pest Management Conference.
http://www.soils.wisc.edu/extension/wcmc/2008/pap/Jokela.pdf

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

IMPACT OF MANURE APPLICATION IN DIFFERENT SEASONS ON PHOSPHORUS LOSS IN RUNOFF

Peter Vadas[1], Bill Jokela[1], and Laura Good[2]

Introduction

Agricultural nutrient management continues to be an important area of research and policy due to concerns of phosphorus (P) loss in runoff and water quality degradation. Surface manure application to fields without incorporation can be a significant source of P loss (Daniel et al., 1998). In many northern states, winter manure application without incorporation is common (Srinivasan et al., 2006). This fact, combined with frequent snowmelt runoff, has prompted some states to restrict winter manure spreading. However, restrictions are based more on commonly held perceptions than on research. Studies of winter manure P loss are limited, and most have been observational with mixed results (Kongoli and Bland, 2002). P transport from winter-applied manure varies due to infiltration, runoff, erosion, and nutrient cycling processes, all of which are sensitive to air and soil temperatures. Manure P loss also varies with spreading practices, especially relative to manure placement beneath or on top of snow and the effect of manure on rates of snow melt (Williams et al., 2011). Overall, good understanding of P cycling and transport associated with winter manure application is still lacking.

There is an increasing demand to evaluate all agricultural systems where non-point P pollution is a priority. Relying on physical monitoring is too costly and time-consuming, so models have been developed to simulate and assess those management and process interactions that cannot be physically investigated. Vadas et al. (2007) developed the SurPhos model to predict dissolved P loss in runoff from surface-applied manures (Figure 1).

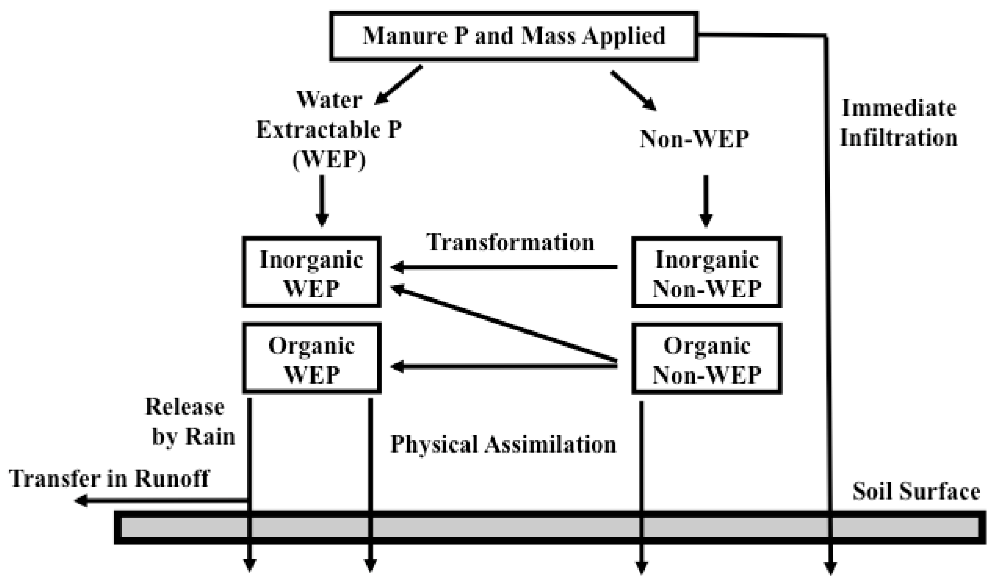


Figure 1. Schematic of the SurPhos manure P runoff model.

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SurPhos is a daily time-step, process-based model that simulates manure application to the soil surface, dry matter and P transformations (e.g., organic matter decomposition, organic P mineralization) as manure ages in the field, physical assimilation of manure into soil by bugs, leaching of P from manure during rain events, and loss of manure dissolved P in runoff when runoff occurs.

The USDA-ARS and the UW-Madison have a collaborative research project that is investigating the physical and chemical processes controlling P loss in runoff from winter-applied dairy manure. As part of that project, we are using the SurPhos model to help estimate how the day of manure application influences P loss in runoff. We are specifically trying to quantify how much greater the risk of manure P loss is from winter-applied manure compared to manure applied in other seasons. To do this, we collected real precipitation and field runoff data from six monitored locations in WI. In total, there were 108 site years of runoff data representing a variety of climate and soil conditions. We divided the data into three groups of high, medium, and low runoff based on how much runoff was observed during the winter period (mid-November through mid-March). We then used SurPhos to simulate a liquid dairy manure (6% solids) application of 10,000 gallons/acre, or 35 lbs total P/acre. We allowed the model to change the day of manure application so that each day of the year was represented. For example, the model was first run so manure was applied on October 1 on each year, with the model simulating about 35 years of runoff data. The results were then processed to determine an average rate of annual manure P loss in runoff. The model was then reset, and the process was repeated with manure applied on October 2, and so on until all days of the year were simulated. This entire process was conducted separately for low, medium, and high groups of runoff data

Results and Discussion

Figure 2 shows the results of the SurPhos manure P runoff simulations. P loss is generally low for all rates of site runoff if manure is applied between March and October. For the low runoff sites, P loss in runoff increases if manure is applied in the winter, but not very dramatically. For medium and high runoff sites, applying manure during the winter can significantly increase the risk of P loss, with peak loss occurring if manure is applied around late January to early February. The results show that avoiding winter manure application could help decrease potential P loss in runoff. Because the rate of runoff (high, medium, or low) is not always the same for a given field every year (i.e., the same field could have low runoff one year and high the next), it may be difficult to reliably identify low runoff fields that may be able to receive winter-applied manure.

Table 1 presents a summary of the effect of applying manure in winter (December-March) vs non-winter on P loss in runoff. These data are averages of P loss for all winter days or non-winter days. Results show generally that applying manure in the winter can increase P loss from 2.8 to 4.2 times, with the increase greater as the amount of runoff increases. High runoff sites have the potential to lose more than seven times the amount of P from surface applied manure as low runoff sites. Medium runoff sites would lose more than three times as much manure P as low runoff sites.

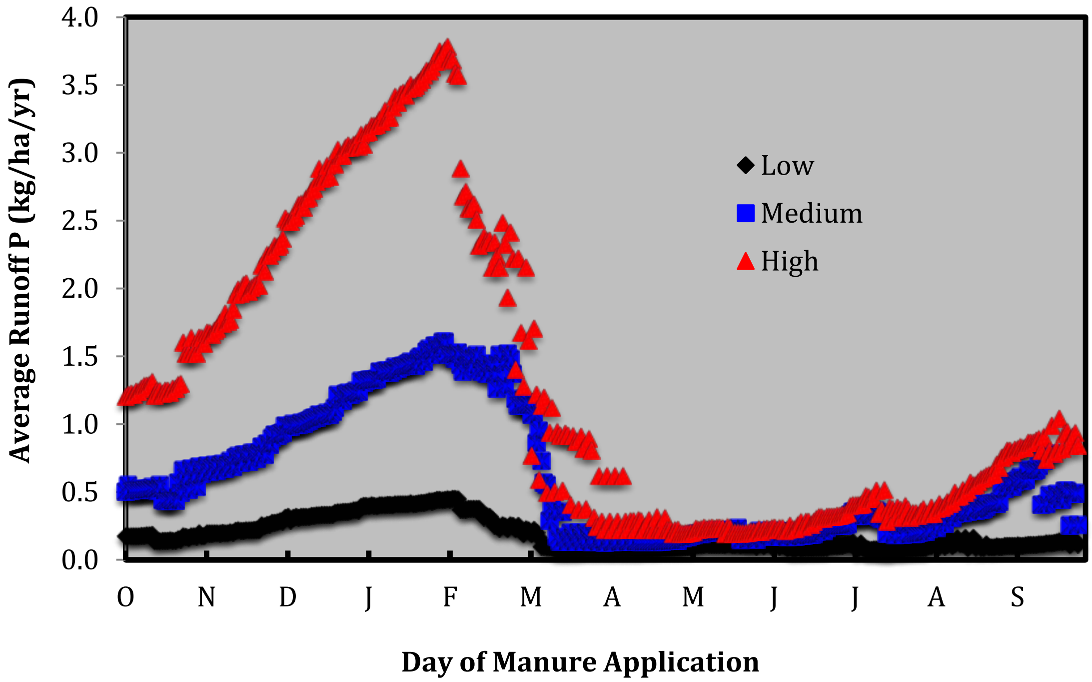

Figure 2. Model simulations showing the effect of manure application day on P loss in runoff for low, medium, and high runoff sites.

Table 1. Summary of the effect of applying manure in winter (December-March) vs non-winter on P loss in runoff.

Runoff Group	Winter P Loss (kg/ha/yr)	Non-Winter P Loss (kg/ha/yr)	Season Difference	Runoff Difference over Low
Low	0.33	0.12	2.8x	--
Medium	1.19	0.33	3.6x	3.4x
High	2.63	0.63	4.2x	7.2x

References

Daniel, T.C., A.N. Sharpley, and J.L. Lemunyon. 1998. Agricultural phosphorus and eutrophication: A symposium overview. J. Environ. Qual. 27:251-257.

Kongoli, C.E., and W.L. Bland. 2002. Influence of manure application on surface energy and snow cover: Field experiments. J. Environ. Qual. 31:1166-1173.

Srinivasan, M.S., R.B. Bryant, M.P. Callahan, and J.L. Weld. 2006. Manure management and nutrient loss under winter conditions: A literature review. J. Soil Water Conserv. 61:200-209.

Vadas, P.A., W.J. Gburek, A.N. Sharpley, P.J.A. Kleinman, P.A. Moore, M.L. Cabrera, and R.D. Harmel. 2007. A model for phosphorus transformation and runoff loss for surface-applied manures. J. Environ. Qual. 36:324-332.

Williams, M.R., G.W. Feyereisen, D.B. Beegle, R.D. Shannon, G.J. Folmar, and R.B. Bryant. 2011. Manure Application under Winter Conditions: Nutrient Runoff and Leaching Losses. Trans. ASABE 54:891-899.

DEFINING NITROGEN MANAGEMENT ZONES WITH APPARENT ELECTRICAL CONDUCTIVITY (EC) MAPPING

Matt Ruark, David Evans, Jim Leverich, and Tom Cox [1/]

Introduction

The use of apparent electrical conductivity to map the variation in fields has been around for several decades (Corwin and Lesch, 2003) and several studies have shown that there can be a statistically significant correlation between EC and various soil physical, chemical, and biological properties (e.g., Corwing and Lesch, 2003; Johnson et al., 2003). However, there isn't a clear or standardized use of apparent EC to develop N management zones within a corn field. What we will describe here is a simple approach to using apparent EC data, with targeted soil sampling, to identify with soil properties are the best upon which to alter N rates within a field.

Approach

One farm field in 2013 is used for this case-study and is located in Rock County, WI. In the spring of 2013 apparent EC mapping and targeted soil sampling were conducted by C3 (now a division of Trimble Navigation Ltd.). Twenty soil samples were collected in the field and analyzed for Maps were developed for each soil variable based by equally distributing the data into three categories of low, medium, and high (i.e., the lowest ⅓ of the values are in the low category and the highest ⅓ of values are in the high category). This is a bit of an arbitrary approach, but useful for this simple exercise. Two soil properties were used for this exercise, soil organic matter and depth to root restriction. The categories for soil organic matter (0 to 12 inches) were: 0.5 to 1.6 (low), 1.6 to 3.5 (medium), and 3.5 to 4.7 (high). The categories for depth to root restriction were: <28 inches (low), 28 to 38 inches (medium), and >38 inches (high).

Prior to corn planting, field length N rate strips (1,200 ft long) were applied at rates of 0, 60, 110, 135, 160, 185, 210, and 235 lb-N/ac, each replicated three times. Field length strips were used in order to ensure each N rate overlapped with each soil category.

Preliminary Results

When averaged across all N rate strips, no significant yield increases were determined above 110 lb-N/ac. But when the N response was graphed for each soil organic matter category (low, medium, and high), not only were different maximum yields achieved, but different optimum N rates were observed for each category (Fig. 1). The agronomically optimum N rate for the medium soil organic matter category was about 120 lb-N/ac, but was closer to 160 lb-N/ac for the low soil organic matter category (Fig. 1).

The relationships between N rate and yield were even stronger when split out among differences in depth to root restriction (Fig. 2), as noted by larger R^2 values. However, it doesn't appear that the agronomically optimum N rate is very different between the medium and low category of depth to root restriction.

While a more thorough analysis will be presented, it is clear that use of apparent EC, coupled with field length N rate strips has tremendous value in identifying which soil properties are controlling yield and response to N on a field by field basis. Additional analysis is needed to best assign values to each soil category.

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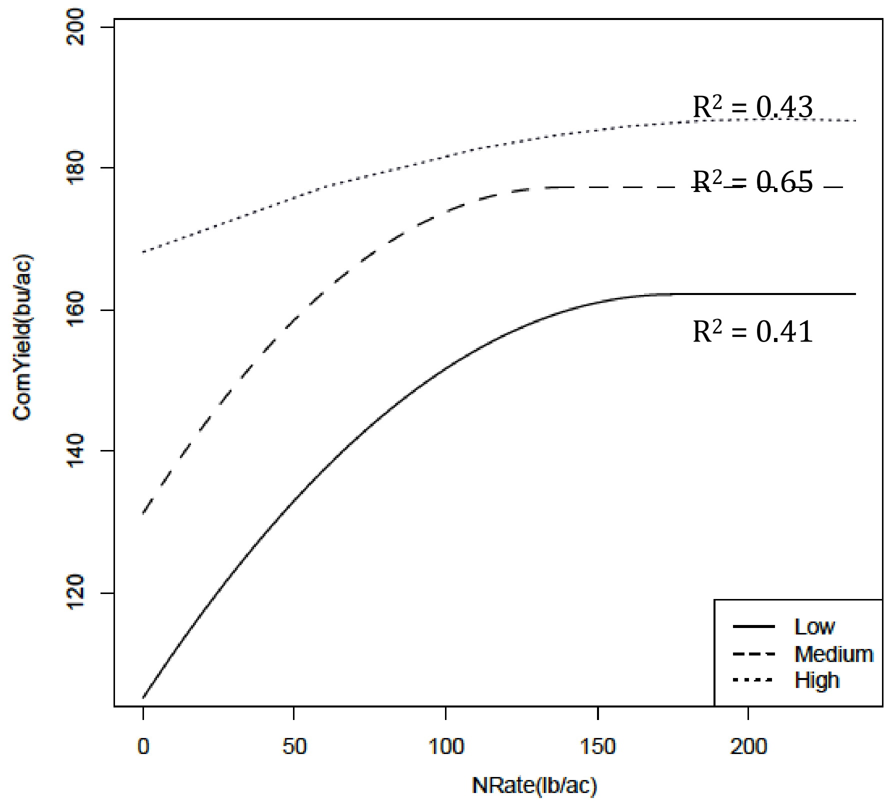

Figure 1. Nitrogen response curves for three categories of soil organic matter.

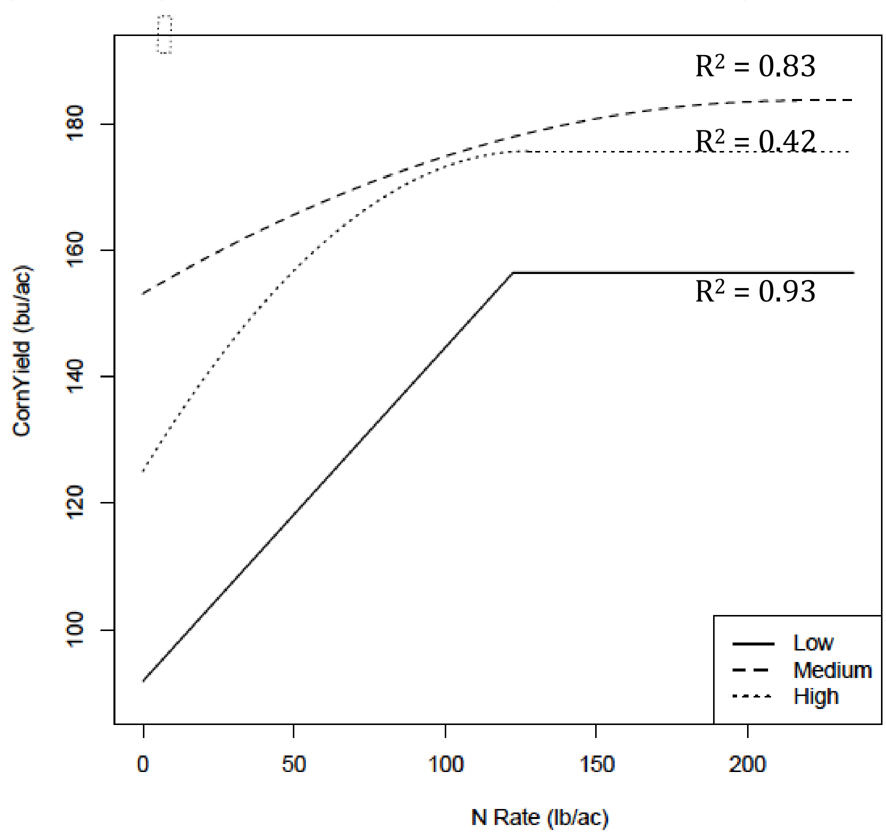

Figure 2. Nitrogen response curves for three categories of depth to root restriction (DRR).

MEASURES OF NITROGEN USE EFFICIENCY AND ENVIRONMENTAL IMPACTS OF DAIRY PRODUCTION SYSTEMS

J. Mark Powell[1]

Nitrogen (N) is the most limiting nutrient for productive agriculture. The principal N inputs on dairy farms are feeds, manure, fertilizers, biologically-fixed N, soil N and atmospheric N deposition. The relative importance of each N source to the production of crops, pasture and milk depends on several factors, including a farm's stocking rate (animals per unit land area), which influences the type and amount of feed grown on a farm, feed and fertilizer purchases, manure management, N use efficiency, whole-farm N balances and environmental N loss. Soil type also impacts N use efficiency (NUE, the amount of applied N transformed into products) and N loss as ammonia (NH_3), nitrate (NO_3^-) and nitrous oxide (N_2O). This presentation will demonstrate how stocking rate, fertilizer, feed and manure management impact NUE and N loss from dairy production systems.

Feed N use efficiency and milk production

On dairy farms, cows are fed forages, grain, protein and mineral supplements, and manure is applied to cropland and pastures to recycle nutrients. When the diets fed to lactating cows are well balanced in energy, crude protein (CP) and other minor ingredients, the dietary N (CP÷6.25) consumed is transformed about equally into milk, feces and urine. The proportion of N excreted in urine is highly influenced however by the form and amount of CP consumed. Whereas the concentration of N in dairy cow feces is fairly constant, concentration of N in urine, especially in the form of urea, can vary greatly. Feed N use efficiency declines and the proportion of urinary N excreted as urea N increases as the concentration of CP in the diet increases. And this increases losses of NH_3 and N_2O from dairy farms.

Nitrogen use efficiency and N loss from manure

The amount of N excreted in manure (Nex), recycled through crops and pastures, and lost to the environment are highly influenced by the conservation of urinary urea N from the time of excretion through manure collection, storage and land application. After excretion, the N contained in dairy feces is relatively stable. Urinary urea N can transform rapidly however to ammonium (NH_4) and lost as NH_3 during manure collection, storage and land application. Ammonium can nitrify and denitrify forming NO_3^- and N_2O (the most potent greenhouse gas emitted from agricultural systems) with further losses and emissions after manure application to soil. On confinement dairy farms, NH_3 losses range from 20% to 55% of Nex. Losses of N as NO_3^- and N_2O are more difficult to ascribe solely to manure because manure N is often combined with other N sources in soil, especially fertilizer N. Of the total manure N that is land-applied, estimates of NO_3^- loss typically range from 1% to 25% and N_2O from 1% to 4% of the N applied. High leaching of NO_3^- through soils contaminates groundwater, and emissions of N_2O potentially contribute to global warming.

Tradeoffs in N use and environmental N loss

There is increasing evidence and concern that excessive N use in agriculture contributes to water and air quality impairment at local, regional and global scales. Fertilize and manure management highly influence environmental N loss. In the Corn Belt, fertilizer N has been linked to groundwater contamination in wells, and being within the Mississippi Basin, it contributes to hypoxia (dead zone due to nutrient contamination) in the Gulf of Mexico. Nevertheless, recommendations on fertilizer N use continue to be made based almost solely on economic returns to the producer. In the Midwest for example, fertilizer N recommendations for corn are made using the "economic optimum nitrogen rate,

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(EONR)", which is selected from a range of fertilizer N:grain price ratios. Applying this approach to corn grown on a loamy, medium yield potential soil in Wisconsin, fertilizer N recommendations vary from 118 to 162 kg N ha^{-1} for fertilizer N:grain price ratios ranging from 0.20 to 0.05, respectively. Studies have shown however that as one moves from the low end of the EONR range (e.g., fertilizer N:grain price ratio of 0.20) to the high end of the EONR range (fertilizer N:grain price ratio range of 0.05) NUE (the percent applied N taken up by corn) declines and N loss as NO_3^- increases. There seems to be great uncertainty on how best to strike a balance between fertilizer N recommendations, profitable corn production, NUE and environmental N loss.

The dynamic nature of N transformations in agricultural systems necessitates a broad understanding of possible tradeoffs between N use, N incorporation into products, N conservation and N loss. In dairy production systems, tradeoffs can occur between feed N use, manure N excretion, crop N use and environmental impacts. The control and conservation of one N form (e.g., NH_3, NO_3^-, N_2O) may result in greater loss of other N forms. There is a need therefore to recognize that N loss management should be a component of sustainable N use in agricultural production. A systems approach to N management is required to maximize NUE, minimize N loss, and control N loss towards pathways that have least detrimental impacts on the environment.

References

Beegle, D. B., K.A. Kelling, and M.A. Schmitt. 2008. Nitrogen from animal manures. p. 823-881. In Nitrogen in agricultural soils. Agronomy Monogr. no. 49. American Society of Agronomy, Madison, WI.

Broderick, G.A. 2003. Effects of varying dietary protein and energy levels on the production of lactating dairy cows. J. Dairy Sci. 86:1370-1381.

Cassman, K. G., A. Dobermann, and D. Walters. 2002. Agroecosystems, nitrogen use efficiency, and nitrogen management. Ambio 31:132–140.

Chase, L.E. 2003. Nitrogen utilization in dairy cows – what are the limits of efficiency? p. 233-244. In Proc. Cornell Nutr. Conf., Syracuse, NY.

Dobermann, A. 2007. Nutrient use efficiency-measurement and management. p. 1-28. In Fertilizer Best Management Practices. IFA International Workshop on Fertilizer Best Management Practices. 7-9 March, 2007. Brussels, Belgium.

Galloway, J.N., J.D. Aber, J.W. Erisman, S.P. Seitzinger, R.W. Howarth, E.B. Cowling, and B.J. Cosby. 2003. The nitrogen cascade. BioSci. 53(4):341-356.

Gourley C.J.P., S.A. Aarons, and J.M. Powell. 2012. Nitrogen use efficiency and manure management in contrasting dairy production systems. Agric., Ecosys. Environ. 147:73–81.

Mitchell, P.D. 2004. Nutrient best management practice insurance and farmer perception of adoption risk. J. Agric. Appl. Econ. 36 (3):657-673

Oenema, O., H.P. Witzke, Z. Klimont, J.P. Lesschen, and G.L. Velthof. 2009. Integrated assessment of promising measures to decrease nitrogen losses from agriculture in EU-27. Agric. Ecosyst. Environ. 133:280-288.

Powell, J.M., Jackson-Smith, D.B., McCrory, D., Saam, H. and Mariola. M. 2007. Nutrient management behavior on Wisconsin dairy farms. Agron. J. 99:211-219.

Powell, J.M., Gourley, C.J.P., Rotz, C.A., Weaver, D.M., 2010. Nitrogen use efficiency: A potential performance indicator and policy tool for dairy farms. Environ. Sci. & Policy. 13:217-228.

Ribaudo, M., J. Delgado, L. Hansen, M. Liningston, R. Mosheim and J. Williamson. 2011. Nitrogen in Agricultural Systems: Implications for Conservation Policy. Economic Research Report No. (ERR-127) 89 pp, September 2011

Rotz, C.A. 2004. Management to reduce nitrogen losses in animal production. J. Anim. Sci. 82(E. Suppl.):E119–E137

Rotz, C.A., J. Oenema, and H. van Keulen. 2006. Whole farm management to reduce nitrogen losses from dairy farms: a simulation study. Applied Eng. Agric. 22(5):773-784.

Sutton M.A., A. Bleeker, C.M. Howard, M. Bekunda, B. Grizzetti, W. de Vries, H.J.M van Grinsven, Y.P. Abrol, T.K. Adhya, G. Billen, E.A. Davidson, A. Datta, R. Diaz, J.W. Erisman, X.J. Liu, O. Oenema, C. Palm, N. Raghuram, S. Reis, R.W. Scholz, T. Sims, H. Westhoek, and Zhang F.S. 2013. Our Nutrient World: The challenge to produce more food and energy with less pollution. Global Overview of Nutrient Management. Centre for Ecology and Hydrology, Edinburgh on behalf of the Global Partnership on Nutrient Management and the International Nitrogen Initiative. Accessed July 11, 2014. www.gpa.unep.org/gpnm.html.

Wisconsin NPM. 2012. University of Wisconsin Nitrogen Guidelines for Corn. University of Wisconsin Nutrient and Pest Management Program. Accessed July 11, 2014. http://ipcm.wisc.edu/downloads/nutrient-managment/

FERTLIZER MARKET UPDATE

Yao Yao [1/]

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[1/] Potash Corporation.

UNDERSTANDING THE SCIENCE OF MANAGING SPATIAL VARIABILITY

Raj Khosla
Professor of Precision Agriculture
Colorado State University

Spatial variation in soil properties exists within fields, farms and across landscapes. Although spatial variation in agricultural fields has received considerable attention recently, its importance and impact on crop management has been discussed for over a century. Many approaches have been proposed over the last two decades for quantifying and managing spatial variation in crop production fields to implement site-specific crop management. However, most or all of these approaches utilize complex geo-statistical techniques which often prove to be challenging for practicing crop advisors to implement such techniques in field conditions. This is primarily because of lack of understanding and accessibility to “simple to understand” educational materials on such complex techniques and topics. This presentation will simplify the concept of spatial variability and how to understand the science of managing spatial variability in an easy to comprehend educational material.

CAN WE USE SPECTRAL IMAGING TO DETECT PRODUCTION ISSUES

Philip A. Townsend [1/]

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INTEGRATING UAV'S INTO YOUR CROP MANAGEMENT SYSTEM

Brian Luck [1/]

Abstract

Unmanned aerial vehicles (UAV's) have recently been a hot topic of discussion. Several industries, including agriculture, have expressed interest in implementing these devices to aid in performing various tasks. Implementation of UAV's in our current infrastructure poses several potential problems which are currently being addressed by Federal Aviation Administration (FAA) regulators. Integration of UAV's in agriculture production will have a major impact on how information about a crop is gathered throughout the growing season. Visual crop assessment and vegetative index data currently provide indicators to the state of the crop. This data is usually collected manually or via sensors mounted on a machine based tool bar. Several benefits can be gained by gathering this data with an aerial platform. This presentation will cover the FAA's progress on regulating the use of UAV's in the United States, the different types of UAV's currently available with pro's and con's of each, and the data collection capabilities of the UAV's and how the data can help crop management.

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THE REALITIES OF PRECISION FARMING FOR CORN A CASE STUDY ON THE CORN RESPONSE TO SEEDING RATE: THE IMPLICATIONS FOR VARIABLE RATE SEEDING

Joe Lauer and Hayley Bunselmeyer [1]

More site-specific management has been adopted by farmers to increase field productivity and profitability, although successful prediction of input response within management zones remains challenging. For some inputs, like plant density, the maximum yield plant density (MYPD) and the economic optimum plant density (EOPD) changes as new genetics become available. The objective of this research is to determine whether an MYPD and EOPD could be determined for one soil type given that genetics constantly change.

The experiments were conducted from 1987 to 2013 on a Plano silt loam (fine-silty, mixed, mesic, Typic Argiudolls) near Arlington, Wisconsin. Since 1987, the MYPD has been increasing at the rate of 500 plants A^{-1} $year^{-1}$. However, on 40% of the site*years no significant relationship between plant density and grain yield was found, while in 56% of the site*years a positive relationship occurred, and in 3% of the site*years a negative relationship was detected.

When significant relationships were observed, the MYPD for the Plano silt loam soil series varied by site*year and ranged from 30 800 to 38 800 plants A^{-1}. The EOPD was lower than the MYPD and also varied by year and site ranging from 26 500 to 34 800 plants A^{-1}.

A variable rate seeding experiment was established at Arlington on three fields during 2013. Management zones were identified using 2 to 12 years of previous yield history. Subfields were characterized as high or low yielding and high or low standard deviation. Three management zones were identified with 25% of the subfields as low yield/low standard deviation (L/L), 25% of the subfields as high yield/low standard deviation (H/L) and 50% of the subfields as high or low yield/high standard deviation (HL/H).

For both MYPD and EOPD, temporal variability is greater than spatial variability. There is an overall response to plant density, but not by management zone. An MYPD was found in 22% of the subfields and 25% of the management zones. An EOPD was found in 41% of the subfields and 0% of the management zones. An algorithm using edaphic (i.e., organic matter, P, K, pH, and elevation) measurements did not find any relationship between grain yield and MYPD or EOPD.

Since MYPD and EOPD varied widely between sites and years for a Plano silt loam it would be difficult to predict site-specific seeding rate prescriptions within a management zone. Site-specific management of seeding rate was not more profitable than whole field management for grain yield classified management zones.

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CAN SOYBEAN GROWERS BENEFIT FROM PRECISION AG DATA?

Ethan R. Smidt and Shawn P. Conley[1/]

Growers are collecting many forms of spatial data for their fields including yield, elevation, and soils data. Highly accurate GPS systems along with advances in variable rate technology (VRT) are allowing growers to create and use variable rate planting prescriptions to optimize yields and seed placement. Finding the key measureable parameters determining soybean seed yield in Wisconsin and using them to create VRT prescriptions are the objectives of this research.

Materials and Methods

This study was conducted on 11 fields scattered across Wisconsin in 2013 and 11 different fields were used in 2014, as shown in Figure 1. Prior to planting, a prescription for each field was created by defining zones roughly perpendicular to the majority of the soil types as shown in Figure 2. Seeding rates were confirmed using the as-planted data collected from the planter as well as multiple plant population counts in each zone. Soil samples were also taken at these georeferenced points.

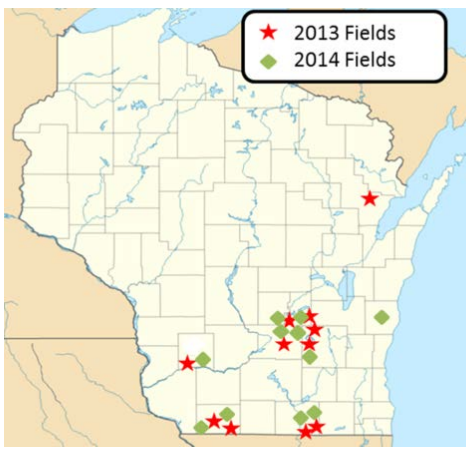

Figure 1: Map of field locations.

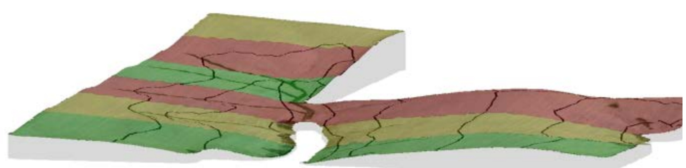

Figure 2: Example of seeding rate by soil type map.

Each field was harvested with combines equipped with GPS receivers and calibrated yield monitors to collect the final seed yield data. This yield data was "cleaned" to discard outliers and incorrect data points as outlined by Wiebold et al. (2003). Inverse distance weighting was used for data interpolation. Elevation data was obtained from differential GPS receivers during planting and harvest. The data were analyzed using the random forest process, then the optimal number of important variables were determined by cross-validation. A decision tree model was then created from those most important parameters to facilitate soybean yield predictions.

Results and Discussion

The random forest process indicated that soil type was the primary variable in determining yield across the 2013 pooled data set. Cross-validation showed the next 5 variables were also important and useful in dividing the data and those were soil phosphorus (ppm), soil organic matter (%), soil water storage capacity from 0-39 inches (in), elevation (ft), and soil pH. Within a given soil type the remaining explanatory variables were used to create a soil type independent decision tree diagram as seen in Figure 3.

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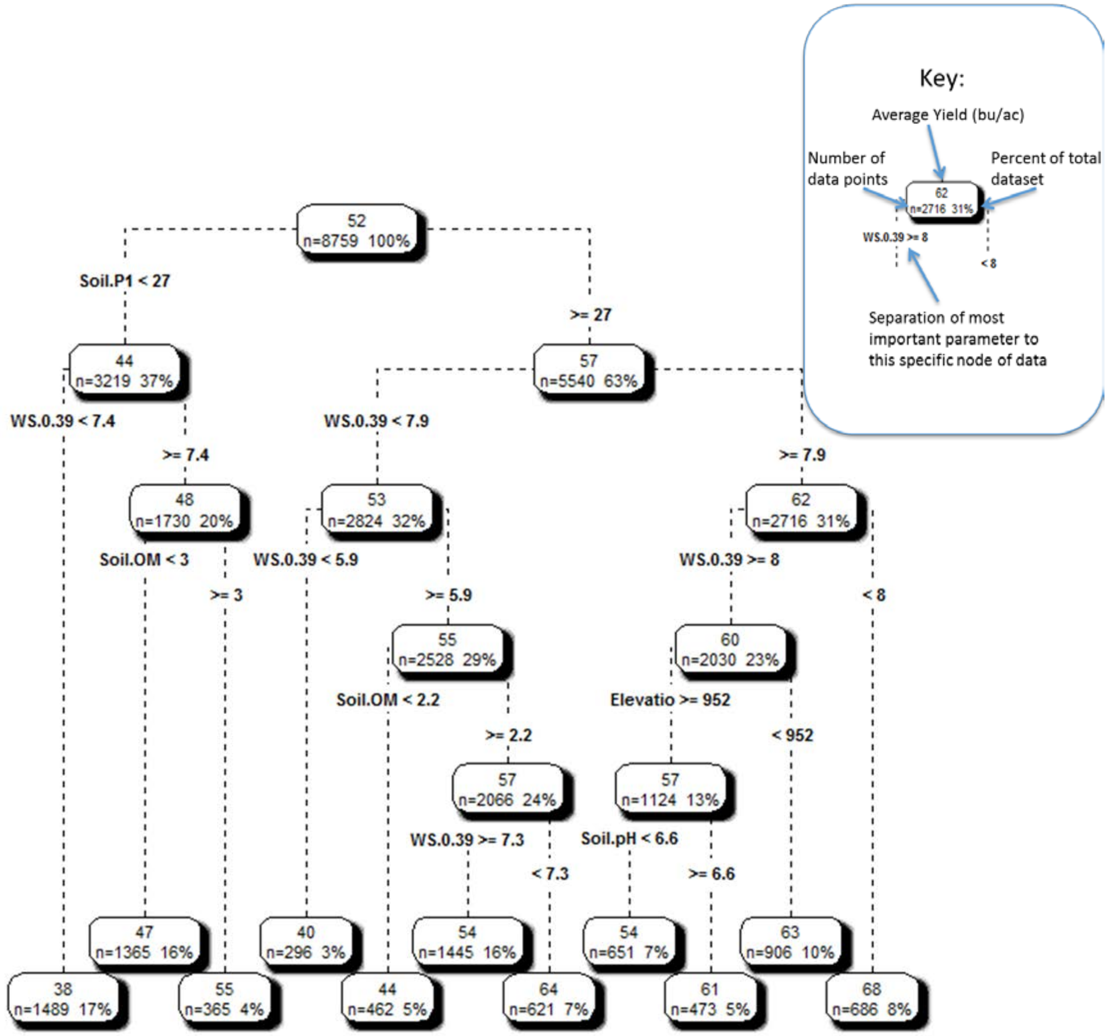

Figure 3: Soil type independent decision tree.

Both the random forest and decision tree models found soil type as the leading factor determining soybean yield in 2013. Maximum predicted yields are attained in soil types Brr, Brp, Bls, Joy, LRy, Mrk, Mnd, Mrm, Pln, Stn, and Tdd and have soil potassium levels >= 155 ppm. Soil type independent maximum yields are attained when soil phosphorus is >= 27 ppm and water storage capacity in the top 39 inches = 8in. Seeding rate was not found to be an important factor in determining 2013 soybean yield in Wisconsin. The 2014 data are currently being analyzed.

Acknowledgments: The authors would like to thank DuPont Pioneer for providing the graduate assistantship for this research project.

References

Wiebold, W., H. Palm, K. Sudduth, N. Kitchen, B. Batchelor, K. Thelen, D. Clay, D. Bullock, G. Bollero, and R. Schuler. 2003. The basics of cleaning yield monitor data. Produced as part of a project jointly funded by the North Central Soybean Research Program and the United Soybean Board, posted 2003. Cited at: http://www.planthealth.info/pdf_docs/yield_data_guide.pdf.

UH OH…44 OZ OF GLYPHOSATE DIDN'T TOUCH IT…WHAT DO I DO NOW?

Bryan G. Young[1/]

A common progression for farmers in the Roundup Ready crop system has been to gradually increase the rate of glyphosate as inconsistent weed control is observed. Thus, previous failed applications of glyphosate are followed with higher rates of glyphosate in subsequent applications. There are multiple concerns with this approach. First, the use of a single herbicide until failure allows weeds to continue growing with the crop which can reduce crop yields. Even if a successful rescue treatment controls all the surviving weeds the span of time for the failed glyphosate application to the rescue treatment is significant enough to reduce crop yields. Second, the use of glyphosate in this manner has been implicated in the evolution of glyphosate-resistant weed biotypes throughout the U.S., which ultimately results in the loss of the most effective herbicide available for control of our primary weed species.

When faced with a failed glyphosate application a farmer can adopt both a short-term and a long-term strategy with best management practices in mind. The long-term strategy would involve plans for future years with the integration of other herbicides and practices into the overall weed management program. Glyphosate can still be a component for weed management, however, glyphosate should no longer be the primary foundation for managing the most problematic weed species.

The short-term strategy would involve a decision process on what action can be taken in regards to the existing weeds that survived the maximum rate of glyphosate. Any weeds that were historically controlled, but over time survive a postemergence herbicide application, should be viewed as potential seed producers that may carry an herbicide-resistance trait for future weed generations. Thus, all efforts should be made to prevent those weeds from producing viable seed which contribute to the soil seedbank. If the calendar date, crop growth stage, and weed size are favorable, a subsequent rescue treatment can be applied with another herbicide, if available. If a follow-up herbicide application is not deemed possible, then hand-weeding should be another consideration. Finally, a late-season harvest aid application can be considered to potentially reduce the amount of viable seed being produced on the surviving weeds. If the surviving weeds are in patches across the field a farmer may consider not harvesting those areas for fear of spreading the weed seed further with the combine. These areas should also be mapped for monitoring purposes in future years.

In summary, failing to control weeds with a high dose of glyphosate without a backup plan is poor risk management. Nothing positive can come from this situation and, thus, should be avoided by implementing a more diverse weed management strategy prior to glyphosate failure. In other words, a proactive management strategy would be favored instead of allowing the weeds to dictate your fate.

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RESEARCH PROGRESS ON UNDERSTANDING HERBICIDE RESISTANCE IN WISCONSIN GIANT RAGWEED

Dave Stoltenberg, Stacey Marion, Courtney Glettner, and Vince Davis [1/]

Introduction

Giant ragweed is one of the most difficult to manage weed species in Midwestern cropping systems due to its biology and competitive ability. Adaptation to a wide range of soil environments, rapid vertical growth, and high biomass production make giant ragweed particularly competitive (Abul-Fatih et al. 1979; Harrison et al. 2007; Webster et al. 1994). An extended germination period characterized by the ability to germinate early and grow rapidly, combined with embryo dormancy that allows for prolonged emergence periods, contributes to the difficulty of managing giant ragweed (Gramig and Stoltenberg 2007; Harrison et al. 2001; Schutte et al. 2012). In Wisconsin, giant ragweed is found in both corn (Fickett et al. 2013a) and soybean (Fickett et al. 2013b) production fields. As the most competitive species relative to other common weed species in corn and soybean cropping systems (Fickett et al. 2013a,b), giant ragweed represents a serious threat to crop yield potential.

Herbicide resistance contributes further to the difficulty of giant ragweed management (Brabham et al. 2011; Norsworthy et al 2010, 2011; Vink et al. 2012; Westhoven et al. 2008). Glyphosate resistance in giant ragweed was first confirmed in Ohio in 2004 and has since been found in several other states (Heap 2014) including Wisconsin (Glettner 2013; Stoltenberg et al. 2012). Acetolactate synthase (ALS) inhibitor resistance in giant ragweed has also been found in several Midwestern states (Heap 2014), including recent confirmation in Wisconsin (Marion et al. 2013, 2014). In two instances (Minnesota and Ohio), giant ragweed has demonstrated multiple resistance to glyphosate and ALS inhibitors. Resistance to glyphosate, ALS inhibitors, or both of these herbicide modes of action, severely constrains herbicide options available to growers for effective management of giant ragweed and proactive resistance management.

Glyphosate inhibits the chloroplast enzyme *5*-enolpyruvylshikimate-*3*-phosphate synthase (EPSPS), a key enzyme in the shikimate pathway (Shaner 2014). Inhibition of EPSPS disrupts the production of the aromatic amino acids tyrosine, phenylalanine, and tryptophan, ultimately causing plant death. Glyphosate resistance in weeds has been attributed to one or more of three mechanisms: 1) an altered EPSPS target site, 2) changes in vacuolar sequestration and/or reduced translocation of glyphosate to meristematic tissues where the EPSPS gene is primarily expressed, and 3) amplification of the EPSPS gene resulting in increased EPSPS gene expression (Sammons and Gaines 2014; Shaner et al. 2012).

Acetolactate synthase catalyzes the first common step in the biosynthesis of the branched chain amino acids leucine, isoleucine, and valine and is the primary target enzyme for five structurally distinct chemical classes of herbicides, including the sulfonylurea herbicides such as cloransulam-methyl (Shaner et al 2014). In most cases, resistance to ALS inhibitors has been attributed to reduced sensitivity of the ALS enzyme (Tranel and Wright 2002; Tranel et al 2014).

Our research objectives are to better understand herbicide resistance in Wisconsin giant ragweed and the potential of resistance to persist and spread. Research progress on glyphosate resistance in giant ragweed from Rock County and cloransulam-methyl resistance in giant ragweed from Columbia County is reported below.

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Glyphosate Resistance in Rock County Giant Ragweed

Background

In 2010, we identified a giant ragweed population that was suspected of surviving repeated exposure to glyphosate on a farm located in Rock County (Glettner 2013; Stoltenberg et al. 2012). Seeds collected from suspected glyphosate-resistant (R) and -sensitive (S) plants located on this farm were used for subsequent experiments to 1) quantify the whole-plant dose-response of R and S plants to glyphosate, 2) determine the role of glyphosate absorption and translocation in the plant, and the sensitivity of the glyphosate target site (EPSPS) in conferring resistance, and 3) determine if glyphosate resistance has affected the growth, development, and seed production of R plants relative to S giant ragweed plants.

Confirmation of Glyphosate Resistance

Whole-plant dose-response of Rock County R and S giant ragweed plants to glyphosate was determined in repeated greenhouse experiments using eight replications of doses that ranged from 0 to 16.8 kg ae ha^{-1} and included 20 g L^{-1} ammonium sulfate (AMS). Shoot mass was harvested, dried, and weighted 28 days after treatment. The glyphosate ED_{50} value (the effective dose that reduced dry shoot mass 50% relative to non-treated plants) was 6.5-fold greater for R plants (0.86 ± 0.24 kg ae ha^{-1}) than for S plants (0.13 ± 0.02 kg ae ha^{-1}) (Figures 1 and 2).

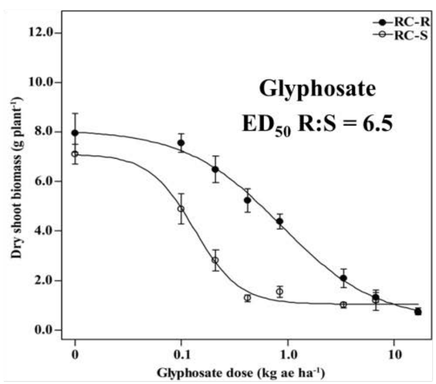

Figure 1. Dry shoot biomass for resistant (R) and sensitive (S) giant ragweed plants from Rock County (RC) 28 days after treatment with glyphosate. Vertical bars represent standard error of the mean. Data were pooled from repeat experiments for analysis.

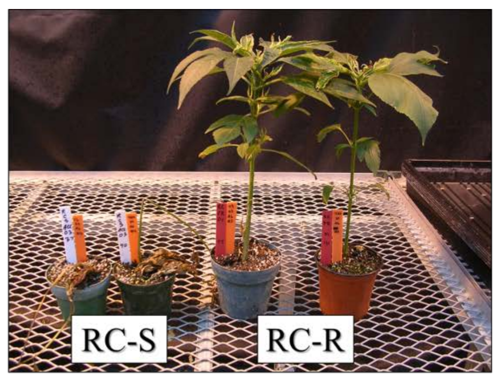

Figure 2. Glyphosate-resistant (R) and sensitive (S) Rock County (RC) giant ragweed plants 28 day after treatment with 3.36 kg ae ha^{-1} glyphosate (3.0 lb ae $acre^{-1}$) under greenhouse conditions.

Glyphosate Absorption and Translocation

Glyphosate absorption into plants and translocation to meristematic tissues were estimated by treating 5- to 6-node plants with 0.84 kg ha^{-1} glyphosate plus 2.8 kg ha^{-1} AMS (the third oldest leaf was covered) and subsequently applying ^{14}C-labeled glyphosate to the third oldest leaf. Plants were harvested 0, 6, 24, 48, and 72 hours after treatment (HAT) and sectioned into the treated leaf, tissue above the treated leaf (excluding the shoot apical meristem), the shoot apical meristem (the uppermost 1 cm of shoot including emerging leaves), aboveground tissue below treated leaf, and roots. Treatments were replicated four times and two experiments were conducted. ^{14}C was quantified using liquid scintillation spectroscopy. We found that glyphosate absorption did not differ between R and S plants, with absorption reaching 57 and 59% of applied

^{14}C 72 HAT for R and S plants, respectively (data not shown). Translocation of ^{14}C-glyphosate did not differ between R and S plants for any plant part (data not shown).

Glyphosate Target Site Sensitivity

Glyphosate target site (EPSPS enzyme) sensitivity was estimated by measuring in vivo shikimate accumulation in excised leaf discs exposed to a range of glyphosate concentrations. Shikimate was extracted from tissue and quantified spectrophotometrically. Each glyphosate concentration was replicated three times and experiments were repeated in time. Glyphosate EC_{50} values (the effective concentration that increased shikimate accumulation 50% relative to nontreated leaf tissue) were 4.6- to 5.4-fold greater for R plants than S plants (Figure 3). However, at high glyphosate concentrations (>1,000 µM), shikimate accumulation in R plants was similar to or greater than S plants.

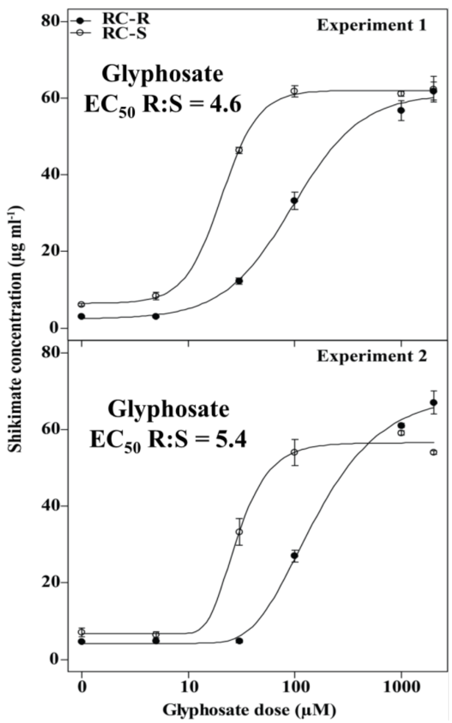

Figure 3. Shikimate concentration in leaf tissue of glyphosate-resistant (R) and -sensitive (S) giant ragweed plants from Rock County (RC) at glyphosate doses ranging from 0 to 2,000 µM after 24 hour incubation under continuous light. Vertical bars indicate standard error of the mean.

To further investigate target site sensitivity to glyphosate, we performed partial sequence analysis of the EPSPS gene extracted from apical meristematic tissue of 4- to 5-node plants. Three replicates from each accession were sequenced. Sequence results showed no missense mutations in the Pro_{106} codon in R plants that would confer resistance to glyphosate (data not shown).

Growth and Seed Production of Glyphosate-Resistant Plants

In greenhouse experiments, plant height, leaf area, and dry shoot biomass were similar between the R and S plants during vegetative growth to the onset of flowering (data not shown). However, seed production of R plants was greater than S plants (Table 1). The percentage of intact-viable seeds, intact-nonviable seeds, and empty involucres did not differ between R and S plants.

Table 1. Seed production of glyphosate-resistant and -sensitive giant ragweed from Rock County under noncompetitive conditions in the greenhouse. Data from repeated experiments were pooled for analysis.

		Seed fate category[†]		
Plant type	Seed yield	Intact-viable	Intact-nonviable	Empty involucre
	seeds/plant	——— % of seeds produced ———		
Glyphosate-resistant	812 a[‡]	75 a	13 a	12 a
Glyphosate-sensitive	425 b	65 a	14 a	21 a

[†] Intact-viable and intact nonviable: involucres contain fully formed seeds with viability of embryo determined by tetrazolium assay; empty involucre: no seed or not fully formed seed.

[‡] Means followed by the same letter within a column do not differ at the 5% level of significance as determined by a Student's t-test.

Summary: Glyphosate Resistance in Rock County Giant Ragweed

- Whole-plant dose-response experiments showed that the Rock County giant ragweed was 6.5-fold resistant (R) to glyphosate compared to sensitive (S) plants based on ED_{50} values (Figures 1 and 2). Both accessions were sensitive to cloransulam-methyl (data not shown).
- The ^{14}C-glyphosate results showed that glyphosate resistance in Rock County giant ragweed is not conferred by reduced glyphosate absorption into the plant or translocation to meristematic tissues (data not shown).
- The similar or greater shikimate accumulation in leaf discs from R plants than S plants at high glyphosate concentrations (Figure 3) and the lack of missense mutations in the Pro_{106} codon of R plants (data not shown) suggest that resistance is not likely due to an altered EPSPS target site. However, the possibility remains that the EPSPS target site is less sensitive in R plants compared to S plants at lower glyphosate concentrations. Current research is investigating other possible mechanisms that may confer resistance.
- Glyphosate resistance has not negatively affected the growth and development of R plants relative to S plants in Rock County giant ragweed. The greater seed production and similar viability of R plants relative to S plants suggests that in the absence of selection by glyphosate, the frequency of the resistance trait for glyphosate may increase in the giant ragweed field population over time.

Cloransulam-methyl Resistance in Columbia County Giant Ragweed

Background

A giant ragweed population with suspected resistance to acetolactate synthase (ALS) inhibitors was identified in a long-term corn-soybean rotation that included cloransulam-methyl (FirstRate herbicide) use in soybean for broadleaf weed management (Marion et al. 2013, 2014). After four rotation cycles (8 years total), field observations suggested that several giant ragweed plants had survived repeated exposure to cloransulam-methyl. Our objectives were to 1) confirm and quantify the whole-plant response of suspected resistant (R) and sensitive (S) plants to cloransulam-methyl, 2) if confirmed, quantify the sensitivity of the target site enzyme (acetolactate synthase, ALS) to cloransulam-methyl, and 3) determine if resistance has affected the relative competitive ability of R and S plants.

Confirmation of Cloransulam-methyl Resistance

The cloransulam-methyl ED_{50} value (the effective dose of herbicide that reduced shoot mass 50% relative to non-treated plants) for R plants was 30 times that of S plants (Figure 4). A high level of variability among R plants in response to treatment with cloransulam-methyl was attributed to incomplete segregation of the resistance trait within the sampled population. Resistant plants treated with cloransulam-methyl at up to 10 times the labeled rate showed little or no injury symptomology compared to non-treated control plants (Figure 5).

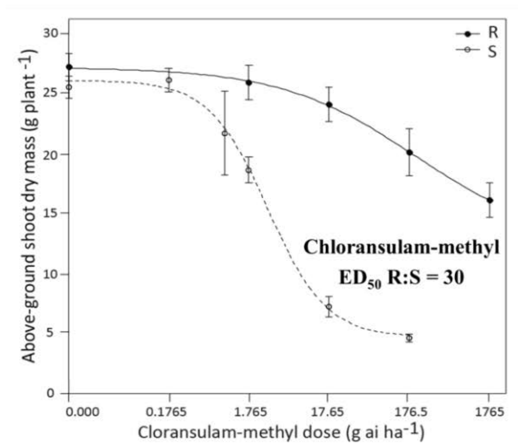

Figure 4. Shoot dry mass for resistant (R) and sensitive giant ragweed from Columbia County 28 days after treatment with cloransulam-methyl (FirstRate). Vertical bars represent standard error of the mean. Data were pooled from four experiments for analysis.

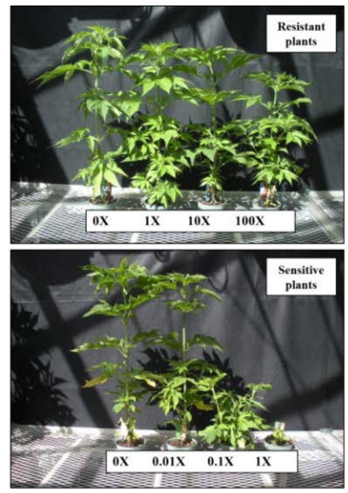

Figure 5. Columbia County giant ragweed plants 28 days after treatment with cloransulam-methyl under greenhouse conditions. The labeled rate of cloransulam-methyl (17.6 g ai ha^{-1} or 3.0 oz product $acre^{-1}$) is designated by 1X. Non-treated plants are designated by 0X.

Cloransulam-methyl Target Site Sensitivity

Cloransulam-methyl EC_{50} values [the effective concentration of herbicide that inhibited target enzyme (ALS) activity 50% relative to non-treated plants] were 10.6- to 13.6-fold greater for R than S plants across experiments (Figure 6). Differential ALS inhibition in response to cloransulam-methyl treatment suggests a less sensitive target site in R compared to S plants.

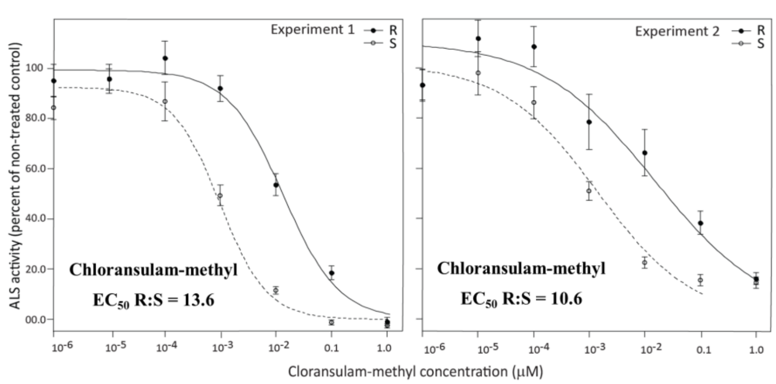

Figure 6. Acetolactate synthase (ALS) enzyme activity (expressed as a percent of control) in response to cloransulam-methyl concentration in R and S giant ragweed plants from Columbia County, Wisconsin.

Competitive Ability of Cloransulam-methyl Resistant Plants

Experiments conducted under competitive conditions in the greenhouse showed that average dry shoot biomass accumulation was less for cloransulam-methyl R (120 ± 5 g plant^{-1}) than S (168 ± 7 g plant^{-1}) plants. However, shoot height over time did not differ between R and S plants (data not shown), nor did total seed mass, total seed number, and seed viability (Table 2).

Table 2. Seed production of cloransulam-methyl-resistant and -sensitive giant ragweed from Columbia County under competitive conditions in the greenhouse. Data from repeated experiments were pooled for analysis.

Plant type	Seed yield		Seed fate category[†]		
			Intact-viable	Intact-nonviable	Empty involucre
	g/plant	seeds/plant	— % of seeds produced —		
Cloransulam-resistant	20 a[‡]	430 a	75 a	17 a	9 a
Cloransulam-sensitive	20 a	451 b	74 a	17 a	9 a

[†] Intact-viable and intact-nonviable: involucres contain fully formed seeds with viability of embryo determined by tetrazolium assay; empty involucre: no seed or not fully formed seed.
[‡] Means followed by the same letter within a column do not differ at the 5% level of significance as determined by a Welch's t-test.

Summary: Cloransulam-methyl Resistance in Columbia County Giant Ragweed

- Whole-plant experiments confirmed a high level of cloransulam-methyl resistance in giant ragweed from Columbia County Wisconsin (Figures 4 and 5).
- In vivo ALS enzyme bioassays suggested that the mechanism of cloransulam-methyl resistance in Columbia County giant ragweed is an altered ALS enzyme (Figure 6). Current research is conducting ALS gene amplification and sequencing to identify point mutations that may confer resistance.
- Despite a difference in shoot biomass produced between Columbian County R and S giant ragweed plants, the lack of difference in seed production and seed viability (Table 2) suggests that the frequency of the resistance trait is likely to persist over time in the field population.

Acknowledgments

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References

Abul-Fatih HA, Bazzaz FA, Hunt R (1979) The biology of *Ambrosia Trifida* L. III. Growth and biomass allocation. New Phytol 83:829-838

Brabham CB, Gerber CK, Johnson WG (2011) Fate of glyphosate-resistant giant ragweed (*Ambrosia trifida*) in the presence and absence of glyphosate. Weed Sci 59:506-511

Fickett ND, Boerboom CM, Stoltenberg DE (2013a) Predicted corn yield loss due to weed competition prior to postemergence herbicide application on Wisconsin farms. Weed Technol 27:54-62

Fickett ND, Boerboom CM, Stoltenberg DE (2013b) Soybean yield loss potential associated with early-season weed competition across 64 site-years. Weed Sci 61:500-507

Glettner CE (2013) Physiology, growth, and fecundity of glyphosate-resistant giant ragweed (*Ambrosia trifida* L.) in Wisconsin. M.S. Thesis. Madison, WI: University of Wisconsin-Madison 100 p

Gramig GG, Stoltenberg DE (2007) Leaf appearance base temperature and phyllochron for common grass and broadleaf weed species. Weed Technol 21:249-254

Harrison SK, Regnier EE, Schmoll JT, Harrison JM (2007) Seed size and burial effects on giant ragweed (*Ambrosia trifida*) emergence and seed demise. Weed Sci 55:16-22

Harrison SK, Regnier EE, Schmoll JT, Webb JE (2001) Competition and fecundity of giant ragweed in corn. Weed Sci 49:224-229

Heap I (2014) International Survey of Herbicide Resistant Weeds. http://www.weedscience.org

Marion SM, Davis VM, Stoltenberg DE. 2014. Characterization of Wisconsin giant ragweed resistance to cloransulam-methyl. Proc North Central Weed Sci Soc 69:30

Marion S, Glettner C, Trower T, Davis V, Stoltenberg D (2013) Acetolactate synthase (ALS) inhibitor resistance in Wisconsin giant ragweed. Wisc Crop Manager 20:52-53

Norsworthy JK, Jha P, Steckel LE, Scott RC (2010) Confirmation and control of glyphosate-resistant giant ragweed (*Ambrosia trifida*) in Tennessee. Weed Technol 24:64-70

Norsworthy JK, Riar D, Jha P, Scott RC (2011) Confirmation, control, and physiology of glyphosate-resistant giant ragweed (*Ambrosia trifida*) in Arkansas. Weed Technol 25:430-435

Sammons RD, Gaines TA (2014) Glyphosate resistance: State of knowledge. Pest Manag Sci 70:1367-1377

Schutte BJ, Regnier EE, Harrison SK (2012) Seed dormancy and adaptive seedling emergence timing in giant ragweed (*Ambrosia trifida*). Weed Sci 60:19-26

Shaner DL, ed (2014) Herbicide Handbook. Lawrence, KS: Weed Sci Soc America 513 p

Shaner DL, Lindenmeyer RB, Ostlie MH (2012) What have the mechanisms of resistance to glyphosate taught us? Pest Manag Sci 68:3-9

Stoltenberg D, Yerka M, Glettner C, Stute J, Trower T. 2012. Giant ragweed resistance to glyphosate in Wisconsin. Wisc Crop Manager. 19:43-44

Tranel PJ, Wright TR (2002) Resistance of weeds to ALS-inhibiting herbicides: what have we learned? Weed Sci 50:700-712

Tranel PJ, Wright TR, Heap IM (2014) Mutations in herbicide-resistant weeds to ALS inhibitors. http://www.weedscience.com

Vink JP, Soltani N, Robinson DE, Tardif FJ, Lawton MB, Sikkema PH (2012) Glyphosate-resistant giant ragweed (*Ambrosia trifida* L.) in Ontario: Dose response and control with postemergence herbicides. Am J Plant Sci 3:608-617

Webster TM, Loux MM, Regnier EE, Harrison SK (1994) Giant ragweed (*Ambrosia trifida*) canopy architecture and interference studies in soybean (*Glycine max*). Weed Technol 8:559-564

Westhoven AM, Davis VM, Gibson KD, Weller SC, Johnson WG (2008) Field presence of glyphosate-resistant horseweed (*Conyza canadensis*), common lambsquarters (*Chenopodium album*), and giant ragweed (*Ambrosia trifida*) biotypes with elevated tolerance to glyphosate. Weed Technol 22:544-548

HERBICIDE-RESISTANT PIGWEEDS (*AMARANTHUS SPP*.) ARE IN WISCONSIN, HOW SERIOUS IS IT? [1/]

Thomas R. Butts and Vince M. Davis [2/]

Introduction

Pigweeds, specifically common waterhemp (*Amaranthus rudis Sauer*) and Palmer amaranth (*Amaranthus palmeri S. Wats.*), are an increasing threat to current agricultural production systems. Common waterhemp and Palmer amaranth are dioecious, small seeded, broadleaf weed species' known for their prolific growth characteristics and high competitive ability. Exceedingly plastic in nature, common waterhemp and Palmer amaranth can grow at rates of 0.16 and 0.21 cm per growing degree day, respectively (Horak and Loughin, 2000). Furthermore, both species can produce over 250,000 seeds per female plant (Sellers et al., 2003). This intensifies the likelihood and speed that herbicide-resistant biotypes can increase in a population and transfer from one location to another through seed dispersal. Moreover, common waterhemp and Palmer amaranth cause significant yield loss in corn (74 and 91%, respectively) and soybean (56 and 79%, respectively) when left unmanaged (Bensch et al., 2003; Massinga et al., 2001; Steckel and Sprague, 2004).

Control of common waterhemp and Palmer amaranth has become increasingly difficult due to their ability of evolving resistance to numerous herbicide sites-of-action. These two weed species have developed herbicide resistance to more than five different sites-of-action, with resistance to at least one site-of-action occurring in 32 states (Heap, 2014). Wisconsin currently has one confirmed ALS-resistant biotype of common waterhemp, but there are indications of further resistance problems throughout the state. In 2012, the *Late-Season Weed Escape Survey in Wisconsin Corn and Soybean Fields* was initiated. A main objective of this research was to identify herbicide-resistant weed species in Wisconsin and begin proactively educating growers about herbicide resistance management.

Materials and Methods

The survey identified fields containing potential herbicide-resistant weeds through grower communication, field history, and in-field sampling. Five, ten, and six separate common waterhemp populations were identified for herbicide resistance screening in 2012, 2013, and 2014, respectively. Moreover, these surveys identified the first confirmed case of Palmer amaranth occurrence in Wisconsin (Dane County) in 2013 (Davis and Recker, 2014), and a second Palmer amaranth occurrence (Iowa County) was identified in 2014. To confirm herbicide resistance, seed heads from at least 30 mature plants were collected in situ, dried, and threshed for use in whole plant herbicide dose response bioassays. Twelve common waterhemp populations were screened for glyphosate resistance, one Palmer amaranth population was screened for glyphosate resistance, and one Palmer amaranth population was screened for both glyphosate resistance and tembotrione resistance. Progeny were grown; and seven to ten plants per herbicide

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[1/]Funding for this research provided by the Wisconsin Corn Promotion Board and United Soybean Board.
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rate plus the appropriate adjuvants were sprayed when they reached four inches tall. Glyphosate (Roundup PowerMAX®) rates used for common waterhemp populations were 0, 0.22 (5.5), 0.43 (11), 0.87 (22), 1.74 (44), 3.48 (88), and 6.96 (176) kg ae ha^{-1} (fl. oz. ac^{-1}). Glyphosate rates used for Palmer amaranth populations were 0, 0.0087 (0.22), 0.087 (2.2), 0.87 (22), and 8.7 (220) kg ae ha^{-1} (fl. oz. ac^{-1}). Tembotrione (Laudis®) rates used were 0, 0.023 (0.75), 0.046 (1.5), 0.092 (3), 0.184 (6), 0.368 (12), and 0.736 (24) kg ai ha^{-1} (fl. oz. ac^{-1}). Plant dry biomass data were collected 28 days after application and analyzed using the dose response model package in R statistical software. Comparisons between our putative resistant and susceptible biotypes were determined by the effective herbicide dose needed to reduce plant dry biomass 90% (ED_{90}) and 50% (ED_{50}) for common waterhemp and Palmer amaranth, respectively (Knezevic et al., 2007). Two separate screenings were conducted for the common waterhemp populations to confirm resistance, and one initial screening was conducted for the Palmer amaranth populations.

Results and Discussion

Two Wisconsin common waterhemp populations from Eau Claire and Pierce Counties were confirmed glyphosate-resistant. The Eau Claire County plants sprayed at the 0.87 kg ae ha^{-1} (22 fl. oz. ac^{-1}) rate all survived and grew to an average of six times their spray date height. At the 1.74 kg ae ha^{-1} (44 fl. oz. ac^{-1}) rate, 95% survived and grew to an average of five times their spray date height. The glyphosate ED_{90} for the Eau Claire County and susceptible populations was 3.91 and 0.40 kg ae ha^{-1}, respectively (Figure 1). This indicates the Eau Claire County population is nearly 10-fold glyphosate-resistant.

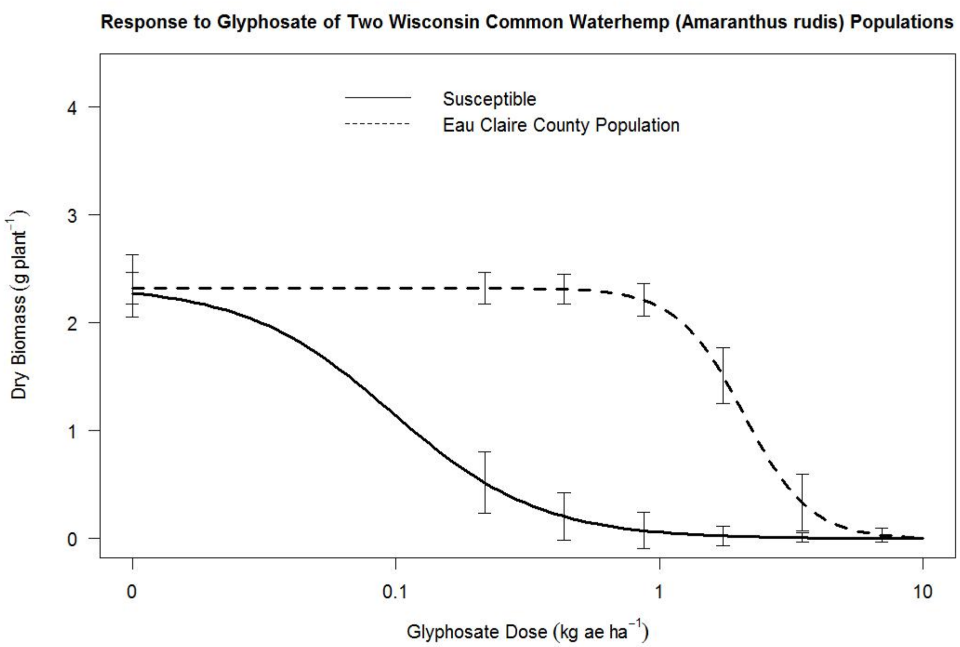

Figure 1. Glyphosate dose response models for two Wisconsin common waterhemp (*Amaranthus rudis*) populations. A three parameter log logistic function was used for analysis.

The Pierce County plants sprayed at the 0.87 kg ae ha^{-1} (22 fl. oz. ac^{-1}) rate all survived and grew to an average of six times their spray date height. At the 1.74 kg ae ha^{-1} (44 fl. oz. ac^{-1}) rate, 85% survived and grew to an average of four times their spray date height. The glyphosate ED_{90} for the Pierce County and susceptible populations was 5.15 and 0.40 kg ae ha^{-1}, respectively (Figure 2). This indicates the Pierce County population is nearly 13-fold glyphosate-resistant.

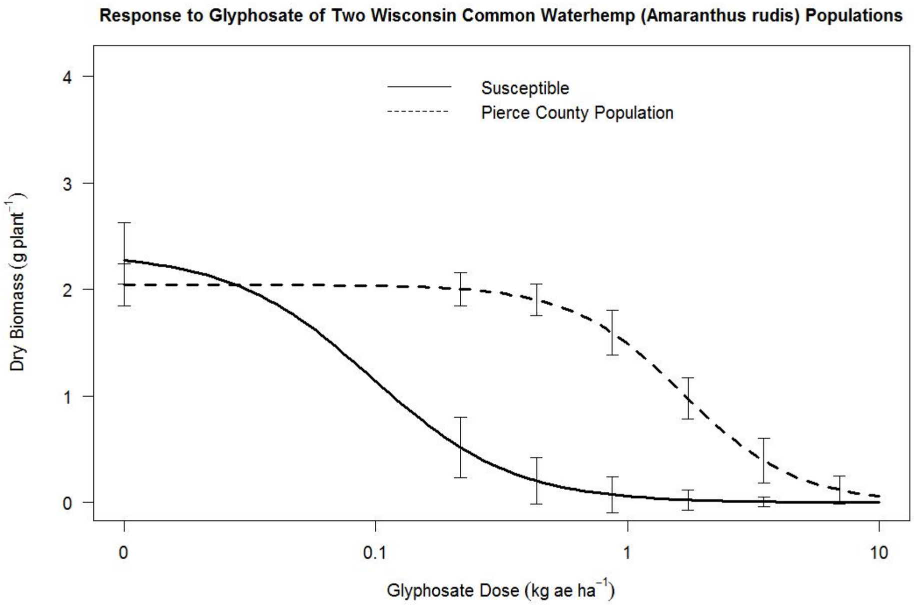

Figure 2. Glyphosate dose response models for two Wisconsin common waterhemp (*Amaranthus rudis*) populations. A three parameter log logistic function was used for analysis.

The Dane County Palmer amaranth population was confirmed glyphosate-resistant. Leaf tissue samples were sent to Dr. Patrick Tranel at the University of Illinois where a polymerase chain reaction (PCR) technique detected a 3- to 20-fold amplification of the EPSPS gene indicating high likelihood of glyphosate resistance. To confirm these results, the whole plant glyphosate dose response bioassay was conducted. Dane County plants sprayed at the 0.87 kg ae ha^{-1} (22 fl. oz. ac^{-1}) rate all survived and grew to an average of two times their spray date height. Due to high variance in biomass production of individual plants, dry plant biomass averages were used to compare putative resistant and susceptible ED_{50} estimates (Figure 3). This demonstrated nearly an 18-fold level of glyphosate resistance validating previous results from the PCR technique. Furthermore, ANOVA showed significant differences in plant dry biomass between the Dane County and susceptible populations at the 0.087 and 0.87 kg ae ha^{-1} rates (Table 1).

Table 1. Comparison of plant dry biomass 28 days after application between the Dane County and susceptible Palmer amaranth populations at each glyphosate rate.

	Glyphosate Rate (kg ae ha^{-1})				
	0	0.0087	0.087	0.87	8.7
Significance	NS	NS	**	**	NS

*Significant at the *P*=0.05 probability level.
**Significant at the *P*=0.01 probability level.
***Significant at the *P*=0.001 probability level.

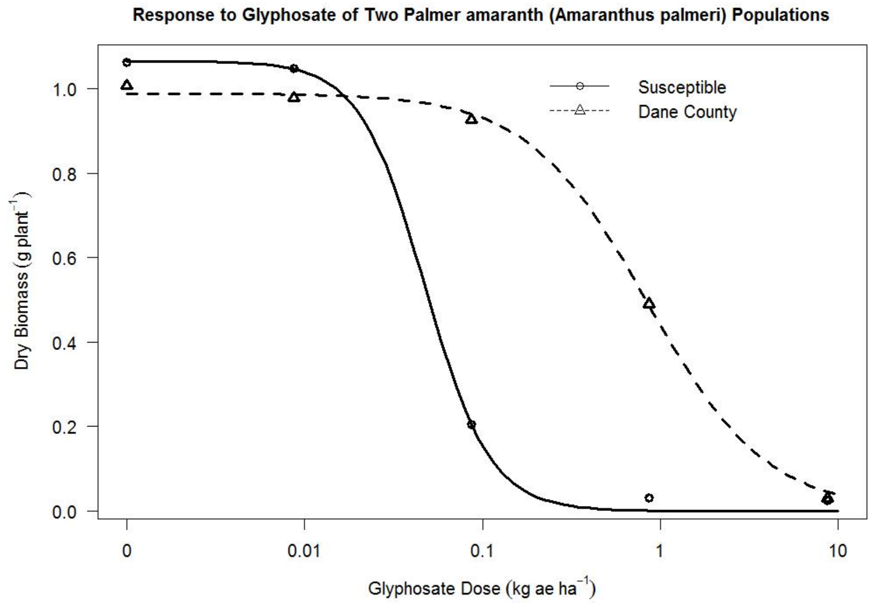

Figure 3. Glyphosate dose response models for two Palmer amaranth (*Amaranthus palmeri*) populations. A three parameter log logistic function was used for analysis.

Preliminary results indicate tembotrione controlled the Iowa County Palmer amaranth population less than the susceptible population. The Iowa County plants sprayed at the 0.046 kg ai ha^{-1} (1.5 fl. oz. ac^{-1}) rate had a 90% survival rate and grew to an average of two times their spray date height. At the 0.092 kg ai ha^{-1} (3 fl. oz. ac^{-1}) rate, 40% survived. The tembotrione ED_{50} for the Iowa County and susceptible populations was 0.034 and 0.023 kg ai ha^{-1}, respectively (Figure 4). This indicates the Iowa County population is nearly 1.5-fold more tolerant to tembotrione than the susceptible population.

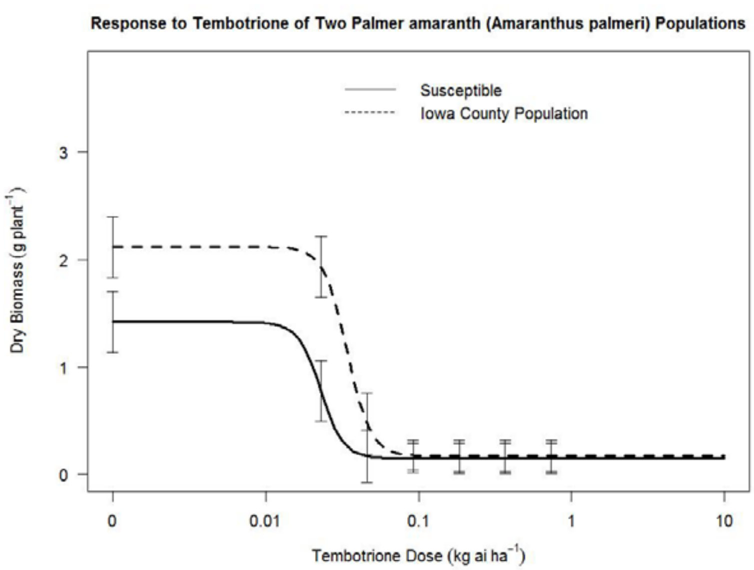

Figure 4. Tembotrione dose response models for two Palmer amaranth (*Amaranthus palmeri*) populations. A four parameter log logistic function was used for analysis.

Conclusions

Two Wisconsin common waterhemp populations from Eau Claire and Pierce Counties were confirmed glyphosate-resistant with 10- and 13-fold levels of resistance, respectively. The first confirmed case of Palmer amaranth occurrence in Wisconsin was discovered in Dane County in 2013 and was confirmed glyphosate-resistant. Preliminary results indicate a second Wisconsin Palmer amaranth population from Iowa County is not adequately controlled by tembotrione. Further screenings will be conducted on the Iowa County Palmer amaranth population to confirm tembotrione resistance.

There are several key components to an effective control strategy to combat herbicide-resistant weeds. The use of alternative herbicide sites-of-action and tank-mixing multiple herbicide sites-of-action will improve glyphosate-resistant weed control. An early planting date and the use of a preemergence residual herbicide will allow crops to gain a competitive advantage over weeds. Herbicide applications should be made at the correct timing when weeds are small and actively growing to ensure the greatest efficacy of the herbicide based on label recommendations. Furthermore, special care should be taken to clean tillage and harvest equipment thoroughly as they can quickly spread weed seed among fields. The focus of these best management practices is to diversify weed control measures, reduce weed seed additions to the soil seedbank, and utilize control measures in the most effective method possible.

For updates on Wisconsin weeds please visit the Wisconsin Crop Weed Science website at http://wcws.cals.wisc.edu/. Further information on controlling common waterhemp, Palmer amaranth, or other herbicide-resistant weeds can be found at: http://takeactiononweeds.com/. Finally, if you believe you may be facing herbicide-resistant weeds in your fields, contact your local county extension agent and/or Dr. Vince Davis at vmdavis@wisc.edu or (608) 262-1392.

References

Bensch CN, Horak MJ, Peterson D (2003) Interference of redroot pigweed (*Amaranthus retroflexus*), Palmer amaranth (*A. palmeri*), and common waterhemp (*A. rudis*) in soybean. Weed Science 51:37-43

Davis VM, Recker RA (2014) Palmer amaranth identified through the late-season weed escape survey. Accessed February 4, 2014, 2014

Heap I (2014) The International Survey of Herbicide Resistant Weeds: Web page. http://www.weedscience.com/Summary/home.aspx. Accessed Nov. 1, 2014.

Horak MJ, Loughin TM (2000) Growth Analysis of Four Amaranthus Species. Weed Science 48:347-355

Knezevic SZ, Streibig JC, Ritz C (2007) Utilizing R Software Package for Dose-Response Studies: The Concept and Data Analysis. Weed Technology 21:840-848

Massinga RA, Currie RS, Horak MJ, Boyer J, Jr. (2001) Interference of Palmer Amaranth in Corn. Weed Science 49:202-208

Sellers BA, Smeda RJ, Johnson WG, Kendig JA, Ellersieck MR (2003) Comparative Growth of Six Amaranthus Species in Missouri. Weed Science 51:329-333

Steckel LE, Sprague CL (2004) Common waterhemp (Amaranthus rudis) interference in corn. Weed Science 52:359-364

EFFICACY OF 'NEW' HERBICIDES AND PROGRAM APPROACHES FOR RESISTANCE MANAGEMENT

Vince M Davis and Elizabeth J. Bosak[1]

Do you want to compare new herbicides, and herbicide programs, to products and programs you are already familiar with?

In the Wisconsin Crop Weed Science program Herbicide Evaluation program, that's what do we do. We evaluate new herbicide products, application timings, and efficacy for controlling an array of weed species of interest to Wisconsin farmers.

The herbicide evaluation trials use a randomized complete block design and replicate each treatment generally four times. This is different from a demonstration plot that only shows the weed control for a single instance of that particular treatment. Replication allows a researcher to observe the variability for that treatment across a field site.

Each year we have a Pest Management Field Day, at Arlington Agricultural Research Station, where we showcase several of our herbicide evaluation trials to the public and provide a book describing all of our trials for the season. If you've never heard of this, it's important to know this generally occurs in the last week of June to first week of July and is advertised in advance in the Wisconsin Crop Management Newsletter: http://ipcm.wisc.edu/wcm/

At the end of the season, we also compile and analyze all of the data and publish a report book. This year's WCWS101:2014 research report is available at: http://wcws.cals.wisc.edu/documents/

In addition to comparing the efficacy of herbicide treatments by product name listed, the back of the report book has an appendix that correlates herbicide products tested for their active ingredients and site-of-action number. Rotating effective herbicide sites-of-action is an important element to sound herbicide resistance management.

To learn about the similarities of herbicide options to herbicide sites-of-action, download the Herbicide Classification chart from: http://takeactiononweeds.com/understanding-herbicides/

References

Wisconsin Crop Weed Science Research Report 2014. V.M. Davis, E.J. Bosak, R.R. Bailey, T.R. Butts, and D.H. Smith. WCWS101:2014. Online: http://wcws.cals.wisc.edu/documents/

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COVER CROP ESTABLISHEMNT FOLLOWING COMMONLY APPLIED CORN AND SOYBEAN HERBICIDES IN WISCONSIN

Daniel H. Smith and Vince M Davis[1]

Introduction

Cover crops are of increasing interest to producers in Wisconsin due to many potential agronomic benefits. These potential benefits include reducing soil erosion, providing and scavenging nutrients, weed suppression, improving soil health, reducing soil moisture losses, protecting water quality, reducing production costs and increasing yield. Cover crops have been utilized for many years in crop organic production. While cover crops are of increasing interest there are often challenges with their establishment. The increasing interest is shown through results from a 2013-2014 survey conducted by the North Central Sustainable Agriculture Research and Education (SARE) program with the Conservation Technology Information Center (CTIC). This survey indicated there has been a steady increase in cover crop acres since 2009 with 415,191 acres planted in the Mississippi river basin in 2014. Of the farmers surveyed 42.5% indicated that establishing cover crops was one of the biggest challenges. (SARE/CTIC, 2014) Some of this challenge may be due to herbicide carryover issues. Herbicide persistence factors include chemical properties of the herbicide, rate of application, soil pH, organic matter content, amount of surface plant residue, temperature, rainfall, and microbial degradation (Walsh, 1993). The objective of this study was to determine if persistence of commonly used residual herbicides applied in the spring to corn and soybean crops affect the subsequent establishment of cover crops in the fall.

Materials and Methods

Field experiments were conducted at Arlington Agricultural Research Station, Arlington, WI. The experimental design was a randomized complete block with four replications. Each replication included a nontreated check where no residual herbicide was applied, but weeds were managed with POST glyphosate. The treatment structure included main plots for corn and soybean with subplots consisting of herbicide treatments and sub-subplots consisting of cover crop species. Corn and soybean plots were seeded with glyphosate-resistant cultivars on June 2, 2013 and May 22, 2014. Cover crops were directed seeded using a no-till drill. Soil type was Plano silt loam soil with 3.4 to 3.8% organic matter and pH ranging from 5.9 to 6.3.

Plots were 10 feet wide and 50 feet long. Corn and soybeans was planted in 30 inch wide rows. Corn was planted at 33,000 seeds per acre. Soybean was planted at 160,000 seeds per acre. Preemergence (PRE) herbicide treatments were applied as close to planting as possible. A burn-down application of glyphosate was applied on all plots prior to planting. Postemergence (POST) herbicides were applied at V2 corn and V3 soybean growth stages. All plots were also sprayed

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with POST glyphosate to control all weeds and limit interactions from weed competition. Herbicide treatments for corn are listed in Table 1 and soybean treatments in Table 2.

Table 1. Corn herbicide treatments.

Treatment	Trade Name	Active Ingredient	Rate	Site of action group	Timing
1	Nontreated				
2	Sharpen	saflufenacil	2 fl. oz.	14	PRE
3	Verdict	saflufenacil	15 fl. oz.	14	PRE
		dimethenamid-p		15	PRE
4	Zemax	s-metolachlor	2 qt.	15	PRE
		mesotrione		27	PRE
	Halex GT	s-metolachlor	3.6 pt.	15	LPOST
		glyphosate		9	LPOST
		mesotrione		27	LPOST
5	Fierce	flumioxazin	3 oz.	14	PRE
		pyroxasulfone		15	PRE
6	Python	flumetsulam	1 oz.	2	PRE
7	Princep 4FL	simazine	2 qt.	5	EPOST
8	Stinger	clopyralid	0.5 pt.	4	EPOST
9	Accent Q	nicosulfuron	0.9 oz.	2	EPOST
10	Resolve	rimsulfuron	1 oz.	2	EPOST
11	SureStart	acetochlor	1.5 pt.	15	EPOST
		flumetsulam		2	EPOST
		clopyralid		4	EPOST
12	Callisto	mesotrione	6 oz.	27	EPOST
13	Basis Blend	rimsulfuron	0.33 oz.	2	EPOST
		thifensulfuron-methyl		2	EPOST
14	Laudis	tembotrione	3 fl. oz.	27	EPOST
15	Impact	topramezone	0.75 fl. oz.	27	EPOST

Table 2. Soybean herbicide treatments.

Treatment	Trade Name	Active Ingredient	Rate	Site of Action Group	Timing
1	Nontreated				
2	Spartan	sulfentrazone	8 fl. oz.	14	PRE
3	Valor	flumioxazin	2.5 oz.	14	PRE
4	Sencor 75DF	metribuzin	0.5 lb.	5	PRE
5	Classic	chlorimuron-ethyl	1 oz.	2	PRE
6	Authority MTZ	sulfentrazon	12 oz.	14	PRE
		metribuzin		5	PRE
7	Gangster	flumioxazin	3.6 oz.	14	PRE
8	Zidua	pyroxasulfone	3 oz.	15	PRE
9	Firstrate	cloransulam-methyl	0.3 oz.	2	EPOST
10	Dual II Magnum	s-metolachlor	1.33 pt.	15	EPOST
11	Warrant	acetochlor	1.5 qt	15	EPOST
12	Flexstar	fomesafen	16 fl. oz.	14	EPOST
13	Pursuit	imazethapyr	4 fl. oz.	2	EPOST
14	Extreme	imazethapyr	3 pt.	2	EPOST
		glyphosate		9	EPOST
15	Cobra	lactofen	12.5 fl. oz.	14	EPOST

Corn plots were harvested as silage, and soybean plots were also harvested to simulate a forage harvest. After harvest seven different cover crop species and/or varieties were direct drilled perpendicular across all herbicide treatments. These plots were approximately 6.5 feet wide with row spacing of 7.5 inches. The cover crops included Tillage Radish® (Raphanus sp;), crimson clover (Trifolium incarnatum), cereal ryegrass 'Guardian' (Secale cereal), 70% oat 'Ogle' (Avena sativa) plus 30% peas 'Austrian winter field' (Pisum sativum) mixture, and three annual ryegrass (Lolium multifloram) varieties. The annual ryegrass varieties included 'Bruiser' and 'King', diploids, and a tetraploid. Table 3 outlines seeding population and planting depth.

Table 3. Cover crop seeding rate and depth.

Species	Winter Rye	Oats + Peas Mix	Crimson Clover	Tillage Radish®	Annual Ryegrasses
Depth(inch)	1	1	0.25	0.25	0.25
Seeding Rate (lbs./ac	120	90 oats 10 peas	10	12	32

Cover crops were evaluated for herbicide injury just after emergence, which occurred approximately two weeks after seeding. Digital images were taken at 36 inches above each sub-

sub plot weekly using methods for digital imagery analysis (DIA) data collection techniques adapted from Purcell (2000). The camera was mounted at a 70 degree angle on a 1 inch wide by 45 inch long board. This board created a stand for the camera to capture consistent photos of the plots. The camera used was a Canon PowerShot A1400 with a 16 gigabyte class 4 SDHC card (Canon USA, Inc., Melville, NY). The camera was set to auto mode with zoom set to 0. Images were resized using FastStone Image Viewer (FastStone Image Viewer). Once resized, images were analyzed using Sigma Scan Pro© 5 with the macro Turf Analysis 1-2 (SigmaScan Pro© 5, Richardson 2001, and Karcher 2005). Taking the readings at the subplot level allows for data analysis of each herbicide treatment and cover crop combination.

Biomass was collected from quarter meter squared quadrats prior to the first killing frost. According to NOAA, the average first frost date at the Arlington, WI research farm ranges from October 11 until October 20. (NCDC 2013) The biomass samples then were dried at 140°F for two weeks and weighted.

Data were analyzed using a mixed model using the pro mixed procedure in SAS statistical software (SAS Institute, Inc., Cary NC 27513). Cover crop, herbicide, and cover crop by herbicide interaction were the fixed effects. Replication was a random effect.

Results and Discussion

Winter rye was the only cover crop not adversely impacted by the herbicide treatments applied in the corn and soybean trials in 2013 and 2014 ($P<0.05$) (Table 4). All other cover crops had significantly ($P<0.05$) reduced cover (Table 4) and biomass (Table 5) for at least one of the residual herbicide treatments.

Table 4. Percent cover from cover crops in 2013. Only data which were significantly different from the nontreated check at alpha 0.05 are shown

	'King' Ryegrass	'Bruiser' Ryegrass	Tetraploid Ryegrass	Oat+Pea Mix	Tillage Radish®	Crimson Clover	Winter Rye
Nontreated	66	61	63	61	54	39	51
S-metolachor	18	29	22	54		24	
Imazethapyr	44	56	57	40	18		
Flumioxazin	38	47	35	45		24	
Pyroxasulfone	35	39	40	43			
Flumetsulam	51				41		
Sulfentrazon		46			40		
Fomesafen					22		

Table 5. Biomass from cover crops in 2013. Only data which were significantly different from the nontreated check at alpha 0.05 are shown

	'King' Ryegrass	'Bruiser' Ryegrass	Tetraploid Ryegrass	Oat+Pea Mix	Tillage Radish®	Crimson Clover	Winter Rye
Nontreated	2.8	3.0	2.9	3.5	4.5	2.0	2.9
S-metolachor	0.6	0.4	0.9	1.8		0.9	
Imazethapyr	2.0	2.3	2.3	1.5	1.6		
Flumioxazin	1.7	1.9	1.3	1.6		1.4	
Pyroxasulfone	1.1	1.2	1.6	2.2			
Flumetsulam	1.5				2.5		
Sulfentrazon		2.2			2.8		
Fomesafen					1.6		

Two varieties 'King' and tetraploid were the only cover crops to have significant ($P<0.0001$) reduction of percent cover in 2014 (Table 6). All other cover crops did not have a reduction in percent cover due to herbicide treatments.

Table 6. Percent cover from cover crops in 2014. Only data which were significantly different from the nontreated check at alpha 0.05are shown

	'King' ryegrass	Tetraploid ryegrass
Nontreated	19	25
Simazine	13	
Flumetsulam	5	
Sulfentrazone		10

Summary

Commonly used corn and soybean herbicides have the potential to reduce the establishment and green cover of many different species used as cover crops. The severity of damage will be influenced by weather, cover crop species, and the specific residual herbicide combinations previously applied. Symptoms of carryover may go un-noticed if damage is uniform across an entire field and only minor negative effects occur. More research is needed to explore these relationships and develop guidelines to help farmers avoid cover crop establishment problems associated with the persistence of residual herbicides.

Disclaimer

Herbicide trade names listed, used, and described in these trials do not imply any endorsement or recommendation related to use patterns. Always read and follow specific herbicide label recommendations.

References

FastStone Image Viewer Version 4.9- Powerful and Intuitive Photo Viewer, Editor and Batch Converter. Computer software. N.p., n.d. Web..

Karcher, Douglas E., and Michael D. Richardson. "Batch Analysis of Digital Image to Evaluate Turfgrass Characteristics." *Crop Science* 15 (2005): 1536-539. Web.

Karcher, Douglas, and Michael Richardson. *Turf Analysis*. Computer software. *Batch Analysis of Digital Images to Evaluate Turfgrass Characteristics*. Vers. 1-2. University of Arkansas, n.d. Web. 11 Feb. 2014.

"NCDC: U.S. Climate Normals -." *NCDC: U.S. Climate Normals* -. N.p., n.d. Web. 10 Feb. 2014.

North Central Sustainable Agriculture Research and Education (SARE) program with the Conservation Technology Information Center (CTIC). 2013-2014 Cover Crop Survey Report. 2014. www.ctic.org/media/CoverCrops/CTIC_04_Cover_Crops_report.pdf

Purcell, Larry C. "Soybean Canopy Coverage and Light Interception Measurements Using Digital Imagery." *Crop Science* 40 (2000): 834-37. Web. <https://www.crops.org/publications/cs/pdfs/40/3/834>.

Richardson, M. D., D. E. Karcher, and L. C. Purcell. "Quantifying Turfgrass Cover Using Digital Image Analysis." *Crop Science* 41.6 (2001): 1884-888. Print.

SAS Version 9.3.Cary NC 27513: SAS Institute Inc., 2014. Computer software.

SigmaScan Pro© 5.0 for Windows 95, 98 and NT. Chicago, IL: SPSS, Inc., 1999. Computer software.

Walsh, Joseph D., Michael S. Defelice, and Barry D. Sims. "Soybean (Glycine Max) Herbicide Carryover to Grain and Fiber Crops." Weed Technology 7 (1993): 625-32

WHY AGRONOMISTS SHOULD BE CONCERNED ABOUT INVASIVE PLANTS

Mark J. Renz[1]

Invasive plants are defined by Wisconsin Legislation as "nonindigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health" (NR40). These plants can persist in our climate, reproduce, and spread. This is why Wisconsin has developed legislation to prevent the introduction and spread of these species. While much of the benefit from these regulations is focused on non-agricultural areas, this can directly (and indirectly) influence agriculture. Below are several examples of how invasive plants impact agriculture followed by a brief description of how agronomists can assist in preventing the spread of these new invaders.

Poison Hemlock, a new invader that you do not want on your land!

Poison hemlock is a non-native biennial that invades roadside ditches, pastures, and waterways. This plant is in the carrot family and produces inflorescences of large white flowers similar to wild carrot but plants can be up to 10' tall. This plant is easy to identify as stem and branches have distinctive reddish-purple splotches. This plant is common in states to the south of us and is spreading via roads throughout southern Wisconsin. We are concerned about this plant as it is highly toxic, and small amounts (less than a pound) of this plant, if ingested, could kill livestock.

Common Buckthorn, a factor in soybean aphid reproduction.

Common buckthorn is an understory shrub or small tree 10–25' tall. It is common throughout Wisconsin forest understories and is easy to identify by cutting a branch or stem and looking for yellow/orange colored wood within the cut. It also is the earliest shrub to leaf-out in the spring and last to lose its leaves in the fall. Agronomists should despise this plant because it is the primary overwintering location for the soybean aphid. While it is likely too widespread to eradicate, it is likely that we would have never had such large populations of soybean aphids if this plant was not present in our woods!

Spotted knapweed, not a friend for soil conservation.

Spotted knapweed is a short-lived perennial that grows 2–4' tall and produces a showy pink to purple flower from one or multiple stems. While many northern Wisconsinites may consider this plant native, it was introduced long ago to Wisconsin and is now widespread. Spotted knapweed is able to spread into grasslands including production and non-production fields and displaces desirable grasses and forbs. The major problem with this species is that it does not provide the soil conservation benefits that those species typically provide. Research has shown that fields infested with spotted knapweed have more than double the water runoff and nearly four times more sediment removal compared to uninvaded areas. With all the energy we spend in the state to minimize erosion in agriculture, this plant may be countering much of it even if it is not growing in agricultural lands.

Multiflora rose, have you ever tried to walk through it?

Multiflora rose is a woody perennial shrub with arching stems that grow up to 15' tall. Stems are covered in stiff, curved thorns. If you have ever walked through a thicket you will remember this plant. While the impacts from this plant to agriculture are specific to pastures and reductions in available forage, many agronomists recreate in the woods. When these thickets are well established they make it nearly impossible for one to penetrate. I have heard horror stories of groups trying to recover a deer they had shot in these thickets, and anyone who has experienced

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this pest would agree it is not desired on the landscape. While the majority of populations are in southern Wisconsin, this plant appears to be spreading north as new locations have been recently reported in north-central Wisconsin.

Do you like ticks? How about Lyme disease? Japanese barberry promotes both!
Japanese barberry is a common ornamental shrub, typically 2-3' tall, planted in urban areas throughout the United States. The branches are reddish-brown and deeply grooved, with a single sharp spine at each node. While it has no direct impact to agriculture, it invades forests, changing a host of factors related to forest regeneration and health. While these are concerning, why I fear this plant is that it has been documented to provide excellent habitat for deer ticks. As if we didn't have enough in Wisconsin? To make matters worse, this plant has been implicated to be involved in the continued spread of Lyme disease. While the details of exactly how this happens aren't clear I think we can all agree we don't need more ticks or Lyme disease in Wisconsin.

In summary, invasive plants can impact agronomists and others that work in agriculture. While impacts are specific to the invasive plant, they are likely already affecting you, your business, and potentially even your health. The best way to prevent these impacts from occurring is to prevent the introduction and spread of these species. It is relatively easy to control new establishing populations, but more challenging to eradicate entrenched populations that have been present for many years, therefore control efforts are focused on early detection and eradication. While limited funding does exist for regulated species, populations need to be reported in order to qualify for those funds. Reports can be sent directly to DNR or reported through an online website www.gledn.org. Recently a smartphone App was created that allows users to submit locations directly from apple or android devices (see: http://apps.bugwood.org/mobile/gledn.html to download; it is FREE). So if you see a population of an invasive plant, please report its location, and if on property you own or manage, remove it. A variety of resources are available on management options at fyi.uwex.edu/weedsci. Only with collaborative efforts can we slow the spread and impact of these plants.

GMO ISSUES WORLDWIDE AND WHAT IT MEANS TO U.S. GRAIN HANDLERS

Jared Hill [1/]

{This page provided for note taking}

[1/] National Grain and Feed Association.

TRANSPORTATION ISSUES: RAIL CAR, WATERWAY LOCKS AND DAMS, TRUCKS

Dan Mack [1/]

{This page provided for note taking}

[1/] CHS Inc.

WORLD GRAIN PRODUCTION TRENDS, SUPPLY/DEMAND, PRICE AND YIELD PROJECTIONS, MARKET OUTLOOK

Dewey Hull [1/]

{This page provided for note taking}

[1/] Advance Trading.

LATE BLIGHT AND DOWNY MILDEW UPDATES IN VEGETABLE CROPS

Amanda J. Gevens, Department of Plant Pathology, Univ. of Wisconsin-Madison

Introduction

Late blight is a potentially destructive disease of potatoes and tomatoes caused by the fungal-like organism, *Phytophthora infestans*. This pathogen is referred to as a 'water mold' since it thrives under wet conditions. Symptoms include leaf lesions beginning as pale green or olive green areas that quickly enlarge to become brown-black, water-soaked, and oily in appearance. Lesions on leaves can also produce pathogen sporulation which looks like white-gray fuzzy growth. Stems can also exhibit dark brown to black lesions with sporulation. Tuber infections are dark brown to purple in color and internal tissues are often reddish brown in color and firm to corky in texture. The time from first infection to lesion development and sporulation can be as fast as 7 days, depending upon the weather.

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. In the U.S., clonal lineage (also referred to as genotype or strain) US-1 (A1 mating type) 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. New clonal lineages have predominated epidemics in recent years with varying levels of mefenoxam resistance. Late blight pathogen populations in the U.S. have and continue to experience major genetic changes or evolution. The end result is the production of pathogen isolates with unique genotypes and epidemiological characteristics. As such, continued investigation of this pathogen is necessary to maintain best management strategies in susceptible crops.

Our objective was to monitor for late blight on a state-wide basis and characterize *P. infestans* in a timely manner to inform appropriate management recommendations and enhance understanding of the pathogens introduction and persistence in Wisconsin.

RESULTS & DISCUSSION

To date here in Wisconsin, our late blight diagnostics and management approaches address clonal or **asexual** populations of the pathogen. In this scenario, we can genotype the pathogen and receive a result which is tightly associated with mating type, mefenoxam/metalaxyl resistance, and often host preference. This scenario also includes an end to the late blight disease cycle when the affected plant tissues are dead. A **sexually** recombining population creates a different scenario, one in which we can no longer get a fast-response genotype with correlates with pathogen character or phenotype. And, the disease cycle in this latter scenario does not end when plant tissues are dead. Rather, the pathogen remains in the soil in absence of plant tissues, providing an ongoing source of inoculum for the long-term. This article provides some key biological concepts and management of each of these potential scenarios, and offers a review of late blight in 2014.

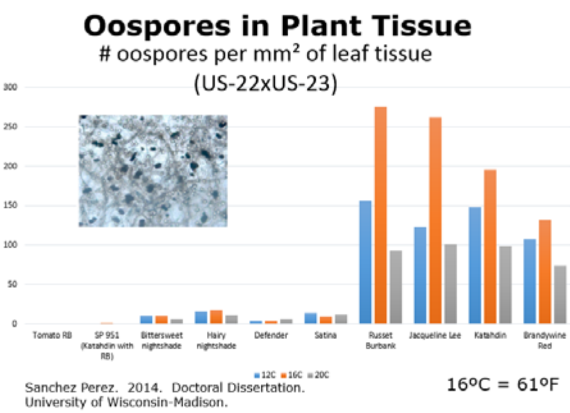
Volunteer survival 2013-2014: When soil temperatures do not get low enough to kill unharvested potato tubers, they can remain alive through the winter and emerge as unwanted volunteer plants in the spring. While the volunteers can create stubborn weeds in the following season, they can also harbor pathogens such as *Phytophthora infestans* in its **asexual** forms (sporangia, zoospores, and mycelia) and initiate the disease in the next year. A model for categorizing risk of survival of potato volunteers developed by researchers at Michigan State University categorizes risk based on accumulation of cold soil temperatures at 2 and 4 inch depths occurring between November 1 and March 31. This past winter in Wisconsin, we had accumulated hours of cold temperatures below -3◦C (27◦F) at 2 and 4" depths at Hancock (204 hrs below at 2"/120 hrs below at 4") and Arlington (984 hrs below at 2"/563 hrs below at 4") indicating low risk for volunteer survival. And, low risk for overwintering of the late blight pathogen in its current (non-oospore) form. Indeed, risk will vary by location, soil type, vegetative ground cover, as well as snow cover, but the risk assessment provides helpful information in considering weed and disease management.

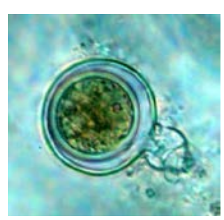
Results of Blitecasting and late blight character in 2014: Spring was slow to warm in 2014, but by the first week in June, the earliest planted potatoes in the Grand Marsh area of WI had accumulated environmental conditions favorable to late blight – as determined by Blitecast Disease Severity Values (DSVs) of ≥18 or risk threshold for early planted potatoes. By late June, Bitecasts for all early and mid-season plantings of potato plantings across Wisconsin had reached or surpassed the 18 DSV threshold. Late blight was first detected in the state in mid-July in Portage County, with subsequent reports from six additional counties (Adams, Marinette, Milwaukee, Oconto, Racine, Waushara). As in previous years, our UWEX Vegetable Pathology Blitecast tool provided timely information to aid in preventative disease management. Late blight of the US-23 (A1) clonal lineage was determined in all of the seven counties, with US-8 (A2) also identified in three of the counties (Adams, Portage, Waushara) – posing additional risk for sexual recombination and oospore production. The table below shows the pathogen clonal lineages from this and previous 5 years here in Wisconsin. Recall the predominance of US-8 during the late blight of the 1990s. Continued monitoring of genotypic and phenotypic characteristics of the *P. infestans* population will contribute to both short-term and long-term management of late blight in Wisconsin and surrounding states.

Year	**Clonal Lineage (Mating Type, and Mefenoxam Sensitivity) of the Late Blight Pathogen (*Phytophthora infestans*) Detected in Wiscsonsin**
2014	US-8 (A2, Resistant), US-23 (A1, Sensitive)
2013	US-8 (A2, Resistant), US-23 (A1, Sensitive)
2012	US-23 (A1, Sensitive)
2011	US-23 (A1, Sensitive), US-24 (A1, Intermediately Sensitive)
2010	US-22 (A2, Sensitive), US-23 (A1, Sensitive), US-24 (A1, Intermediately Sensitive)
2009	US-22 (A2, Sensitive)

Impact of mating types and sex on pathogen character and management: Knowledge of the mating types in a *P. infestans* population is important for immediate and long-term management of late blight. By knowing the distribution of mating types, future changes in the population due to sexual recombination can be anticipated and potential problem fields closely managed and monitored. The mating types (A1 and A2) can be thought of as male and female components of a population. Under close proximity and specific environmental conditions, the mating types can sexually recombine and produce oospores ("Kids"). Of which, some will be genetically similar to A1 ("Dad") and some similar to A2 ("Mom"), while others will be genetically brand new with unknown clonal lineages and phenotypic characters such as mating type, fungicide resistance, aggressiveness, and host preference. A soil persistent oospore phase of *P. infestans* would drastically change current management practices.

Recent oospore research from UW-Potato Pathology helps us understand risk: In our recent laboratory research, we have documented the potential for oospore production between US-22 (A2) and US-23 (A1) clonal lineages. We started our work on oospores in 2011 when US-22 seemed to be the most likely A2 type to cause mating risk. Since that time, US-8 has reappeared and would be the more immediate A2 risk. On late blight susceptible tomato and potato foliage, roughly 100-275 oospores formed within 1 mm² of plant tissue when inoculated with both US-22 and US-23. 'Russet Burbank' resulted in the highest number of oospores per mm² at 16ºC (61ºF) among the plant types we tested. The graphic below shows the number of oospores produced in 1 mm² leaf tissue of multiple tomato and potato varieties including tomato transformed with *RB* late blight resistance gene, 'Katahdin' potato transformed with *RB*, bittersweet nightshade, hairy nightshade, 'Defender' potato, 'Satina' potato, 'Russet Burbank' potato, 'Jacqueline Lee' potato, 'Katahdin' potato, and 'Brandywine Red' tomato. Further studies have shown that roughly 85% of the oospores formed in green leaf tissues are alive and of those, nearly 40% can germinate with potential to cause disease. In our simulated overwintering experiments, less than 35% of oospores remained viable in the soil with very low potential (<7% incidence) of causing infection on susceptible tomato leaves under flooded conditions.





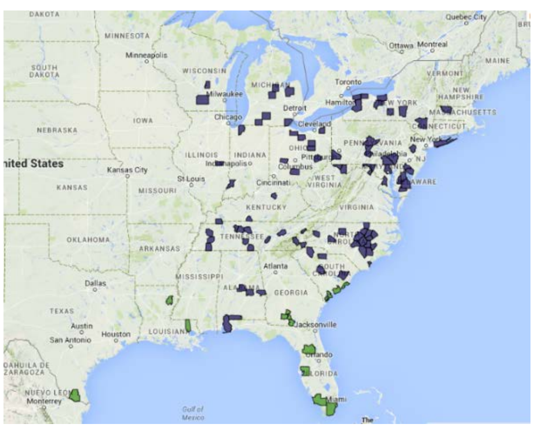
How long do oospores remain in the soil and can they travel?
Oospores are the largest of the spore types that the late blight pathogen can potentially make and they are designed to be persistent in soil outside of plant tissues for many years. While oospores can be associated with soil and be moved with soil – they are not known to

move aerially or long distances through irrigation or precipitation splashing. Equipment and any implement or plant part that may have soil associated with it could potentially move oospores.

Where to find information on late blight types in the U.S.?: Since 2011, many national late blight confirmations and characterizations have been made publicly available in an online format (www.usablight.org) through the efforts of research and extension scientists funded by the United States Department of Agriculture, National Institute of Food and Agriculture (AFRI). The coordinated project, entitled "Reducing losses to potato and tomato late blight by monitoring pathogen populations, improved resistant plants, education, and extension" conducts basic and applied research with the team goal of learning more about the pathogen and disease to further reduce losses in crop yield and quality. As per the national database, the US-23 lineage has again predominated epidemics on tomato and potato in 2014.

Cucurbit Downy Mildew Updates for Wisconsin 2014

In Wisconsin, there were few confirmed reports of curcurbit downy mildew in Dane, Green Lake, and Calumet Counties primarily on cucumber. In recent years, WI has had mid- and late-season downy mildew on primarily cucumber. There is risk of downy mildew to WI cucurbits in 2015 likely through spores moving in air from southerly growing regions. Incidence and severity is dependent upon temperature and moisture. Nationally, reports came from over 20 states, primarily along the eastern seaboard and the Midwestern states (see Figures below). Cucumber remains the primary crop affected by cucurbit downy mildew, followed by squash of various types (summer, winter) (see Figures below). Further information and disease forecasting can be found at http://cdm.ipmpipe.org/.



Crop Type	# of Reports in 2014	% of Total Reports
Cucumber	96	**45**
Squash	59	**28**
Cantaloupe	25	**12**
Pumpkin	22	**10**
Watermelon	11	**5**
TOTAL	**213**	**100**

Further information on late blight and disease management recommendations can be found at the University of Wisconsin Potato & Vegetable Pathology website:
http://www.plantpath.wisc.edu/wivegdis/

and, in the University of Wisconsin Extension Publication entitled "Commercial Vegetable Production in Wisconsin," publication number A3422 (http://learningstore.uwex.edu/assets/pdfs/A3422.PDF).

1. Fry, William E. and Niklaus J. Grünwald. 2010. Introduction to Oomycetes. *The Plant Health Instructor.* DOI:10.1094/PHI-I-2010-1207-01

2. Legard, Daniel E. and William E. Fry. 1996. Evaluation of field experiments by direct allozyme analysis of late blight lesions caused by *Phytophthora infestans*. Mycologia 88(4) 608-612.

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CO-APPLICATION OF THE DIMAIDE INSECTICIDES IN SNAP BEANS[1]

Anders S. Huseth[2], Russell L. Groves[3], Scott A. Chapman[3], and Brian A. Nault[2]

Abstract. Multiple applications of pyrethroid insecticides are used to manage European corn borer, *Ostrinia nubilalis* Hübner, in snap bean, but new diamide insecticides may reduce application frequency. The objective of this study was to examine the potential for improving control of *O. nubilalis* in processing snap bean with diamide insecticides. Specifically, we compared *O. nubilalis* control with chlorantraniliprole, cyantraniliprole, and bifenthrin at three different phenological snap bean stages (i.e., bud, bloom, pod formation) to determine the duration of residual activity for each insecticide under field conditions in snap bean, and co-applied cyantraniliprole and bifenthrin insecticides with either herbicides or fungicides at each vegetative stage to determine if tank mixing cyantraniliprole and bifenthrin with common agrochemicals would reduce *O. nubilalis* control, and finally we confirmed the suitability of diamide insecticides for *O. nubilalis* control using commercial snap bean fields and processing plant contamination data, over two consecutive field seasons. Cyantraniliprole applications timed either during bloom or pod formation controlled *O. nubilalis* better than similar timings of bifenthrin. Co-applications of insecticides with fungicides controlled *O. nubilalis* as well as insecticide applications alone. Insecticides applied either alone or with herbicides during bud stage did not control this pest. In commercial snap bean fields, yield and quality were equivalent in fields treated once with chlorantraniliprole and twice with pyrethroids. Diamides are an excellent alternative to pyrethroids for manage *O. nubilalis* in snap bean. Adoption of diamides by snap bean growers could improve the efficiency of production by reducing the number of sprays required each season.

Table 1. Average *O. nubilalis* infestation (mean percentage±SE) of snap bean pods and plants treated at three phenological plant stages with chlorantraniliprole cyantraniliprole and bifenthrin in 2012.

Phenological stage	Insecticide	Plant damage	Pod damage
untreated[a]	-	18.5±5.2	8.7±2.5
bud	bifenthrin	9.0±6.4a	2.6±1.2a
	chlorantraniliprole (51.2 g AI ha^{-1})	4.1±3.3ab	1.9±1.1a
	cyantraniliprole (150 g AI ha^{-1})	1.0±0.7b	0.7±0.3a
bloom	bifenthrin	0.7±0.4b	1.4±0.4a
	chlorantraniliprole (51.2 g AI ha^{-1})	0.0±0.0b	0.0±0.0a
	cyantraniliprole (150 g AI ha^{-1})	0.0±0.0b	0.2±0.1a
pod formation	bifenthrin	0.0±0.0b	0.0±0.0a
	chlorantraniliprole (51.2 g AI ha^{-1})	0.0±0.0b	0.3±0.1a
	cyantraniliprole (150 g AI ha^{-1})	0.0±0.0b	0.0±0.0a

[a]Untreated controls were not included in analyses, but have been provided for comparison.
[b]Within each vegetative structure column, means followed by the same lower-case letter do not differ significantly (Tukey HSD test at *P*=0.05).

[1]Funding for the project was partially support by the USDA SCRI, "*Building Market Foundations for Sustainable Vegetable Production and Processing: A Consumer and Metrics-Based Approach*" FY2012-51181-20001

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Table 2. Average *O. nubilalis* infestation (mean percentage±SE) of snap bean pods and plants treated at three phenological plant stages with cyantraniliprole and bifenthrin in 2013 and 2014.

Vegetative stage	Insecticide	Plant damage		Pod damage	
		2013	2014	2013	2014
untreated[a]	-	63.5±9.8	13.3±3.8	14.8±4.6	6.0±1.4
bud	bifenthrin	22.1±10.1a	11.3±3.5a	5.0±2.7a	4.4±1.5a
	cyantraniliprole (100 g AI ha^{-1})	19.4±7.5ab	6.9±2.2ab	3.7±1.2a	2.8±1.0ab
	cyantraniliprole (150 g AI ha^{-1})	20.5±2.0a	9.6±6.4ab	2.4±0.5ab	2.4±1.5ab
bloom	bifenthrin	12.5±3.9abc	1.2±1.2ab	3.7±2.0ab	0.4±0.2b
	cyantraniliprole (100 g AI ha^{-1})	1.5±1.1bc	1.4±0.7ab	0.2±0.1bc	0.8±0.4ab
	cyantraniliprole (150 g AI ha^{-1})	1.7±1.3bc	1.0±0.7ab	0.1±0.1c	0.8±0.3ab
pod formation	bifenthrin	7.7±3.4abc	0.0±0.0b	1.2±0.7abc	0.7±0.5b
	cyantraniliprole (100 g AI ha^{-1})	0.8±0.8c	3.8±2.2ab	0.2±0.1bc	0.6±0.3ab
	cyantraniliprole (150 g AI ha^{-1})	0.5±0.5c	1.1±1.1b	0.0±0.0c	0.5±0.2b

[a]Untreated controls were not included in analyses, but have been provided for comparison.
[b]Within each vegetative structure and year column, means followed by the same lower-case letter do not differ significantly (Tukey HSD test at *P*=0.05).

REFERENCES

Eckenrode CJ, Robbins PS and Andaloro JT, Variations in flight patterns of European corn borer (Lepidoptera: Pyralidae) infestation in snap beans. *J Econ Entomol* **12**:393-396 (1983).

Dively GP and McCully JE, Nature and distribution of European corn borer feeding injury on snap beans. *J Econ Entomol* **72**:152-154 (1979).

Barry JD, Portillo HE, Annan IB, Cameron RA, Clagg DG, Dietrich RF, Watson LJ, Leighty RM, Ryan DL, McMillan JA, Swain RS, and Kaczmarczyk RA, Movement of cyantraniliprole in plants after foliar applications and its impact on the control of sucking and chewing insects. *Pest Manag Sci* DOI:10.1002/ps.3816 (2014).

R-Core Development Team, R: a language and environment for statistical computing. Version 3.1.0, Vienna, Austria: R Foundation for Statistical Computing. (2014). Available at: http://cran.r-Project.Org

WEB-BASED PEST AND DISEASE FORECSTING TOOL FOR ENHANCED PROCESSING VEGETABLE CROP MANAGEMENT: UPDATE ON CARROT FOLIAR DISEASE FORECASTING COMPONENT

Kenneth Frost[1], Amanda Gevens[1], Steve Jordan[1], and Russell Groves[2], [1]Dept. of Plant Pathology, [2]Dept. of Entomology, Univ. of Wisconsin, Madison, WI 53706

Research Overview. Alternaria leaf blight, caused by the fungus *Alternaria dauci*, and Cercospora leaf spot, caused by the fungus *Cercospora carotae*, infect leaves and petioles of carrot and are the most prevalent foliar diseases of carrot worldwide. These foliar blight pathogens reduce yield by limiting the plant's photosynthetic capacity and by weakening the petioles needed for mechanical harvest. Typically, carrots are harvested by implements that loosen the soil and simultaneously grasp the foliage while lifting the roots out of the soil; blighted petioles break when gripped by the mechanical harvester and carrots are left in the soil. Environmental conditions greatly influence the occurrence and progression of these foliar diseases of carrot and the anticipation of heightened disease risk through the identification and monitoring of critical environmental factors, such as, relative humidity and temperature, can enhance disease management by optimizing the timing of fungicide applications. However, implementation of the weather-based models is difficult because, typically, each field requires a customized forecast that is dependent on disease severity, weather conditions, and fungicide program, factors that are field-specific. A goal of this research is to provide a set of generalized recommendations for managing foliar diseases of carrot that can be used for the majority of WI fields without the need for grower investment in weather stations.

Table 1) TOM-CAST model logic for scoring a daily severity value. Under the current scheme, a fungicide application would be recommended after the accumulation of 20 severity values over consecutive days.

Mean Temp (C)	Leaf-wetting time (hr) required to produce daily disease severity values (S) of:				
	0	1	2	3	4
13-17	0-6	7-15	16-20	21+	
18-20	0-3	4-8	9-15	16-22	23+
21-25	0-2	3-5	6-12	13-20	21+
26-29	0-3	4-8	9-15	16-22	23+

Methods. *Weather data and modified TOM-CAST model.* Computers housed in the Dept. of Plant pathology at UW-Madison ingested daily gridded weather predictions from the North American Meso-scale weather model (NAM 12km) from the National Weather Service (NWS). Weather data were organized and uploaded to a relational database created to house the forecasted weather predictions and disease forecasts. Computer code was written to organize and utilize the gridded data and a filing system was created to facilitate rapid data loading. Computer code was written to implement a modified version of the TOM-CAST model (Table 1) based on the NAM 12km weather predictions. The running of this disease model was automated so that risk predictions were updated daily following the download of the weather data. This model assumes that air temperature and relative humidity (i.e. a surrogate for leaf wetness) are the two primary weather factors that lead to disease occurrence/or progression. The model scores a severity value for each day based combinations of relative humidity and temperature and accumulates the severity values either from crop emergence or the last fungicide application. The accumulation of 20 disease severity values triggers a fungicide application. ***Results.*** Model predictions are currently output daily for research purposes and we have been posting static figures of DSV forecasts for Wisconsin at the vegetable pathology website (see <http://www.plantpath.wisc.edu/wivegdis/> for updates). General infrastructure improvements to improve grower accessibility are ongoing and include, 1) updating the computing hardware that currently ingest, house, and calculate the weather-based disease forecasts, 2) updating the computer software that is currently used for database management and 3) continued development of applications (i.e. writing the computer programs) for the GUI that growers can use to access the weather database directly from their home computers.

2013 field evaluation. In 2013, the modified TOM-CAST model was being evaluated in field trials for the management of *A. dauci* and *C. carotae*, respectively. Research plots were established at the UW-Hancock Agricultural Research Station and on a commercial farm in a randomized complete block design with four replicates. Plots were scouted for disease from mid-July to early September and experiments at both locations contained a standard calendar-based fungicide program (Table 2).

Table 2) Experimental treatments, at the Hancock, WI location, used to evaluate the TOM-CAST model based on in-field weather data and NAM 12km weather data.

Trt	Program	Initiation	Initiation	Fungicide Apps.	Rate	Field EIQ[1]
1	UTC	NA	-	-	-	-
2	Calendar	First Symptom	July 17	6	2.0 pint / acre	242
3	In-field DSV	First Symptom	July 17	6	2.0 pint / acre	242
4	In-field DSV	Calendar	July 17	4	2.0 pint / acre	162
5	NAM-based DSV	First Symptom	Aug 7	4	2.0 pint / acre	162
6	NAM-based DSV	Calendar	Aug 7	3	2.0 pint / acre	121

Experimental treatments were established based on fungicide application 1) initiation – fungicide programs were initiated based on the number of days after emergence or the occurrence of the first disease symptom and 2) interval – fungicides were applied according to DSV accumulations calculated based on in-field weather stations or calculated using the NAM 12 km weather model. Bravo Weather Stik was the sole fungicide used in these experiments and was applied at 2 pints per acre when an application was prescribed. ***Results.*** In 2013, we experienced low foliar disease pressure at both experimental locations. This resulted in similar disease control among all fungicide treatments (Figure 1); at Hancock, all fungicide programs performed significantly better than the untreated control and there was no difference in foliar

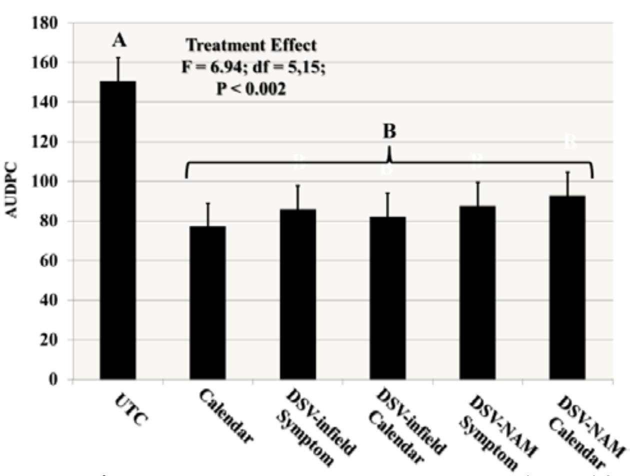

Figure 1) Average area under the disease progress curve (AUDPC) for experimental treatments at Hancock, WI in 2013.

disease control among fungicide programs. Additionally, there were no differences in yield among fungicide programs (F=1.99; d.f. = 5,18; P = 0.15). Thus, at Hancock, WI, all fungicide programs provided the same foliar disease control – those with fewer applications provided equivalent control. For the experiment conducted on-farm, no differences in yield (F=0.94; d.f. = 5,18; P = 0.48) nor disease severity (F=0.79; d.f. = 5,18; P = 0.57) were observed among fungicide programs.

Future work. ***Model validation and optimization.*** To optimize the large scale pest and disease forecasts, model predictions that have been calculated using NWS weather data, specific to field location, will be compared to model predictions that have been calculated using field-observed data. Regression analysis will be used to determine if there is a discrepancy between the action thresholds calculated using NWS weather data and those using field-based weather data. Finally, a correction factor will be developed so that model predictions made over large geographic areas can be (mathematically) mapped to field-level predictions. ***GUI development and information dissemination.*** Currently, efforts are being focused on the development of an internet-based graphical user interface to automate the functionality of the database and to make disease forecasts available to vegetable growers in WI. Stay tuned as there may be a web application coming on-line in the Spring <http://www.plantpath.wisc.edu/wivegdis/>.

Discussion. Disease forecasting systems that inform the timing of fungicide application based on environmental conditions may be useful for managing pathogens that cause foliar diseases of carrot. A typical fungicide program in Wisconsin is initiated when disease symptoms are first detected by scouting and subsequent fungicide applications typically follow a calendar-based spray schedule. However, fungicide reapplication may not be necessary if environmental conditions do not favor disease progression; the severity of disease epidemics largely depends on environmental conditions, dictated primarily by wind and weather patterns. Thus, the application of fungicide informed by a weather-based disease forecasting system could control disease while reducing the number of pesticide applications, thereby improving profitability for vegetable growers and reducing environmental impact. The implementation of the weather-based models to inform spray programs requires a customized forecast for each field that is based on disease severity, weather conditions, and fungicide program, factors that are field-specific. The primary goal of our research is to provide a decision tool for the management of carrot foliar diseases that can be used for the majority of fields and doesn't require grower investment in a weather station for each field.

Acknowledgments. Many thanks to Paul Miller Farms of Hancock, WI for setting up the carrot field trials at the UW-Hancock Agricultural Research Station (HARS) in 2013. We appreciate the crop management efforts of the UW-HARS staff, specifically, Glenn Carlson and Paul Sytsma. Funding for this project was provided, in part, by the WI Specialty Crop Block Grant project entitled "Implementing pest and disease forecasting for enhanced management of vegetable crops grown on muck soils" in addition to support from the Wisconsin Potato and Vegetable Growers Association, the Wisconsin Fresh Market Vegetable Growers Association, and the Midwest Food Processors Association.

IMPLICATIONS OF OFF-TARGET HERBICIDES NEAR SPECIALTY CROPS

Jed Colquhoun, Daniel Heider and Richard Rittmeyer [1]

The introduction of new agronomic crop herbicides in recent years that are active at low doses, as well as the pending introduction of crop traits conferring resistance to additional herbicides, have spurred an interest among specialty crop producers in knowing more about the potential off-target implications of these tools. While pesticide drift remains a concern, our recent work has focused more on implications of potential spray tank contamination when specialty crops are sprayed after agronomic crops, such as corn, soybean or small grains. We recently completed a replicated study in snap bean and potato in this subject area and have also completed the first repetition of a 2-year study looking at the implications of potato seed crop exposure to herbicides on daughter tuber germination and growth.

In 2011 and 2012 our research focused on the implications of off-target synthetic auxin and glyphosate herbicides on snap bean and potato production. The overall goal of this research was to describe the relationship between visually estimated crop injury and snap bean and potato yield and quality. In snap bean in 2011, injury from dicamba 7 DAT (days after treatment) ranged from 19% at the 1.2 g ae ha^{-1} application rate to 45% at the 7.0 g ha^{-1} application rate. By 28 DAT in 2011, injury from 2,4-D was similar to the nontreated control. However, early-season injury in 2011 delayed snap bean flowering and reduced crop yield compared to the nontreated control for all treatments except where the 1.4 g ae ha^{-1} rate of 2,4-D and glyphosate at 7.0 g ae ha^{-1} were applied. Snap bean injury from dicamba was greater than that from 2,4-D at all rating timings in 2011 and two of three rating timings in 2012, and crop yield was reduced compared to where 2,4-D was applied and the nontreated control in both years. Potato tuber size distribution was variable and total yield did not differ among treatments and the nontreated control in 2011. In 2012, tuber size distribution was again variable, but more non-marketable cull potatoes were harvested when dicamba was applied to 25 cm potato plants at the 7.0 g ha^{-1} rate compared to any other treatment. Snap bean injury observations about three weeks prior to harvest were strongly correlated with crop yield ($r = -0.84$ and -0.88 in 2011 and 2012 respectively), allowing time to make informed harvest decisions relative to crop quality. In contrast, the relationship between potato injury and tuber yield was poor and highly variable in both years [2].

In 2013 we initiated the first replication of a 2-year study investigating the implications of potato seed crop exposure to off-target herbicides (such as through tank contamination) on daughter tuber germination, growth and yield. Thirteen herbicides commonly used in agronomic and non-crop areas nearby potato seed production were evaluated at 1% of the commercial use rate applied at potato tuber initiation. Glyphosate was also evaluated at 2 and 4% of typical use rates. In the seed crop production year (2013), potato injury visually estimated 5 DAT was greatest where mesotrione was applied. By 28 DAT, potato injury differed from the nontreated check only where dicamba or aminopyralid were applied. Other than the aforementioned herbicides, injury from other herbicides was 5% or less at all visual evaluation timings. Total potato tuber yield and individual potato grade class weights were similar among herbicide treatments and the nontreated check. Additionally, non-marketable and misshapen cull tuber weight did not differ among treatments. Seed from the mother plants was stored and planted in

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[2] Adapted from a 2014 Weed Technology article (in press) by the same authors.

the 2014 growing season. Injury was observed in some cases from the 2013 herbicide application, but statistical analyses of these data were not available at the proceedings deadline. Interestingly, the injury was sporadically observed among plants within a plot, where affected potato plants were often surrounded by healthy plants. A repetition of this study was initiated in 2014 and subsequent seed potatoes will be planted in 2015.

COVER CROP OPTIONS FOR PROCESSING VEGETABLES

Erin Silva [1/]

Cover crops are increasingly recognized for their multiple agronomic benefits, including improving soil quality and health, enhancing soil fertility, and preventing erosion. Choosing cover crops for a particular farming system requires consideration of several factors, including planting window, termination time and strategy, desired functionality (weed suppression, erosion prevention, nitrogen credits), and potential disease and insect interactions. Resources exist to assist farmers in the selection of appropriate cover crops for their specific system and crop rotations. The Midwest Cover Crop Council has created one of the most extensive sources of information regarding cover crops for the upper Midwest; comprised of a diverse group of academia, farmers, non-governmental organizations, and state and federal agency representatives, this group works to provide materials on cover crop practices and opportunities, including farmer profiles, webinars, and field days. The information is housed on their website, www.mccc.msu.edu.

The cover crop selector tool, housed on MCCC's website, is a powerful tool that provides farmers information as to cover crop options and agronomic recommendations. Farmers can input their location, cash crop, planting and harvest dates, soil drainage classes, and cover cropping goals, and obtain cover crop recommendations. From this page, farmers can generate information sheets that provide seeding rates, attributes and performance, cultural traits, agronomic advantages and ecosystem services, and potential disadvantages. With this information, farmers can more effectively evaluate cover crop options for their farms.

References

Midwest Cover Crop Council (MCCC). Cover Crop Decision Tool. http://www.mccc.msu.edu/selectorINTRO.html

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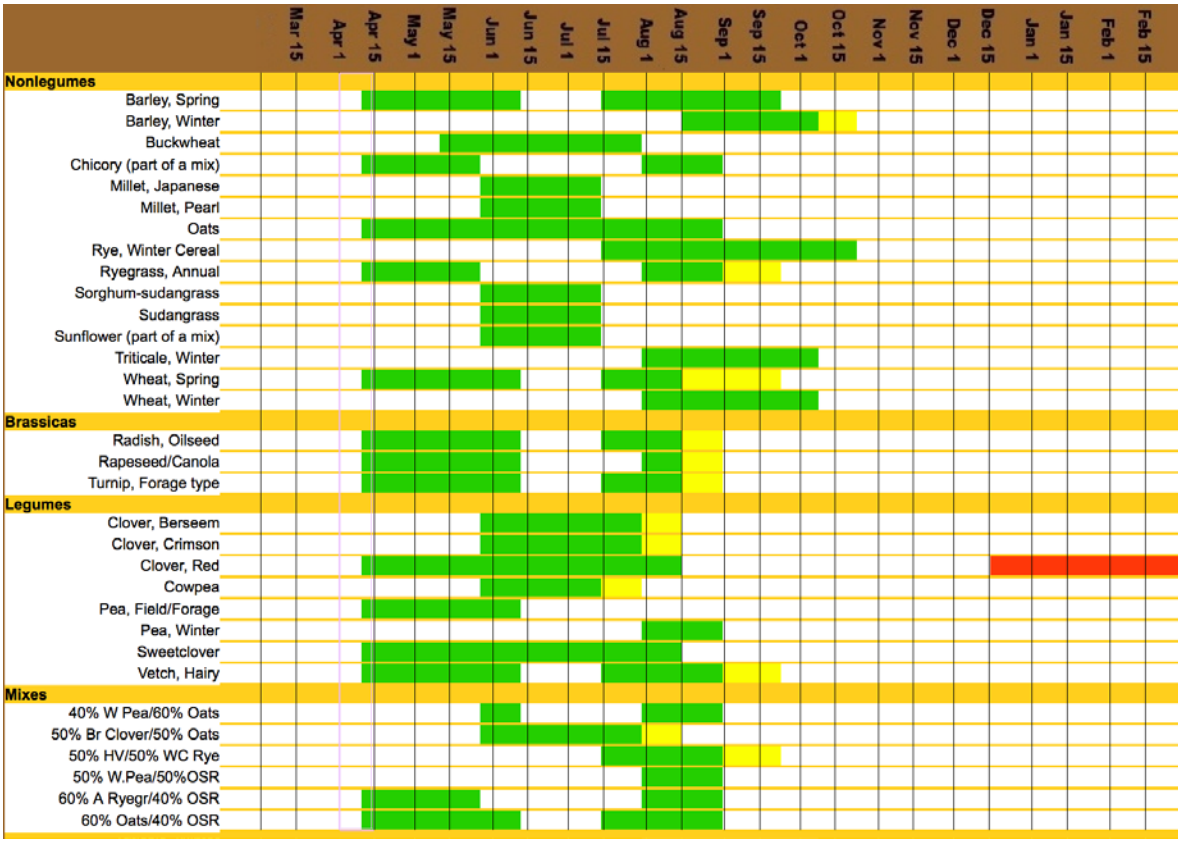
Table 1. Example information from the MCCC interactive cover crop selector tool, summarizing cover crop options for vegetable crops in Wisconsin



USE OF CROP SENSORS FOR NITROGEN MANAGEMENT

Richard Ferguson [1/]

{This page provided for note taking}

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EVALUATION OF ADAPT-N IN THE CORN BELT

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Introduction

Nitrogen is the plant nutrient required in the largest quantity, the most likely to be deficient, and the most impactful on corn yield as well as grower profit. Providing N to a corn crop in the right amount while minimizing loss is difficult because of complex biological and chemical reactions that result in the loss of N from the crop root zone via deep percolation to ground water, lateral flow, runoff and erosion to surface waters, and volatile losses to the atmosphere as ammonia, nitrogen gas, nitric oxide, nitrous oxide, etc. Increasing crop utilization of N and reducing loss of N outside the field is important to the sustainability of corn production in the Corn Belt.

Optimizing the rate of fertilizer N based on profit is one approach to reducing fertilizer N loss from corn production systems. Nitrogen rate recommendations for most Corn Belt states are based on the aggregation of results from numerous N response trials and a simple economic analysis that considers the value of grain and the cost of N. This approach is commonly referred to as MRTN – Maximum Return to Nitrogen (Sawyer et al., 2006). Nitrogen recommendations from this approach “should provide an N rate that reflects economic value and probability of achieving expected economic return across a range of locations and period of time.” The recommendations are general in nature and therefore not responsive to variations in seasonal weather.

Adapt-N is a mechanistic model that utilizes several soil and management parameters, anticipated yield, and actual and historic weather to provide a field- and season-specific N recommendation that is purported to be more accurate than the general recommendation given by the MRTN approach (http://adapt-n.cals.cornell.edu/manual/index.html).

This project compared the accuracy and profitability of N recommendations from MRTN and Adapt-N in Iowa, Indiana, and Wisconsin.

Methods and Materials

Data from 79 replicated field strip and small plot corn N response trials in Iowa (n=24), Indiana (n=15), and Wisconsin (n=40) were compiled. Trial sites had corn following soybean or corn. All trials were conducted in 2013 except for two Indiana trials which were conducted in 2014. In Wisconsin, N application rates were applied to sites where N was previously applied at uniform rates across the study area. In Iowa and Indiana some sites were part of ongoing studies where N was applied at the same rates in consecutive years, others had uniform N rates in prior years. Twenty-seven of the Wiscosin sites were part of a larger manure application timing trial at three locations were manure (none, raw, or digested) was applied in early fall, late fall, or spring and sidedress N applications were imposed on the manure/timing treatments. Nitrogen was applied sidedress, with the exception of a small amount of starter fertilizer at some sites, for all N response trials in Wisconsin and Indiana, whereas N was applied either at sidedress or just prior to planting in Iowa. Regression models were used to fit the corn grain yield response to the total N application rate, including starter fertilizer, for each trial. The economic optimum N rate (EONR) was calculated at a N:corn price ratio of 0.10.

The MRTN recommended N rate for each site was determined using a 0.10 N:corn price ratio and the Corn Nitrogen Rate Calculator (http://extension.agron.iastate.edu/soilsfertility/nrate.aspx) or a tabular version of MRTN rate recommendations for Wisconsin (Laboski and Peters, 2012) and Indiana (Camberato et al., 2014). Manure N credits were subtracted from the MRTN rate as per Laboski and Peters (2012) using manure that was sampled at the time of application and subsequently analyzed. The corn yield at the MRTN rate was determined by inputting the MRTN rate into the N response model for each site.

The Adapt-N recommended rate was determined by entering required site information in the online model at http://adapt-n.cals.cornell.edu (2013) or http://www.adapt-n.com (2014). The required information included: geo-referenced location, soil texture or series name, slope, soil organic matter, rooting depth, tillage system, previous crop, corn hybrid maturity, planting date and population, expected yield range, starter fertilizer N, manure application date, manure ammonium-N and organic-N concentrations. The model predicted sidedress N application rate was determined with the actual sidedress N application date as the model run date in Wisconsin and Indiana and with June 1 as the sidedress application date in Iowa, regardless of when N was applied sidedress or preplant. The corn yield at the Adapt-N recommended rate was determined by entering the Adapt-N plus starter fertilizer rate into the N response model for each site.

Adapt-N and MRTN recommended N rates were compared to the site EONR by subtracting the EONR from the respective recommended rate. Positive numbers indicate an over recommendation while negative numbers indicate an under recommendation. The profitability of Adapt-N and MRTN were calculated by multiplying the yield from each N recommendation system by $4.00 per bushel and subtracting the cost of N. Cost of N was determined by multiplying the total N appliation rate, including starter, by $0.40 per pound of N. The MRTN advantage was calculated by subtracting Adapt-N profitability from MRTN profitability. The Adapt-N subscription fee was not included in the profitability calculation. MRTN recommendation tools are freely available to the public.

Results and Discussion

The distribution of Adapt-N or MRTN recommended N rate differences from site specific EONRs was variable among states and previous crops (Figures 1 and 2). It is very difficult for any N recommendation system to exactly estimate a site EONR due to many uncontrollable factors; however, N recommendation systems can be compared with regard to how close they come to providing a recommendation within 25 lb N/a of site EONRs. Adapt-N recommended N within 25 lb N/a of site EONR at 6, 7, and 39% of the sites where corn followed soybean in IA, IN, and WI, respectively; while MRTN recommended N within 25 lb N/a of site EONR at 63, 36, and 50% of the sites in IA, IN, and WI, respectively. Where corn followed corn grain or silage, Adapt-N rates were within 25 lb N/a of site EONR at 13 and 23% of sites in IA and WI, respectively; whereas MRTN rates were within 25 lb N/a of site EONR at 38 and 5% of of sites in IA and WI, respectively. In all states, MRTN recommended rates were more likely to be within 25 lb N/a of site EONR compared to Adapt-N with the exception of corn following corn in WI.

An N recommendation system is considered to have under or over recommended N if the recommended N rate was more than 25 lb N/a different than the site EONR. Where corn followed soybean, Adapt-N under recommended N at 94, 86, and 39% of sites in IA, IN, and WI, respectively; while MRTN under recommended N at 38, 50, and 39% of sites in IA, IN, and WI, respectively. Where corn followed corn grain or silage, Adapt-N under recommeded N at 75 and 18% of sites in IA and WI; while MRTN under recommended N at 38 and 27% of sites in IA and WI. The general trend is for Adapt-N to under recommend N to a greater extent than MRTN in IA and IN. In WI, both Adapt-N and MRTN under recommend N at a similar percentage of sites. The IA data are consistent with data from 2011 and 2012 which was previously reported by Sawyer (2013). Spring 2013 was wet throughout much of the study region. The large under recommendations of N by Adapt-N in IA and IN suggest that Adapt-N may not be adequately modeling N loss from excessive spring rainfall in these environments.

The wider range in distribution of differences in N recommendation systems compared to site EONR in WI (Figure 2) was investigated more closely. The three locations that were part of a manure study contributed 27 sites for this analysis, nine per location. Each location was approximate 5 to 6 acres in size with one-third of the area devoted to each manure application timing. At each manure application timing, raw, digested, or no manure was applied in 4 replicates. Sidedress N application rates were imposed over all manure treatments at each time of application. Where no manure was applied the EONR ranged from 139 to 210, 130 to 205, and 0 to 132 lb N/a at each of the three locations. The large range in EONR at a location demonstrates within field variability in N response in a year following a major drought. The Adapt-N input parameters for each location would not vary across the manure application timings; thus Adapt-N would not be able to predict this variability. The previous crops at these locations were soybean, corn silage, and corn silage. At the corn silage locations (n=18), it is possible that residual N from the drought carried through to 2013, and even though spring 2013 was wet, perhaps not all of the residual N was lost and thus contributed to variability in N response. This hypothesis will be tested using soil profile nitrate concentrations in samples collected in spring of 2013. Where soybean was the previous crop, one manure application timing was in an area where the soil was a bit rockier on the surface and the slope was steeper, but not enough to change Adapt-N input parameters. There were a few weeks of dry weather from July into August, and in the rockier area, corn was visually showing signs of moisture stress that was not apparent in the other manure application timings.

At the manure study locations, there was substantial within field variability that can not fully be explained; thus, sites from these locations were excluded and the differences in N recommendation systems compared to site EONR were re-evaluated. Upon exclusion of these sites, there were nine sites where corn followed soybean and four where corn followed corn. The evaluation will focus on the larger corn following soybean data set. Figure 2 shows the distribution of differences in N recommendation systems compared to site EONR when corn follows soybean using this smaller data set. Recommended N rates were within 25 lb N/a of site EONR at 44% of the sites using Adapt-N and 89% of sites using MRTN. Adapt-N under recommended N at 33% of sites, while there were no under recommendations with MRTN.
Removing all sites from the manure study where manure was and was not applied, greatly reduced the extreme deviation in N recommendation systems compared to site EONR.

Profitability of N recommendations is important to farmers. Under application of N usually presents a larger risk of reduced profitability compared to over application. Difference in mean profitability of the N recommendation systems from site EONR, along with the mean difference in N recommendations, is provided in Table 1. In IA and IN, profitability of Adapt-N was $85 and $95 per acre less than site EONR. MRTN offers an average economic advantage over Adapt-N of $66 and $77 per acre, for all sites in IA and IN (Table 1). In contrast, Adapt-N had an average economic advantage over MRTN of $2 per acre in WI. MRTN was more profitable than Adapt-N for all previous crops in IA ($66/acre) and for a previous crop of soybean in IN ($84/acre). There was only one IN location with a previous crop of corn. In WI, there was no substantial economic advantage to either N recommendation system when all sites were considered. However, when sites from the manure study were excluded and where soybean was the previous crop, MRTN was more profitable than Adapt-N ($13/acre, Table 2).

The effect of manure applied for the 2013 crop on profitability of N recommendation systems in WI is provided in Table 2. Adapt-N was more profitable where corn was the previous crop and no manure was applied; however when soybean was the previous crop Adapt-N was more profitable when manure was applied. The difference in N recommendation systems may be a result of how well manure N credits are predicted, but is complicated by the high variablity in EONR when no manure was applied at these sites, as previously discussed. Further evaluation of Adapt-N where manure is applied is warranted.

Summary

- The general trend was for Adapt-N to under recommend N to a greater extent than MRTN in IA and IN. In WI, both Adapt-N and MRTN under recommended N at a similar frequency. In addition, Adapt-N did not reduce the variability in recommended N rates compared to site optima.
- In all states, MRTN recommended rates were more likely to be within 25 lb N/a of site EONR compared to Adapt-N with the exception of corn following corn in WI.

- The MRTN system was more profitable than Adapt-N in IA and IN. In WI, the two N recommendation systems had similar profitability when all sites were considered. However, when sites with large spatial variability in N response were removed from the WI dataset, MRTN was more profitable than Adapt-N.
- Adapt-N is unable to capture all spatial variability in N response because there are not enough input parameters to adequately characterize zones within fields, and some input parameters have little impact on the N rate recommendation.
- Adapt-N may not adequately model N loss from excessive rainfall or mineralization and subsequent availabilty of manure N.

References

Camberato, J., R.L. Nielsen, and B. Joern. 2014. Nitrogen management guidelines for corn in Indiana. URL: http://www.kingcorn.org/news/timeless/NitrogenMgmt.pdf.

Laboski, C.A.M. and J.B. Peters. 2012. Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin. UWEX Publication A2809. p. 88.

Sawyer, J.E. 2013. Comparison of the MRTN and Adapt-N derived N rates for corn. Proc. North Central Extension-Industry Soil Fertility Conf. 29:60-67.

Sawyer, J., E. Nafziger, G. Randall, L. Bundy, G. Rehm, and B. Joern. 2006. Concepts and rationale for regional nitrogen rate guidelines for corn. Iowa State Univ. Extension (PM-2015). URL: http://www.extension.iastate.edu/Publications/PM2015.pdf.

{From the Proceedings of the North Central Extension-Industry Soil Fertility Conference}

Table 1. Difference in profitability of Adapt-N or MRTN N recommendation systems compared to the site economic optimum N rate (EONR) (profitability of N recommendation system minus profitability of site EONR) for corn along with the economic advantage of MRTN over Adapt-N (profitability of MRTN minus profitability of Adapt-N) for corn N rate recommendations in Iowa, Indiana, and Wisconsin, 2013 all states and 2014 for 2 sites in IN. Negative MRTN advantage numbers indicate Adapt-N was more profitable than MRTN.

			Adapt-N - EONR	MRTN - EONR	MRTN Advantage		
State	Previous crop	n	Mean	Mean	Mean	Min	Max
			$/acre				
IA	All	24	-85 (-74) †	-19 (-18)	66	-9	180
	Corn grain	8	-78 (-64)	-15 (0)	63	-9	141
	Soybean	16	-89 (-80)	-21 (-27)	68	-3	180
IN	All	15	-95 (-78)	-17 (-17)	77	-21	166
	Corn grain	1	-15 (-33)	-29 (-47)	-14	--	--
	Soybean	14	-100 (-82)	-16 (-15)	84	-21	166
WI	All	40	-24 (24)	-26 (5)	-2	-87	56
	Corn grain/silage	22	-29 (51)	-29 (29)	0	-87	36
	Soybean	18	-19 (-9)	-23 (-25)	-3	-52	56

† Number in parenthesis is the N application rate, lb N/a, difference of the N recommendation system from the EONR.

Table 2. Effect of previous crop and manure application for 2013 sites on the economic advantage of MRTN over Adapt-N (profitability of MRTN minus profitability of Adapt-N) for corn N rate recommendations Wisconsin. Negative numbers indicate Adapt-N was more profitable than MRTN.

Previous crop	Manure	n	MRTN Advantage		
			Mean	Min	Max
			$/acre		
Corn grain/silage	No	10	-10	-87	10
	Yes	12	8	-50	36
Soybean	No	12	8	-12	56
	Yes	6	-27	-52	4
Soybean †	No	9	13	-3	56

† Excludes all sites from manure study.

Figure 1. Distribution of Adapt-N (sidedress + starter if applied) and MRTN (includes starter if applied) N recommendations compared to site economic optimum N (EONR) rates at a 0.10 N:corn price ratio in Iowa for 2013 and Indiana for 2013 (n=12) and 2014 (n=2).

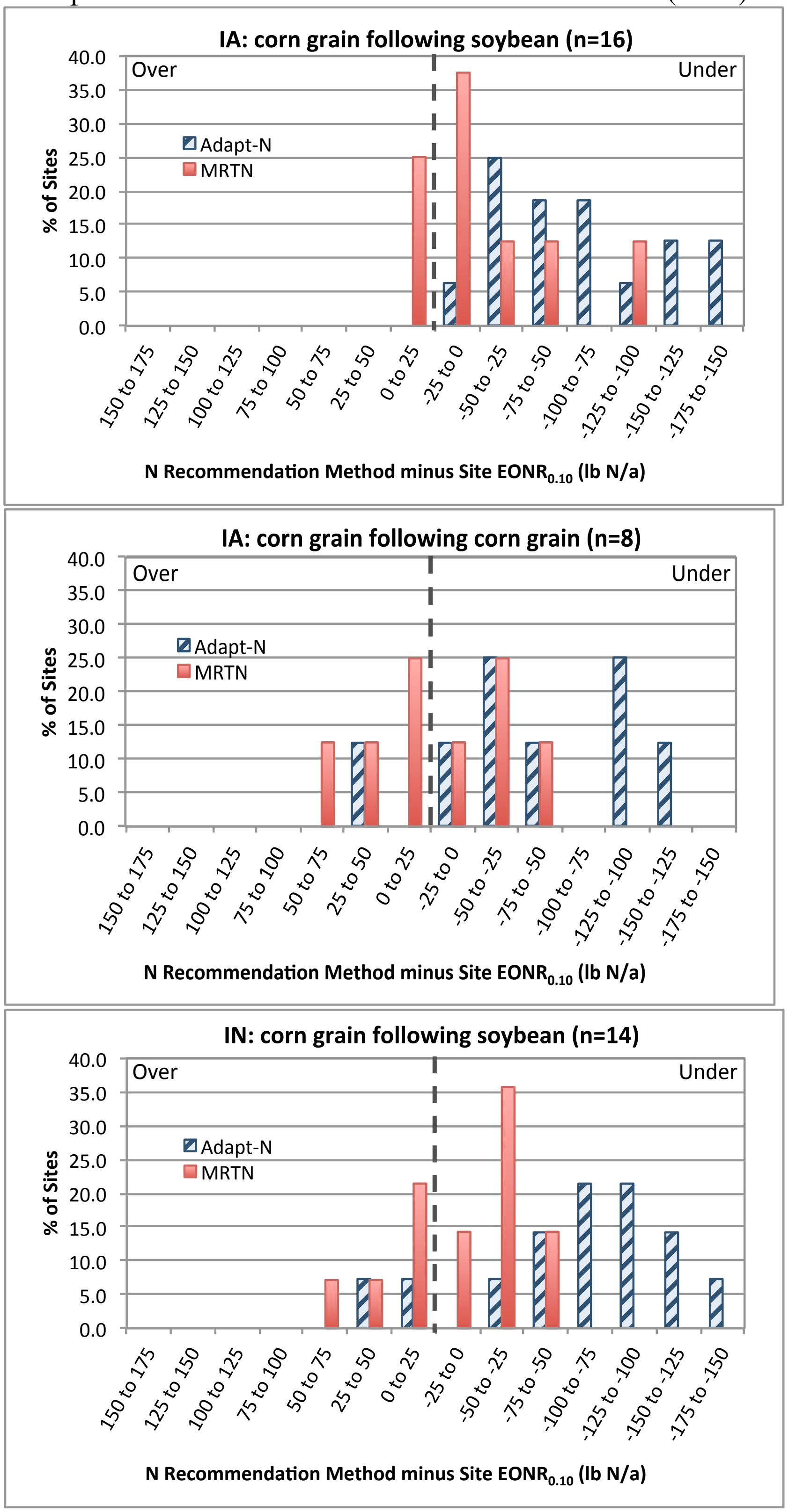
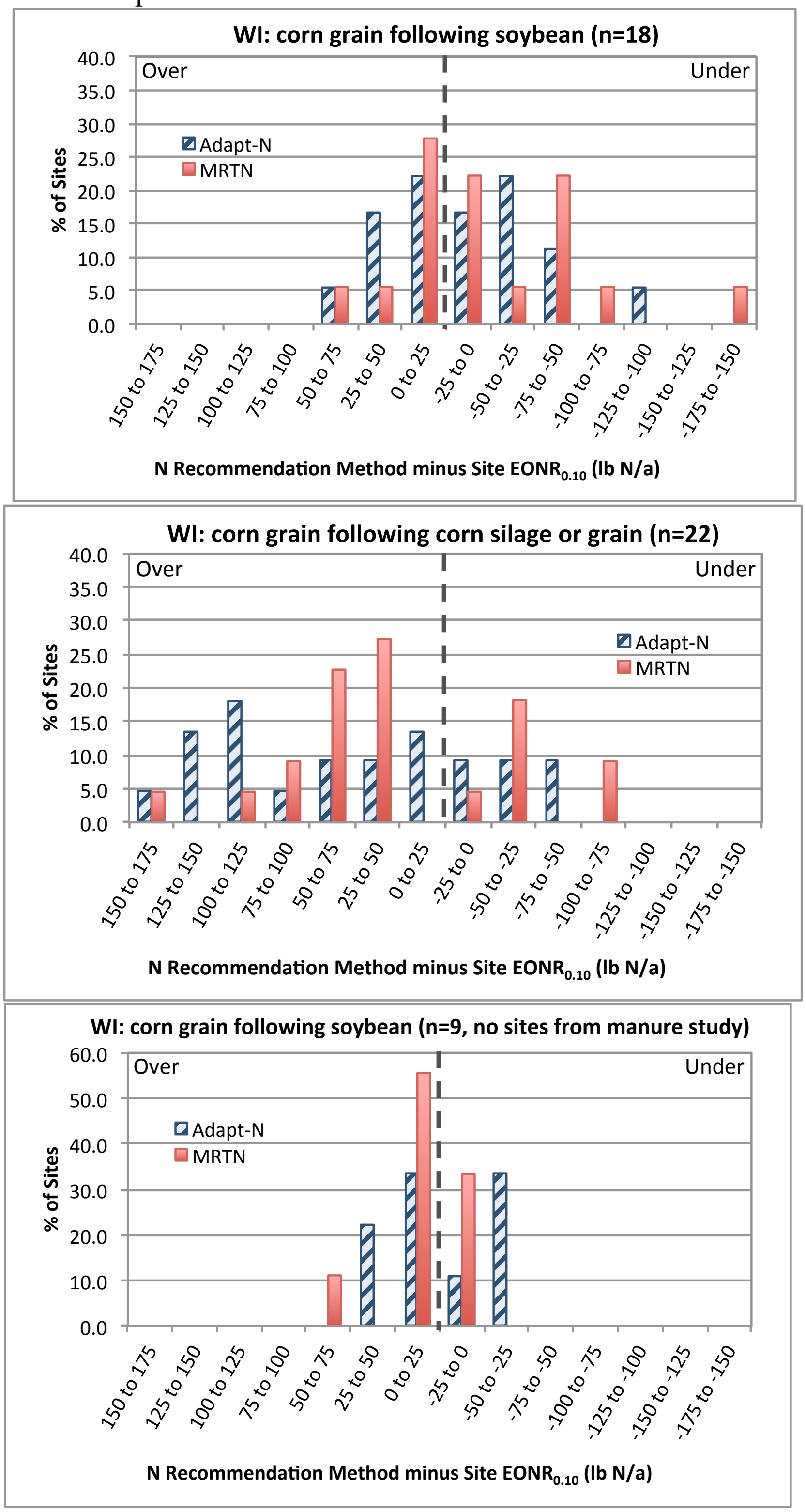


Figure 2. Distribution of Adapt-N (sidedress + starter if applied) and MRTN (includes starter if applied) N recommendations systems compared to site economic optimum N rates (EONR) at a 0.10 N:corn price ratio in Wisconsin for 2013.



GOVERNMENT AGENCY PANEL ON NUTRIENT MANAGEMENT

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GROUNDWATER QUALITY AND NITROGEN USE EFFICIENCY IN NEBRASKA'S CENTRAL PLATTE RIVER VALLEY

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Abstract

In response to increasing levels of nitrate-N in groundwater in the Central Platte River Valley of Nebraska, intensive education and then regulatory efforts were implemented starting in the 1980s, to encourage adoption of nitrogen fertilizer and irrigation management practices which can reduce nitrate leaching to groundwater. Since 1988, there have been steady declines in average NO_3-N concentrations in groundwater in the Central Platte River Valley, resulting from adoption of recommended practices – in particular conversion from furrow to center-pivot irrigation. However, fertilizer nitrogen use efficiency has remained fairly static over the past 25 years. Trends suggest that further improvement in nitrogen use efficiency may require development and adoption of next-generation nutrient management tools, such as increased use of fertigation, controlled release formulations, or crop canopy sensors for in-season fertilization.

Introduction

Elevated nitrate-N levels in groundwater have been a concern in Nebraska since the early 1960s, with the first reported NO_3-N concentrations of greater than 10 mg L^{-1} in Merrick County in 1961 (Nebraska Water Quality Survey 1965; Meals et al., 2012). Merrick County is in the eastern portion of the Central Platte River Valley, and is characterized by relatively shallow, coarse-textured soils, shallow aquifers, and extensive irrigation development. Exner and Spalding (1976) found elevated nitrate levels in groundwater through much of the Central Platte Valley in 1974, with approximately 20% of the area exceeding 10 mg NO_3-N L^{-1}. Nitrate movement into groundwater in the Central Platte Valley can be attributed primarily to overuse of both nitrogen (N) fertilizer and irrigation water (Spalding and Exner, 1993). By the late 1980s, it was not unusual to find irrigation wells with 30-40 mg NO_3-N L^{-1} in the Central Platte Valley, especially in Merrick County.

Approach

In 1988, the first Groundwater Management Area (GWMA) was established in Nebraska, in the area covered by the Central Platte Natural Resources District (CPNRD) (CPNRD, 2014). The CPNRD covers all or parts of 11 counties in the central part of the state. Regulations associated with the CPNRD-GWMA vary by region, or phase, within the district, according to the severity of nitrate contamination. Regulations discourage or ban fall nitrogen application, especially to sandy soils. The use of nitrification inhibitors is encouraged or required, depending on the region of the GWMA. Producers in Phase 2 and 3 areas are required to report annually to the CPNRD on the rate and timing of nitrogen fertilizer, as well as irrigation water amounts. Producers in Phase 2 and 3 areas are also required to be certified by the CPNRD in fertilizer and irrigation water management every four years, either through attendance at certifying workshops or conferences, or by taking an exam. Regulations in the CPNRD-GWMA also include the potential for imposition of Phase 4 areas, in which the CPNRD would set expected yield and thus the fertilizer N rate. However, no Phase 4 areas have been designated to date.

Beginning in 1979 with the Hall County Water Quality Special Project, and continuing to date, the CPNRD and the University of Nebraska-Lincoln (UNL) have collaborated on educational efforts to encourage adoption of nitrogen and irrigation best management practices. A central component of these efforts have been demonstration/on-farm research efforts with area producers. Practices demonstrated include use of the UNL N recommendation algorithm for corn, scheduling irrigation based on stored soil water and crop water use, appropriate use of irrigation technologies such as flow meters and soil moisture sensors, and the use of nitrification inhibitors. Over the past 30 years hundreds of demonstrations have been conducted in collaboration with area growers - typically field-length, randomized and replicated treatments implemented by the producer.

One of the benefits of the CPNRD-GWMA has been the development of a large database of producer practices over time. This resource allows tracking of change in producer practices as a result of educational and regulatory efforts in the GWMA. Figure 1 illustrates the trend in expected and actual yields over the past 25 years. On average expected and actual yields have increased between 1.1 and 1.6 bu $acre^{-1}$ yr^{-1}, as yield potential has increased with improved hybrids and production practices. While we would like to see greater congruence between expected and actual yield, producers are more realistic today when setting expected yield than they were 30 years ago (Schepers et al., 1986; 1991).

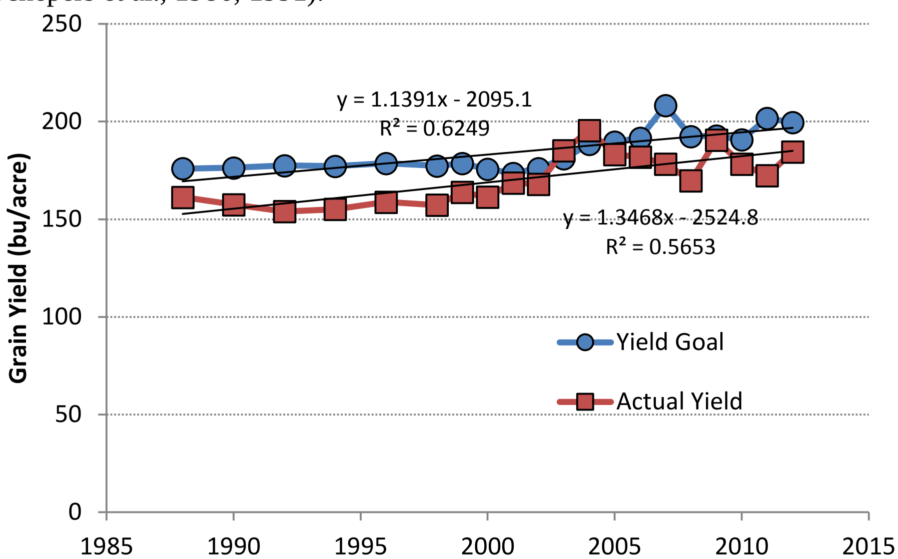

Figure 1. Trends in expected and actual corn grain yield, CPNRD-GWMA, 1988-2012.

Recommended fertilizer N rates have gradually increased over the past 25 years (Figure 2), as have actual applied rates. Based on current trends, grower N rates are closer to the desired goal in 2012 than they were in 1988. The environmental impact from 24 years of combined education and regulatory efforts is shown in Figure 3. On average, groundwater NO_3-N concentrations in these Phase 2 and 3 areas has declined by 0.15 mg NO_3-N L^{-1} yr^{-1}, from a peak of around 19 mg L^{-1} to around 15 mg L^{-1} in 2012. These trends indicate that grower adoption of recommended practices is having a positive impact on groundwater quality.

In a study conducted over a Phase 3 area of the CPNRD-GWMA as part of the National Institute of Food and Agriculture (NIFA) Conservation Effects Assessment Project (CEAP), Exner et al. (2010) found that in this area conversion of irrigated land from furrow to sprinkler irrigation had the greatest effect on improving groundwater quality – accounting for ~ 50% of the decline in groundwater NO_3-N concentration from 1988 to 2003. During this period, approximately 15% of fields on the Platte River terrace converted from furrow to center-pivot irrigation. They also found increased crop removal of N – associated with increased yield while fertilizer N rates remained static – to be responsible for ~20% of the decline.

The GPNRD-GWMA database allows calculation of one measurement of nitrogen use efficiency (NUE) – Partial Factor Productivity, or lb of grain produced per lb of fertilizer N (PFP_N). Figure 4 illustrates that in this GWMA there has been little change in PFP_N over the past 24 years, increasing from around 60 in 1988 to around 65 lb grain/lb fertilizer N in 2012. This is in contrast to the average trend statewide for Nebraska (Figure 5) – around 49 lb grain/lb fertilizer N in 1988, and around 65 lb grain/lb fertilizer N in 2012. These trends suggest that the level of N

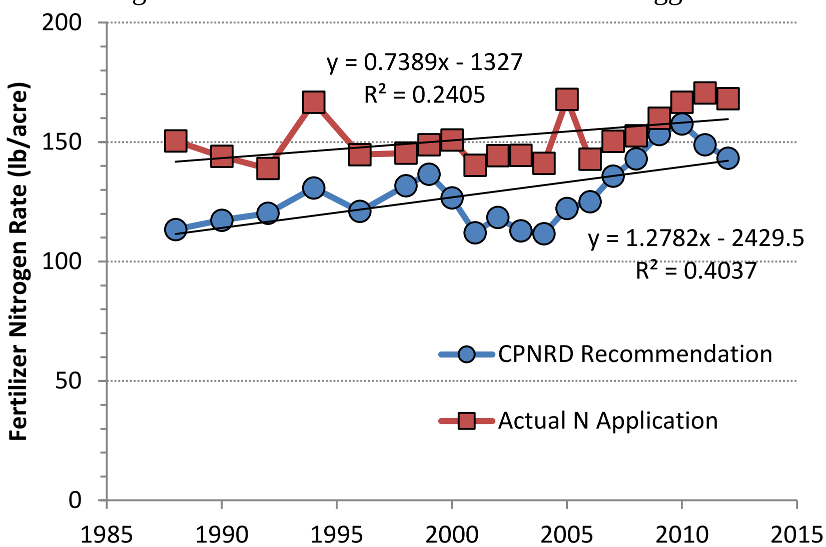

Figure 2. Trends in recommended and actual fertilizer N rate, CPNRD-GWMA, 1988-2012.

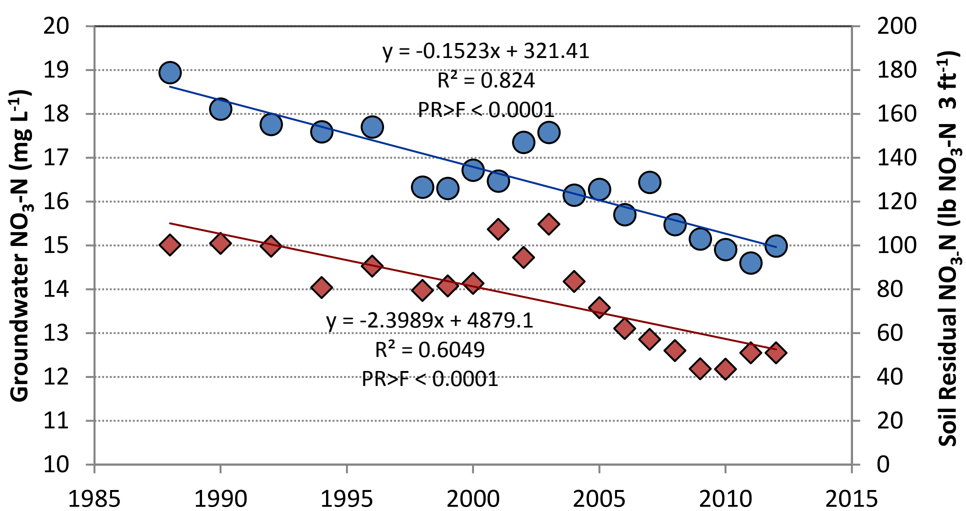

Figure 3. Groundwater and soil residual nitrate-N trends, CPNRD-GWMA, 1988-2012.

management in the CPNRD-GWMA was above the state average in 1988, but about the same as the rest of the state in 2012. The lack of substantial improvement in NUE in the CPNRD-GWMA over the past 24 years is of concern. When credit for other sources of N is accounted for, where measureable available inorganic N is the sum of fertilizer N, soil residual nitrate, and irrigation water nitrate credit, the trend is more positive. However, these trends suggest that current practices may be reaching their maximum efficiency, and that further gains in NUE will require more aggressive or refined practices.

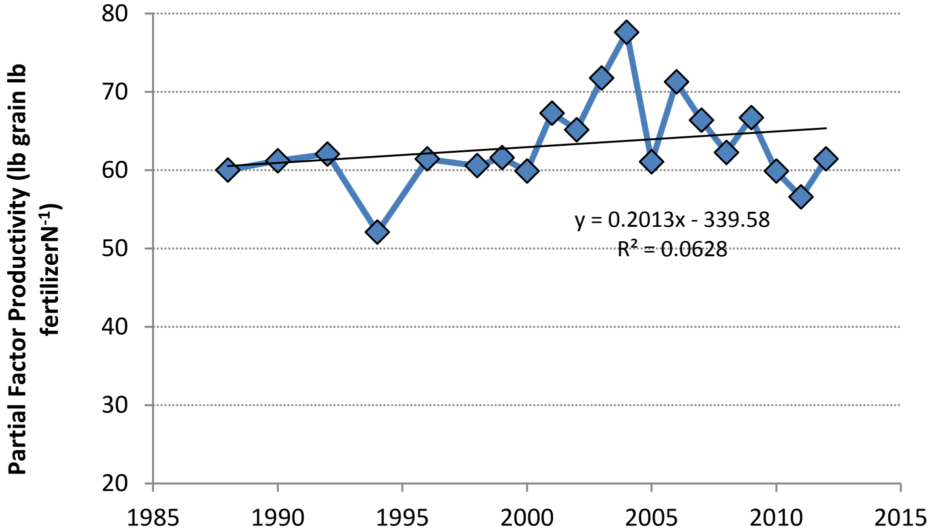

Figure 4. Partial factor productivity for nitrogen, CPNRD-GWMA, 1988-2012.

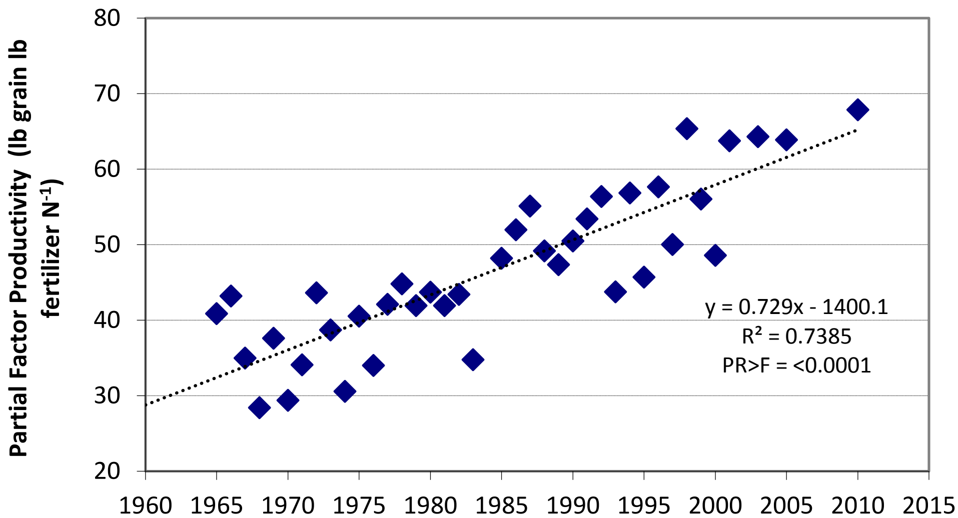

Figure 5. Partial factor productivity for nitrogen, state of Nebraska (includes rainfed and irrigated corn).

Summary

Groundwater nitrate contamination has been of concern in the Central Platte River Valley of Nebraska for over 50 years. Elevated nitrate in groundwater is due to the combination of extensive irrigation development, growing primarily corn, with initially inefficient irrigation and nitrogen fertilizer management, as well as shallow aquifers and frequent occurrence of sandy soils. Improved irrigation and nitrogen management practices implemented over the past 25 years have resulted in measured improved in groundwater quality, although NO_3-N levels are still high. Trends in PFP_N statewide and in the CPNRD-GWMA suggest that current N fertilizer management practices may be reaching their limit on improving N use efficiency. The development, refinement, and adoption of next-generation nutrient management techniques, such as increased use of fertigation, controlled release formulation, or use of crop canopy sensors for in-season N application, may be required for further significant gains in N use efficiency in these irrigated systems.

References

Central Platte Natural Resources District, Groundwater Management Area Plan (http://www.cpnrd.org/GW%20Quality%20Mgnt%20Controls.pdf) (referenced May 2014).

Exner, M.E., and R.F. Spalding. 1976. Groundwater quality of the Central Platte Region, 1974. Resource Atlas No. 2, Lincoln, NE. Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska.

Exner, M.E., H. Perea-Estrada, and R.F. Spalding. 2010. Long-term response of groundwater nitrate concentrations to management regulations in Nebraska's Central Platte Valley. TheScientificWorld Journal 10:286-297.

Meals, D.W., R. Spalding, M. Exner, R. Ferguson, M. McFarland, D. Osmond, J. Spooner. 2012. Groundwater beneath a Phase III Management Area in the Central Platte Natural Resources District, Nebraska: National Institute of Food and Agriculture, Conservation Effects Assessment Project. In: How to Build Better Agricultural Conservation Programs to Protect Water Quality: The National Institute of Food and Agriculture – Conservation Effects Assessment Project Experience. Soil and Water Conservation Society, Ames, IA.

Nebraska Water Quality Survey. 1965. Lincoln, NE. University of Nebraska Extension Service. University of Nebraska.

Schepers, J.S., K.D. Frank, and C. Bourg. 1986. Effect of yield goal and residual soil nitrogen considerations on nitrogen fertilizer recommendations for irrigated maize in Nebraska. J. Fert. Issues 3:133-139.

Schepers, J.S., M.G. Moravek, E.E. Alberts, and K.D. Frank. 1991. Maize production impacts on groundwater quality. J. Environ. Qual. 20:12-16.

Spalding, R.F., and M.E. Exner. 1993. Occurrence of nitrate in groundwater – a review. J. Environ. Qual. 22:392-402.

MAKING EVERY SEED COUNT: WHO'S RESPONSIBLE FOR STAND LOSS[1]

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Seedling diseases of soybean and corn can cause significant losses through poor stand establishment and reduced plant vigor. Identifying the causal agent of seedling disease is not a simple process as the soil environment is complex and contains many thousands of microbe species but only a small portion of these actually cause disease. The primary causes of soybean seedling disease are *Pythium* spp., *Phytophthora sojae, Rhizoctonia solani* and *Fusarium* spp. In this study it was our objective to identify the predominant oomycete (*Pythium* and *Phytophthora*) species that cause soybean seedling disease. Only by understanding which pathogens cause disease are we are ultimately able to improve disease management.

A survey was conducted over two years across the north central region to identify oomycete species that contribute to seedling disease. The survey was conducted in collaboration with Extension specialists in each state. In each state approximately 6 fields with emergence issues were sampled by collecting 50 diseased soybean seedlings. The soybean seedlings were then taken back to the individual labs at each state, washed thoroughly and isolations were made using agar medium containing antibiotics to limit the growth non-oomycete species.

Overall, 82 different oomycete species were identified across the Midwest, including species of *Pythium, Phytophthora, Phytopythium* and *Aphanomyces*. *Pythium sylvaticum* was the most abundant species across both years. In 2011, a total of 52 *Pythium,* 2 *Phytopythium* and 3 *Phytophthora* spp. were recovered, with *Py. sylvaticum* (16%) and *Py. oopapillum* (12%) being the most frequent. In 2012, a total of 57 *Pythium* spp., 7 *Phytophthora* spp., and 4 *Phytopythium* were found, with *Py. sylvaticum* (15%) and *Py. heterothallicum* (13%) species being most abundant.

Analyses of the oomycete species collected by location have demonstrated that similar geographies group together, i.e. the species identified in one state closely reflect the species collected in a neighboring state. This indicates that fungicide seed treatments may need to be tailored by region to have maximum efficacy. Further analysis to understand these geographic patterns using GIS and metadata are currently being conducted.

We have screened representative isolates of all 82 oomycete species for their pathogenicity to soybean seed and soybean seedlings. Using a combination of this pathogenicity data and the distribution data we will be able to identify the predominant pathogens by region.

By identifying the most significant pathogens that cause seedling and root rot disease we will be able to direct soybean breeding efforts by screening germplasm (cultivars) for resistance against the most appropriate pathogens. The same is true for seed treatments. Understanding which species are the primary pathogens enables us to work with companies in screening and developing chemical or biological seed treatments to minimize the impact of seedling disease. Using data generated from this study we are also in the process of developing improved diagnostic methods, which will assist in establishing more rapid, specific and accurate diagnoses, which will ultimately improve disease management.

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[1]Funded by the National Institute of Food and Agriculture, North Central Soybean Research Program, United Soybean Board and Project GREEEN.

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FUNGICIDE USE IN ALFALFA: WHAT FOUR YEARS OF RESEARCH HAS TAUGHT US

Damon L. Smith [1/], Scott Chapman [2/], Bryan Jensen [3/], Greg Blonde [4/], and Bill Halfman [4/]

Introduction

Over the past several years, interest in using foliar-applied fungicides on alfalfa for dairy production has increased. This has subsequently led to new labeling for foliar fungicide products for use on alfalfa. Research at the University of Wisconsin-Madison began in 2011 to evaluate some of the products labeled for use in alfalfa. From 2011 to 2014 replicated on-farm and research station trials were conducted to evaluate the utility of using fungicide on alfalfa for dairy production.

Methods

Trials were located at various locations in each of the research years and included plots in Monroe County, Waupaca County, and Columbia County. Treatments in all trials were replicated four to six times. Each individual plot comprised a minimum area of 400 sq. ft. Treatments were applied using a backpack small-plot sprayer calibrated to deliver 20 gallons of water per acre. All treatments were applied at six to eight inches of growth after each cutting. Applications were made for three cuttings per season. Alfalfa was harvested from each plot for each cutting using a small plot harvester. For some trials foliar disease data were collected. For all trials, quality was evaluated by the University of Wisconsin Soil and Forage Testing Laboratory located in Marshfield Wisconsin. Yield, quality, and disease (where applicable) data were evaluated for each cutting, at each location, for each year.

Results

In total, 35 separate trials (cutting x site x year) were conducted over the four-year period. In the majority of the trials disease levels were low and no significant difference in foliar disease and defoliation was identified between treatments. Some detectable differences in quality were identified between treatments in some trials. However, relative forage quality was typically greater than 150 (Prime Grade) for both treated and non-treated alfalfa. Yield was significantly greater (α=0.05) in fungicide treated plots for only 12 of the 35 trials. No particular cutting-timing resulted in a consistent increase in yield when the treatment effect was significant. The average dry matter yield increase over the non-treated control plots was 0.22 tons/acre in trials where fungicide treatment resulted in an increase in yield. The average approximate cost to apply one

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fungicide application (fungicide plus custom applicator cost) is estimated to be $28.00 USD. Considering this cost, the added value per acre for the 12 trials where fungicide increased yield was estimated to be $13.80 ($0.10 per pound dry matter hay).

In some cases fungicide can increase alfalfa yield. This is estimated to occur only 34% of the time when fungicide is used. Alfalfa growers are encouraged to focus on timely alfalfa harvest rather than rely on fungicide application to obtain high-quality, high-yielding alfalfa forage.

2014 WISCONSIN CROP DISEASE SURVEY

Anette Phibbs[1], Susan Lueloff[1] and Adrian Barta[2]
http://pestsurvey.wi.gov/

DATCP's 2014 early soybean disease survey found the highest level of **Phytophthora root rot** since the beginning of this survey in 2008 and identified four different species of Phytophthora on Wisconsin soybean. Besides the well-known cause of seedling root rot *Phytophthora sojae*, DNA based testing also determined *P. sansomeana* that was first detected in Wisconsin soybeans in 2012, and two additional new species *P. pini* and P. sp. "*personii*".

Forty-six percent (26 of 57) of all fields that were sampled from June 6 to July 16 during early vegetative stages were infected with ***Phytophthora sojae*** (Fig.1). Twenty plants per field were pooled into a single sample. Samples were collected from 57 fields in 35 counties and tested in the laboratory. Ninety-eight percent (56 of 57) of the fields tested showed mixed infections with Pythium, another water mold that causes damping-off.

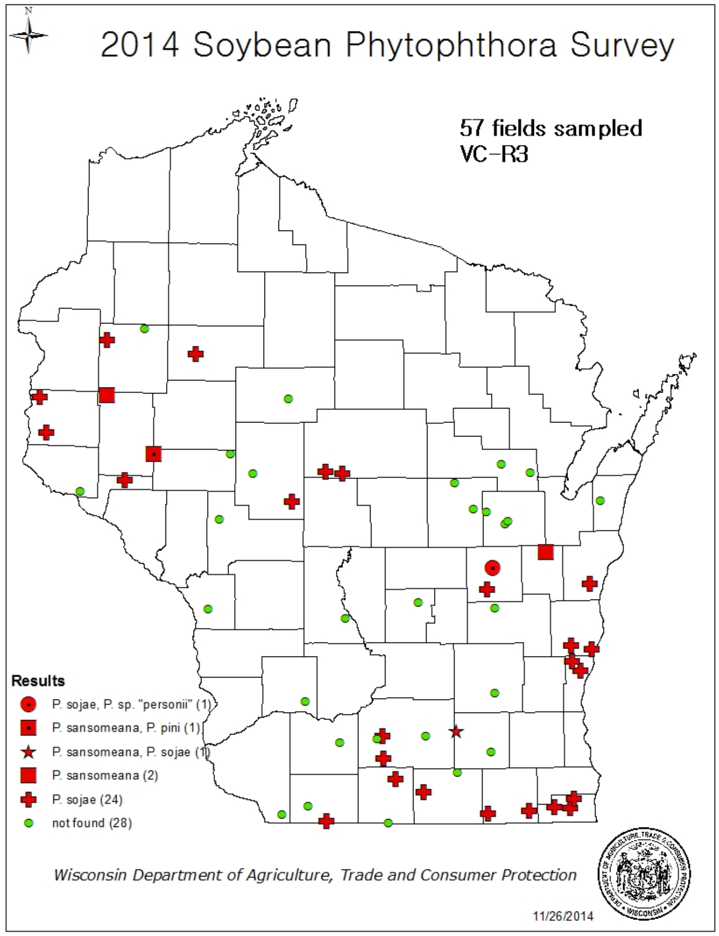

Figure 1

Phytophthora sansomeana was found in four soybean fields in 2014 in Calumet, Dunn, Eau Claire and Jefferson Counties. This pathogen was first detected in Wisconsin soybeans in 2012. *P. sansomeana* has now been documented in soybean fields in nine Wisconsin counties (Dane, Dunn, Calumet, Eau Claire, Green, Jefferson, Marathon, Outagamie and Sheboygan). Unlike *P. sojae* which is specific to soybeans, *P. sansomeana* can infect both soybean and corn, which could lead to a build-up of this pathogen in the soil in a corn-soybean crop rotation. *P. sansomeana* was reported to cause losses on soybean in China (Tang et al 2010). Isolates are being tested on both corn and soybeans at UW-Madison to evaluate pathogenicity under Wisconsin growing conditions.

P. sansomeana has also been detected in Christmas tree plantation on Fraser and Balsam fir in six Wisconsin counties (Clark, Jackson, Lincoln, Manitowoc, Marathon and Price).

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Two additional new species of Phytophthora were isolated from soybean fields in 2014. *P. pini* in Eau Claire Co. and *P. sp. "personii"* in Winnebago Co. In both soybean fields multiple infections were determined, *P. pini and P. sansomeana* in one; *P. sp*. "*personii*" and *P. sojae* in another field. *P. pini* (formerly included in *P. citricola*) is generally considered to be a pathogen of shrubs and trees. The organism survives well in surface waters and could be of concern to nursery production. It probably has been reported as *P. citricola* in this state before. P. sp. "*personii*" is new to science and has yet to be formally described. Almost nothing is known about its host range. To the best of our knowledge it has never been found in Wisconsin. Neither species has previously been found on soybeans and their significance for soybean production remains to be determined.

In 2014, soybean root rot reached the highest prevalence since the start of this survey in 2008, finding *P. sojae* in nearly half the fields tested. During the flood-prone spring of 2010 the pest survey team found 38% of fields infected. The high level of *P. sojae* and the greater pathogen diversity with four different species detected may be due to heavy rainfalls causing saturated soils and relatively low spring temperatures that created favorable conditions for water molds.

Soybean virus survey. During the 2014 soybean virus survey from July 28 to August 28, 155 fields were sampled and tested for three viruses: alfalfa mosaic virus (**AMV**), soybean dwarf virus (**SbDV**) and soybean vein necrosis virus (**SVNV**) (Fig 2 and 3). 37 of 155 (23.87%) fields tested positive for SbDV. That is more than a two-fold increase for SbDV from 2013 (9.27%). It is consistent with the upward trend of this virus since the beginning of the survey in 2003, when SBDV was first detected in Wisconsin (Phibbs 2004). This luteovirus causes significant damage in Japan, but has not been observed to have the same damaging effect on soybeans in the US. The dwarfing strain is the predominant strain in Wisconsin, with few yellowing strain isolates reported. Virus transmission relies on persistently feeding colonizing aphids, such as the soybean aphid in the Midwest. High levels of SBDV infection have been documented in clovers in Wisconsin, making it a possible reservoir for this virus. So far no significant damage to soybean has been associated with SbDV in Wisconsin.

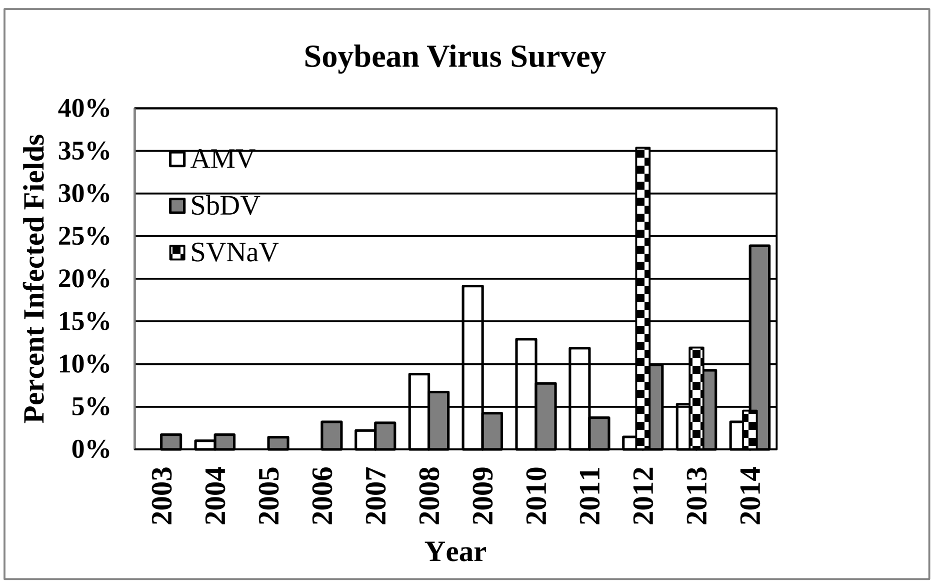


Figure 2

Recent research has proven that **SVNV**, the causal agent for Soybean vein necrosis disease (Zhou & Tzanetakis 2013) is transmitted by soybean thrips. SVNV was detected in seven (4.52%) samples in 2014, which is less than half the number of fields that tested positive in 2013 (11.92%). The highest level with 35.40% fields infected was in 2012, the year SVNV was first detected in Wisconsin (Smith 2013). The arrival of soybean thrips in Wisconsin depends on wind patterns blowing them in from the south. While the hot and dry weather in 2012 was very conducive to thrips reproduction, cold and wet conditions in 2014 kept thrips populations low. First detected in Tennessee in 2008, SVNV has quickly spread throughout the country's soybean production areas. Other susceptible hosts of SVNV are cowpea, mung beans and ivy-leaved morning glory, a common weed in soybean fields. Control treatment for SbDV or SVNV are not recommended at this time.

Alfalfa mosaic virus has decreased to 3.23% of infected soybean fields in 2014. Several aphid species including soybean aphid can transmit AMV from infected reservoirs such as alfalfa and clovers. AMV can also be introduced by infected seed.

The summer survey of soybean fields did not detect any **Asian soybean rust** (*Phakopsora pachyrhizi)* in Wisconsin in 2014. This rust disease, which has never been found in Wisconsin, was limited to eight states in the southern United States (AR, AL, GA, FL, OK, LA, MS, TX).

Frogeye leaf spot (*Cercospora sojina*), a fungal disease that was first detected in Wisconsin in 2000 (Mengistu 2002), has not been detected during the past two years of survey. In 2010 the disease was found in a record 68% of surveyed fields.

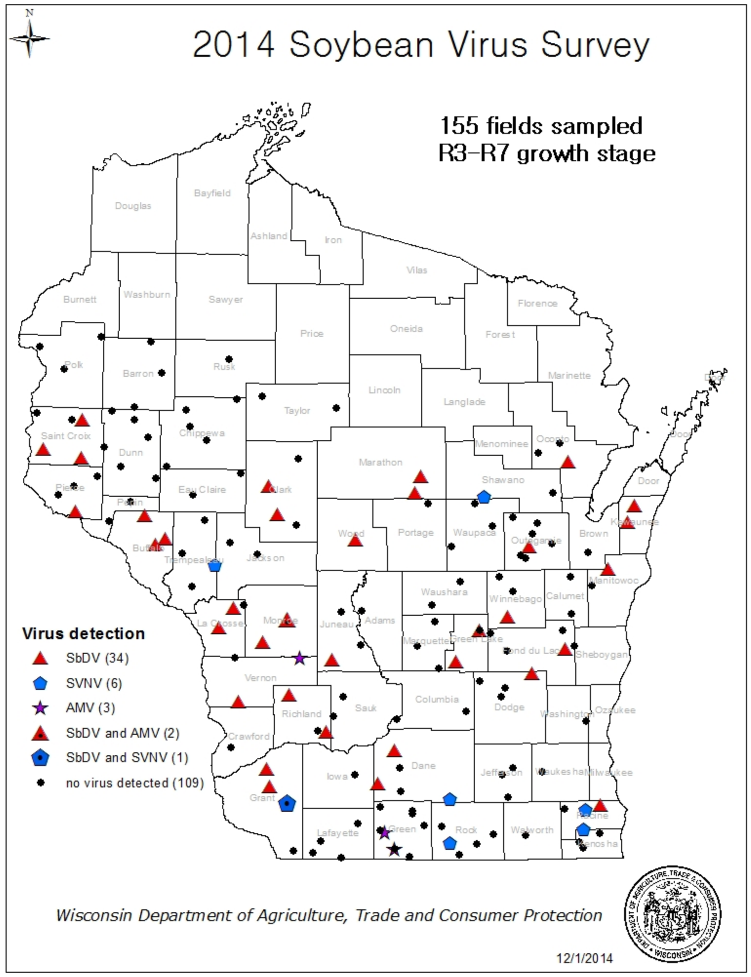


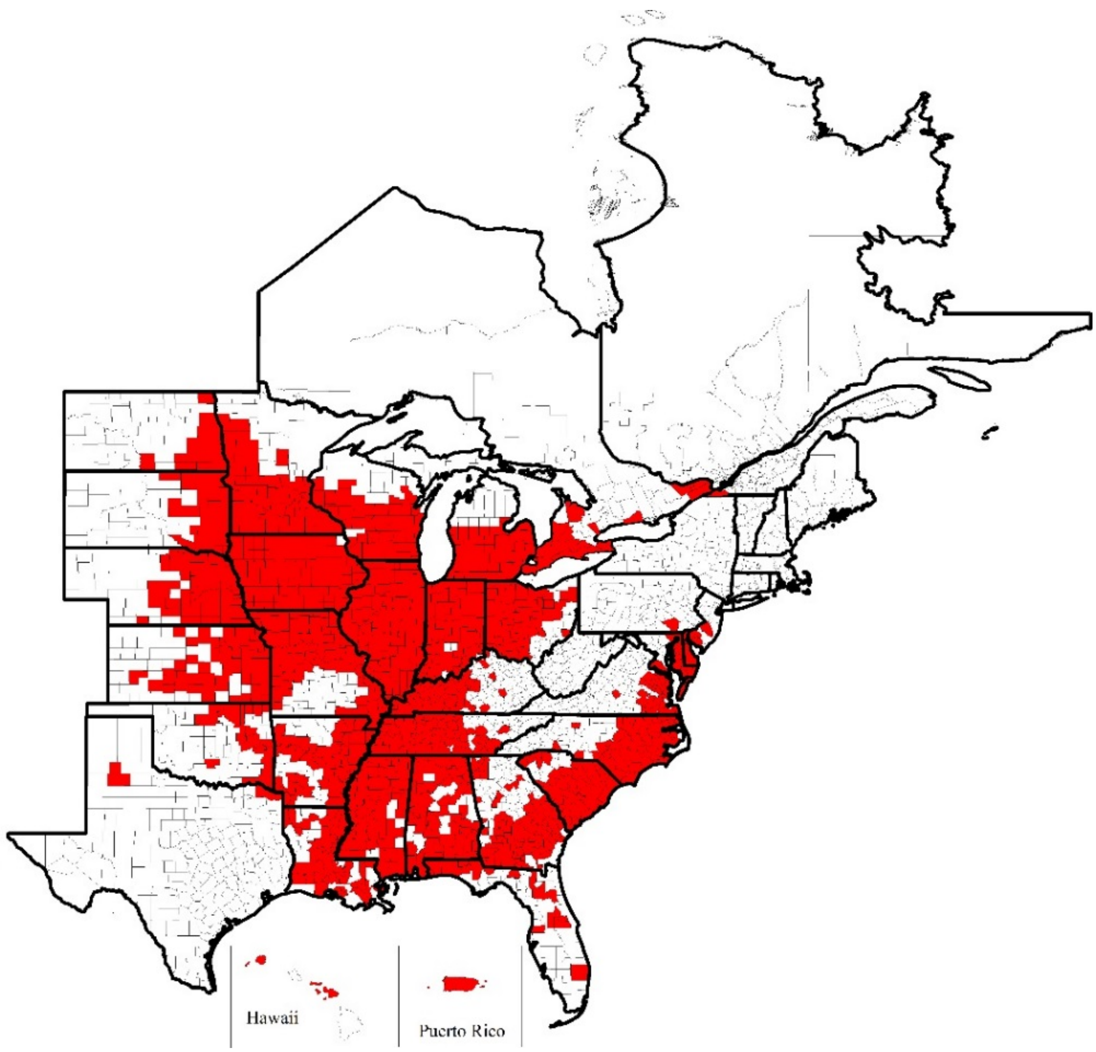
Figure 3

Corn diseases. Field inspections of seed corn and subsequent laboratory testing of corn leaves showed no **Stewart's wilt** in 2014. Ninety-three field plots from eleven Wisconsin counties were tested for two bacterial diseases, Stewart's wilt (*Pantoea stewartii*) and Goss's wilt (*Clavibacter michiganensis nebraskensis*). **Goss's wilt** was found in 11 of 93 (11.8%) leaf samples. Goss's wilt has been found more frequently since 2010. Unlike Stewart's wilt that relies on the corn flea beetle (*Chaetocnema pulicaria*) to spread to new fields and plants, Goss's wilt infection occurs when leaves are injured by heavy winds, rain or hail storms and bacteria splash onto leaves from infected overwintered corn debris. Certain weeds (green foxtail and shattercane) can serve as reservoirs. Important management practices are rotation with non-host crops such as alfalfa, soybean and wheat, also encouraging decomposition of corn stalks and debris.

In 2014 Canada dropped all requirement for imported seed corn to be tested. Other trading partners such as Argentina, Brazil, Mexico, the European Union, Japan and New Zealand still require seed corn testing for a variety of diseases and pests including sugar cane mosaic virus, wheat streak mosaic virus, and high plains virus. None of these viruses were detected in seed fields from eleven Wisconsin counties.

Soybean cyst nematode (*Heterodera glycines*) is widely distributed in soybean growing areas of the United States and Canada. The distribution map in Figure 4 (Tylka 2014) includes Wisconsin's survey data. The current Wisconsin counties where soybean cyst is known to occur include 92% of the state's soybean acres. Soybean cyst nematode **(**SCN) remains the most damaging pest on soybeans and growers in all counties are urged to test fields to assess nematode pressure. Soil testing is offered thru the University of Wisconsin. Since Canada rescinded the requirement for phytosanitary certification for SCN on Nov 25, 2013, testing for export certification is no longer a requirement for soybeans, potatoes, root crops, nursery stock, soil and any other commodity shipping to Canada. DATCP will continue to offer testing for companies that trade with countries that require SCN certification.

Figure 4. Soybean cyst nematode distribution in the US and Canada. (Tylka & Marett 2014)



References

Mengistu, A., Kurtzweil N. C., and Grau C. R. First Report of Frogeye Leaf Spot (Cercospora sojina) in Wisconsin. Plant Disease, November 2002, Vol. 86, No. 11, Pages 1272-1272.

Phibbs A., Barta A., Domier L. L. First Report of *Soybean dwarf virus* on Soybean in Wisconsin. Plant Disease 2004, Vol. 88, No. 11, Page 1285.

Smith D. L., Fritz C.**,** Watson Q., Willis D. K., T. L. German T. L., Phibbs A.**,** Mueller D., Dittman J. D.**,** Saalau-Rojas E., Whitham S. A. First Report of Soybean Vein Necrosis Disease Caused by *Soybean vein necrosis-associated virus* in Wisconsin and Iowa. Plant Disease, May 2013, Vol. 97, No. 5, p. 693.

Tang Q. H., Gao F., Li G. Y., Wang H., Zheng X. B., and Wang Y. C. First Report of Root Rot Caused by Phytophthora sansomeana on Soybean in China. Plant Disease 2010, Vol. 94, No. 3, Pages 378-378.

Tylka, G. L., and Marett, C. C. Distribution of the soybean cyst nematode, *Heterodera glycines*, in the United States and Canada: 1954 to 2014. Plant Health Progress, May 2014. doi:10.1094/PHP-BR-14-0006.

Zhou J. and Tzanetakis, I. E. Epidemiology of Soybean vein necrosis-associated virus. Phytopathology 2013, Vol. 103, pp. 966-971.

TOOLS FOR BETTER MANAGEMENT OF WHITE MOLD ON SOYBEAN

Damon L. Smith [1/] and Jaime Willbur [2/]

Introduction

Sclerotinia sclerotiorum, the causal agent for white mold disease, is a devastating soybean fungal pathogen. In 2006, white mold ranked in the top 10 yield reducing diseases of soybean and was estimated to account for over 2 billion metric tonnes of yield loss world-wide (1). In the United States, soybean losses in 2009 reached an estimated 59 million bushels due to white mold, which cost producers ~$560 million (2, 3). Disease control is limited due to the lack of complete resistance in commercial cultivars and an incomplete understanding of resistance mechanisms (3). Further investigation of white mold resistance mechanisms in soybean and subsequent resistance evaluations of soybean germplasm would improve commercially available resistance.

Currently, chemical control is incomplete and even unnecessary in some cases, as white mold development requires a complex combination of conditions. In the field, *S. sclerotiorum* survives in the soil as a dormant structure until conditions permit sexual reproduction. Under conducive conditions, apothecia form to produce and release sexual ascospores, which must land on a nutrient source, i.e. soybean flowers, for infection to occur (3). Risk assessment tools are often used to more accurately predict the timing of effective fungicide applications based on weather conditions, pathogen presence, and host architecture. White mold forecasting models such as those for carrot and lettuce, however, do not exist for soybean systems (4,5). Studies have also shown that apothecial development is sensitive to a narrow range of ultraviolet wavelengths, thus, light quality will also be studied as a component in our forecasting model (6). Overall, the development of resistant germplasm and an optimized forecasting system will improve management strategies of white mold disease in soybean.

Research Objectives

1. Evaluate physiological resistance to white mold in soybean germplasm using aggressive *Sclerotinia sclerotiorum* isolates and release the best lines for breeding purposes.
2. Investigate the roles of light and other weather variables in the development of white mold in soybeans. Use this information to develop an improved advisory system for white mold in soybean cultivars.

Current Methods and Research Progress

The first step in evaluating soybean germplasm was to select an array of aggressive *S. sclerotiorum* isolates, from an existing collection, and for use in resistance screenings. During 2014 aggressiveness assays of 44 isolates from five locations in the North Central United States

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and Poland were evaluated on soybean. Isolate aggressiveness varied significantly across all hosts and locations; aggressive isolates from this initial experiment were selected for resistance evaluations.

To increase understanding of white mold resistance mechanisms, we are currently evaluating phenotypic resistance by investigating host colonization in resistant and susceptible soybean germplasm. The infection process of a fluorescent isolate of *S. sclerotiorum* will be monitored using epifluorescence and confocal microscopy. Difficulties in visualizing fungal hyphae in soybean tissues have prompted, 1) the transformation of a more aggressive isolate using the green fluorescent protein, and 2) the addition of a quantitative assay of fungal biomass in soybean tissues. This work will complement collaborative work analyzing genotypic resistance mechanisms to aid in developing assays for resistance screening.

Previously, resistant soybean germplasm was generated by crossing a highly resistant experimental line (W04-1002) with lines exhibiting good agronomic traits. After multiple screenings, 31 lines were selected for advanced white mold field screening in 2014. Lines were planted in a nursery with four check varieties. Disease ranged from almost 60 disease severity index (DSI) units in the susceptible breeding line 91-44 to zero DSI units for SSR81-23. All lines identified as physiologically resistant in greenhouse evaluations had less than 20 DSI units in the field trials. Yield loss is generally not expected until rating reaches 25 or more DSI units (Smith, *personal communication*). Yield ranged from 55.9 bu/a for AxN-1-55 to 26.6 bu/a for SSR81-123. Lodging was an important yield component in this trial. Lodging was significantly (α=0.05) correlated with yield. Breeding lines that lodged severely, yielded less than lines that had lower lodging scores (correlation coefficient = -0.47). Lines with the best physiological resistance to white mold (mostly the 9 x 1 population) tended to yield low-to-moderately in the 2014 trial. Further evaluation and selection will take place in 2015.

In 2014, we also monitored the growth and development of *S. sclerotiorum* and collected detailed data of the progression and severity of white mold disease in Wisconsin soybean fields. Publically available weather data are being accessed and a series of statistical models to predict disease development will be generated for testing in the 2015 field season. Additionally, we are studying light quality effects on apothecial development for integration into an optimized forecasting model. Novel prediction models will be validated at universities in Michigan, Iowa, Purdue, and Illinois through the North Central Soybean Research Program.

Conclusion

White mold-resistant soybean germplasm has been registered with the Wisconsin Alumni Research Foundation (WARF). WARF promotes innovative research by facilitating the commercialization of scientific technologies; therefore, soybean germplasm can be accessed by public and private breeders to develop locally and globally available commercial varieties. In addition, our findings pertaining to *Sclerotinia sclerotiorum* epidemiology will help generate a web-based system to conduct site-specific disease forecasting for fungicide application. This will help further increase the sustainability of soybean systems worldwide by reducing pesticide input.

References

1. Wrather, A., et al. (2010). Effect of diseases on soybean yield in the top eight producing countries in 2006. Online. *Plant Health Progress*.
2. Koenning, S. R. & J. A Wrather. (2010). Suppression of Soybean Yield Potential in the Continental United States by Plant Diseases from 2006 to 2009. Online. *Plant Health Progress*.
3. Peltier, A. J., et al. 2012. Biology, Yield loss and Control of Sclerotinia Stem Rot of Soybean. *Journal of Integrated Pest Management*, *3*(2), 1–7.
4. Foster, A. J., et al. (2011). Development and validation of a disease forecast model for Sclerotinia rot of carrot. *Canadian Journal of Plant Pathology*, *33*(2), 187–201.
5. Clarkson, J. P., et al. (2014). A Model for Sclerotinia sclerotiorum Infection and Disease Development in Lettuce, Based on the Effects of Temperature, Relative Humidity and Ascospore Density. *PloS One*, *9*(4), e94049.
6. Thaning, C. & H.-E. Nilsson. (2000). A Narrow Range of Wavelengths Active in Regulating Apothecial Development in Sclerotinia sclerotiorum. *Journal of Phytopathology*, *631*(148), 627–631.

SOYBEAN SUDDEN DEATH SYNDROME: PLANT INFECTION AND MANAGEMENT[1]

Martin I. Chilvers[2], Jie Wang, and Janette Jacobs

Soybean sudden death syndrome (SDS), caused by *Fusarium virguliforme*, is one of the most yield limiting diseases in the US, and effective disease management options are limited. We developed a real-time quantitative PCR assay for the diagnosis and quantification of *F. virguliforme*. Using this assay we investigated the *F. virguliforme* infection process of four soybean cultivars with differing resistance to the foliar SDS leaf scorch symptoms. We found that the quantity of *F. virguliforme* did not differ between the varieties as expected, indicating that leaf scorch resistance is separate to root infection resistance. Interestingly the ratio of *F. virguliforme* to soybean increased sharply just before the R5 growth stage, around the time of foliar disease onset. The findings also demonstrate that use of a soybean variety with resistance to the SDS foliar scorch will not necessarily reduce the subsequent amount of *F. virguliforme* in the soil.

A trial was also conducted to investigate the effect of the Bayer CropScience seed treatment ILeVO (Fluopyram) on the quantity of *F. virguliforme* in the soybean root system over the course of a season. The ILeVO treatment resulted in significantly less *F. virguliforme* accumulation in the soybean root system which was noted at the R3 growth stage.

References

Wang J., Jacobs, J.L., Byrne, J.M., Chilvers, M.I. *In Press.* Improved diagnoses and quantification of *Fusarium virguliforme*, causal agent of soybean sudden death syndrome. Phytopathology http://dx.doi.org/10.1094/PHYTO-06-14-0177-R

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[1]Funded by the Michigan Soybean Promotion Committee, North Central Soybean Research Program, Bayer CropSciences and Project GREEEN

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AG/MANUFACTURING SALES TAX EXEMPTIONS: WHAT FEED, FERTILIZER AND GRAIN EQUIPMENT IS EXEMPT AND WHAT ISN'T

Jerome Leis [1/]

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RECRUITING GOOD PEOPLE FOR YOUR AGRIBUSINESS -- PANEL

Mark Washek, Ag One Source
Jim Fleming and Rich Connell, Agri-Search
Megan O'Rourke, Univ. of Wisconsin-Madison

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LEGISLATIVE UPDATES ON ISSUES IMPORTANTT O AGRICULTURE

Shawn Pfaff [1/]

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[1/] Pfaff Public Affairs.

MAKING BALEAGE

Dan Undersander [1/]

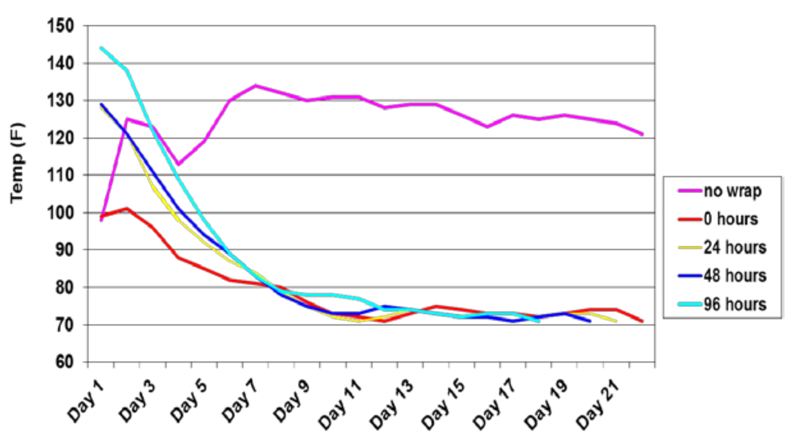
Baleage is a practical method to harvest and store either wet hay or to make haylage. If the harvested forage is less than 50% moisture, preservation is primarily by maintenance of anaerobic (oxygen limiting) conditions and, if harvested forage is 50 to 70% moisture, preservation is due both to anaerobic conditions and acids produced in the fermentation.

First, recognize that no forage preservation method can improve the quality of forage; some quality is always lost in the harvesting process. Therefore, when making baleage, harvest the forage slightly at higher quality than desired for the animals being fed. From harvest to storage, if good harvesting practices are in place, expect a 5 to 10% decline in quality for haylage and 10 to 15% decline in quality for hay. So harvest alfalfa at the mid bud stage (or 29 inches on first cutting whichever is first) and grass at the boot stage for milking dairy cows. For beef, sheep and other growing animals harvest alfalfa at 10% flower and grass at early heading.

Next mow, condition and put into a wide swath (covering at least 70% of the cut area). This increases the initial drying rate and reduces carbohydrate (NFC) loss to continued plant respiration.

Thirdly, make bales (either square or round) as dense as possible. This allows more dry matter in the same storage volume. More importantly, it reduces the oxygen content in the bale and reduces plant and microbial respiratory loss of dry matter and forage quality after baling and wrapping.

Figure 1. Effect of Timing of Bale Wrapping on Bale Temperature



Wrapping bales as soon after baling as possible reduces the heating damage. Figure 1 shows data from wrapped bales made at 36% moisture. Note that the unwrapped bales had internal temperatures of 120 to 130°F for more than three weeks after baling and clearly had significant heating loss of digestible protein and TDN. As soon as bales were wrapped, the internal bale temperature started to decline (day 1 is the day of wrapping). Bales wrapped immediately after baling never got has hot as unwrapped bales, generally remaining below 100°F. Bales wrapped 24 hours after baling were already at 130°F when wrapped. As Figure 1 shows, longer time to wrapping resulted in higher temperatures in the bales (and for a longer time) and presumably resulted in more heating damage loss. Bales made at 65 to 68% moisture and showed the same trends.

In another study, we looked at the number of wraps with plastic necessary to prevent mold growth and heating. Standard plastic is 1 mil thick. There are some plastic quality differences and it is recommended to stay away from the cheapest plastic. Temperatures above ambient (about 80°F) in Figure 2 indicate the oxygen was penetrating the plastic and allowing the microbes to grow and produce heat. The data indicate that at least 6 wraps of 1 mil plastic was necessary to prevent air (oxygen) movement into the bale. This would be true for individually wrapped bales or those wrapped in-line. The data in Figure 2 are from bales at 30% moisture but the same study was also conducted with hay at 62% moisture with the same results.

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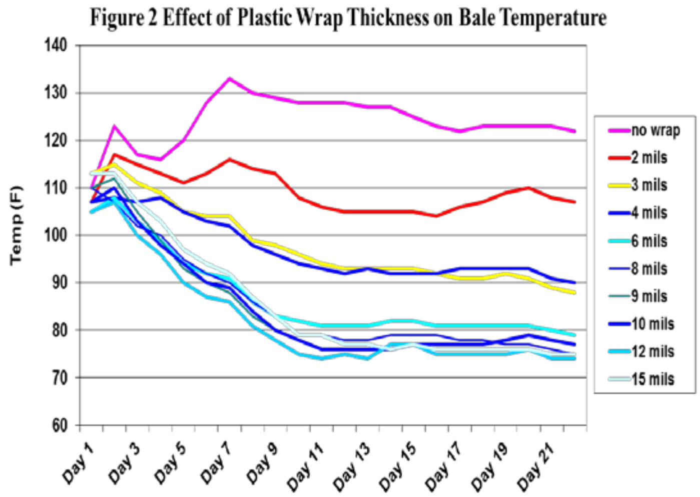

A few additional thoughts about making baleage:

- Fermentation is greatly reduced if the baleage is made at less than 50% moisture. This has no effect on quality except that unfermented baleage will begin to mold more rapidly when feeding. Lack of fermentation will not affect bales consumed within 24 hours exposure to air.
- Lactobacillus inoculant is not recommended for baleage since it must be sprayed onto the top of the windrow in the bale chamber or as the hay is entering the baler. Lactobacillus bacteria are only effective when coverage is good (i.e., that is why the recommendation is to apply at the chopper). Since coverage is reduced in baleage making, the inoculant is likely to have little effect.
- Hay preservative is not recommended as it should not be necessary if the bale is wrapped properly. Note that an advantage of wrapped bales over preservative treated wet hay is that forage at any moisture content can be wrapped and preserved while preservative must be applied in relation to the moisture content of the hay to be effective. So moisture variation of hay within or among fields is no problem.
- Use of a cutter on the front of the baler is recommended to cut the hay into 4-inch lengths. This allows greater packing density, eases use in a TMR (and reduces energy required), and/or reduces feeding losses from a feeder.

In summary, wrapping bales is an effective method of preserving wet hay. It can also produce high-quality haylage equal to that chopped into tubes or bunkers. The decision of which method to use for haylage should depend on herd size with wrapped bales being very cost effective for small herds (less than 100 animals for individually wrapped bales and less than 150 for in line wrapped bales) and less efficient for larger herds.

EFFECTS OF MANURE ON LEGUME PRODUCTIVITY AND PERSISTENCE

G.E. Brink, W.K. Coblentz, and W. Jokela[1]

Abstract

Forage legumes such as alfalfa and red clover have greater nutritive value than grasses, reduce the need for applied N, and may be more productive during drought. Producers often wish to apply manure to grass-legume or pure legume stands, however, to increase yield, amend soil nutrient deficiencies, or address manure storage challenges. This practice may reduce legume persistence and result in poor hay or silage preservation. In two separate studies, dairy manure was applied to red clover – orchardgrass mixtures or to alfalfa to determine its effect on productivity, persistence, and feed quality. Applying liquid or solid manure (60 lb N/acre) to a grazed red clover-orchardgrass mix increased annual yield 500 lb DM/acre above that of the non-fertilized control (7100 lb DM/acre/year), but reduced annual yield when applied in July or September. Applying manure in any form at any time of the year reduced red clover persistence, but the effect was generally greatest when application occurred in July. Applying liquid manure to alfalfa did not improve annual yield. Based on counts of *Clostridium tyrobutyricum,* the greatest risk of undesirable fermentation after harvesting for balage occurred when slurry was applied 7 and 14 days after cutting compared to application directly onto stubble. Results from these studies suggest that 1) spring manure application to grass-legume pastures will improve annual yield but will likely reduce legume persistence, which may ultimately reduce pasture nutritive value; and 2) manure application to alfalfa stubble is preferred, but if application to growing alfalfa is necessary, choose old alfalfa stands and consider additional field wilting to reduce clostridial fermentation.

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CHECKING IN ON WISCONSIN ALFALFA YIELD AND PERSISTENCE

Mike Rankin[1/]

Introduction

Unlike corn and soybeans, obtaining accurate yield information for forage crops involves considerable planning, time, and effort on behalf of the person collecting the yield data and the farmer. Historically, few producers had the capacity or patience during harvest to undertake such a task. Most efforts to measure alfalfa yield in the past were usually limited to the best small area of the best field. Currently, many larger dairies have installed on-farm scales for measuring purchased production of forages and/or feed commodities. These scales now make it relatively easy to weigh production not just from small areas of fields, but entire fields over the course of several years.

Knowing actual alfalfa production offers some unique value beyond just documenting what is being harvested on Wisconsin farms. It allows us to contrast what is being found with current small-plot research trials and identify management areas where improvements can be made. Further, we can document progress over time.

During the early spring of 2007, members of the University of Wisconsin-Extension Team Forage decided to initiate the Wisconsin Alfalfa Yield and Persistence Program. The objectives of the program were to:

1. Verify the yield and quality of alfalfa harvested from production fields over the life of the stand beginning with the first production year (year after seeding).
2. Quantify decreases in stand productivity of alfalfa fields as they age.

To date, 64 Wisconsin alfalfa fields have been measured for yield and stand persistence.

Data Collection

Each year, interested producer participants with qualifying fields are solicited All fields in the program are entered at the beginning of the first production year (the year following seeding). Further, fields must remain in the program for the life of the stand. For each field, an accurate measure of field size is determined (if not previously calculated). Forage yield from an entire project field is weighed (usually this is done with an on-farm drive over scale). Both empty and full weights for all trucks/wagons used are recorded. Two forage samples from each harvest are taken and submitted to the Marshfield Soil and Forage Analysis Laboratory for NIR analysis. Data from the two forage samples are averaged and recorded by the local coordinator. Information is inputted into an Excel spreadsheet program and shared with the producer following each harvest. At the end of the season, all data are collected and summarized. An annual summary report is available on the UW-Extension Team Forage web site at http://fyi.uwex.edu/forage/alfalfa.

Project Summary

Harvest Schedules

Mean cutting dates by year are presented in Table 1. Average first-cut date has ranged from May 16 in 2012 to June 10 in 2013. Regardless of first-cut date, the average fourth-cut date is generally within a week of September 1, with 2012 (earlier) and 2014 (later) being the notable exceptions. The large majority of fields in this study were cut four times. Across years and sites, 13 fields were cut three times, 109 fields were cut four times (generally prior to or soon after September 1), and 20 fields were cut five times (generally four times before September 1 with a final cut in October).

Table 1. Mean cutting dates by year.					
Year	1st cut date	2nd cut date	3rd cut date	4th cut* date	5th cut date
2007	22-May	24-June	25-July	30-Aug	21-Oct
2008	3-Jun	3-Jul	3-Aug	29-Aug	29-Oct
2009	31-May	1-Jul	4-Aug	5-Sep	
2010	22-May	28-Jun	2-Aug	29-Aug	12-Oct
2011	31-May	1-Jul	31-Jul	31-Aug	
2012	16-May	14-Jun	14-Jul	10-Aug	21-Sep**
2013	10-Jun	11-Jul	6-Aug	7-Sep	
2014	4-Jun	9-Jul	7-Aug	13-Sep	

* Average excludes data where a 4th cut was taken in October.

** Average includes 2 fields with 5th cuts taken in late-August and 2 taken in early September.

Forage Dry Matter at Harvest

Alfalfa was harvested as haylage for all but 14 individual cuttings over the 8 years. Harvest dry matter data from the dry hay harvests were not included in the forage dry matter data means. Although project participants are not asked about storage structure, there is good reason to believe most of the farms are storing this forage in bunker or pile silos.

From 2007-2010 forage dry matter ranged between 47 to 50%; during this time many people questioned if this was too dry for obtaining optimum storage porosity in a bunker silo or pile. In the past four years mean dry matters have ranged from 40 to 47%. In 2014, dry matter averaged 43%, though two fields averaged over 50%. Mean dry matter by year and cutting is presented in Figure 1.

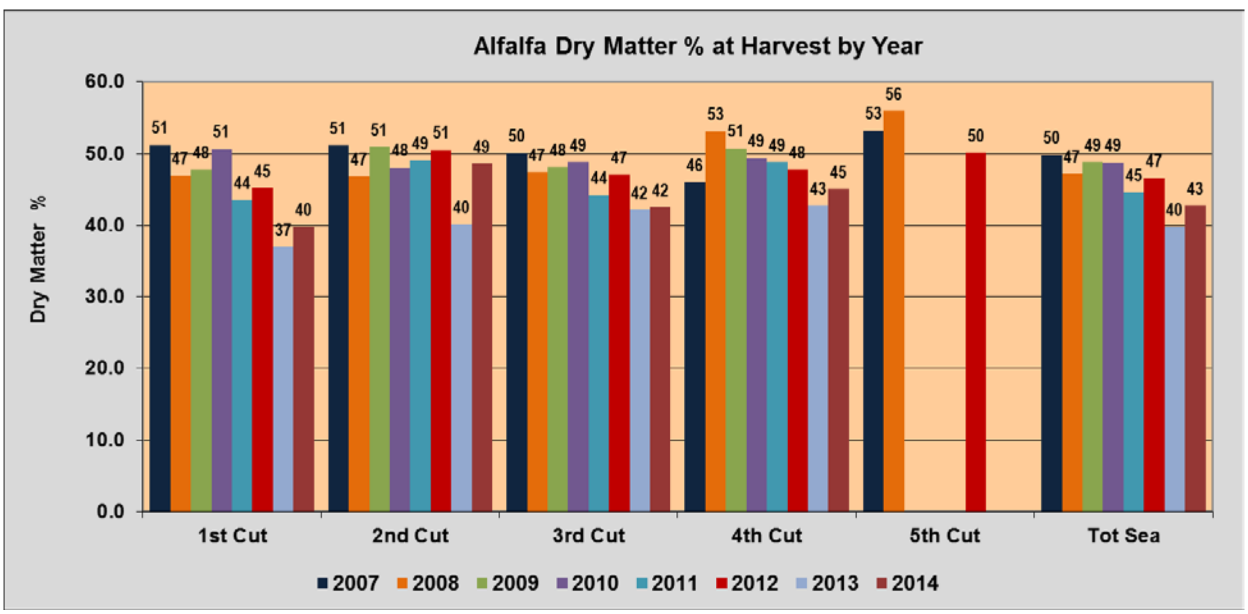

Figure 1. Average dry matter of harvested forage by cutting and as a weighted average for the total season (2007-2014).

Forage Dry Matter Yield

Average total-season dry matter yield variation for 2014 fields is presented in Figure 2. There was a wide range in success for achieving high yields. Fields ranged from 3.1 to 6.3 tons per acre, with 11 of 24 fields averaging under 4 tons. Three fields averaged over 6 tons per acre. The overall average dry matter yield for 2014 was 4.4 tons per acre, 0.4 tons greater than 2013 but below several of the previous years (Fig. 3).

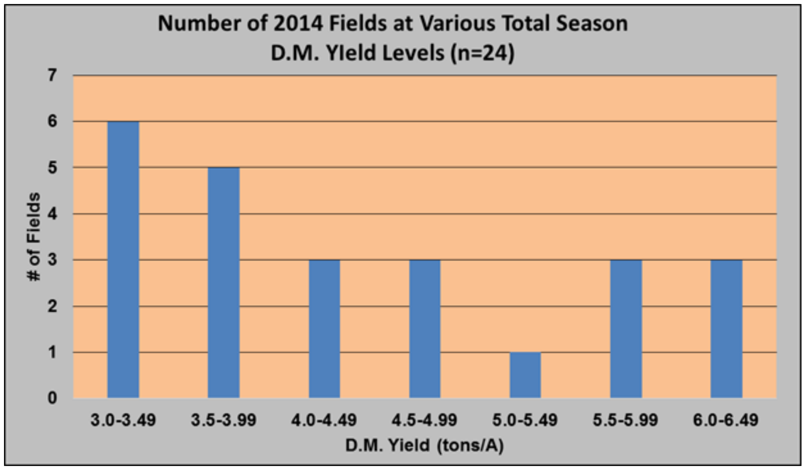

Figure 2. Number of 2014 fields at various yield levels (n=24)

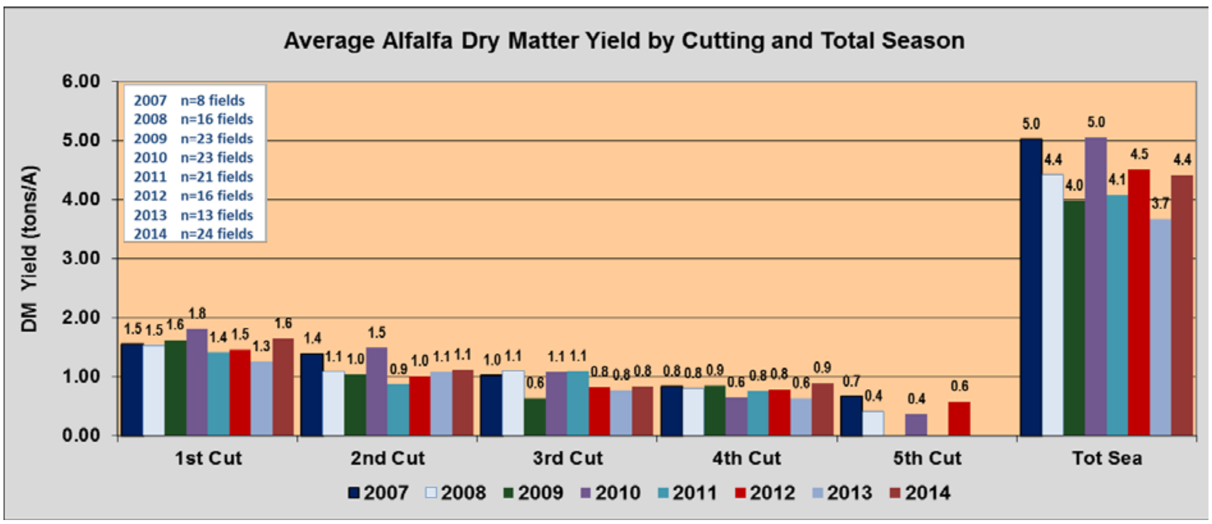

Figure 3. Average alfalfa dry matter yield by cutting and for the total season (2007-2014).

Alfalfa Persistence

One of the objectives of this project is to document how production fields are maintaining yields within a single year and over the course of their life. The amount of forage harvested by cutting as a percentage of total season yield varies by the number of harvests taken. The mean percentage of total season yield by cutting averaged over all site-years is presented in Table 2.

Table 2. Average percent of total season yield by cutting for 3, 4 and 5 cut harvest systems (2007-14)

	1st cut	2nd cut	3rd cut	4th cut	5th cut
3-cut system (N=12 site years)					
Mean	43	31	26		
4-cut system (N=115 site years)					
Mean	36	25	21	18	
5-cut system (4+1 fall) (N=20 site years)					
Mean	31	23	18	16	12

Persistence is influenced over time by the age of the stand, cutting schedule, and environment. For this project, persistence is being measured as a percent of 1st production year dry matter yield. Persistence data in Table 3 consists of 2006 through 2013-seeded fields and is averaged over all cutting schedules. Average forage yield in the 2nd and 3rd production year have been near to the 1st production year. The yield for 4th year stands drops to 78% of the 1st production year. It appears alfalfa is capable of maintaining yield that keeping stands for at least three production years seems to be the prudent decision.

Table 3. Percent of 1st production year yield by cutting and total season for 2nd and 3rd production year stands.

	1st cut	2nd cut	3rd cut	4th cut	Total season
2nd production year stands (n=40 site years)					
Mean	117	109	111	101	102
3rd production year stands (n=25 site years)					
Mean	109	110	97	100	98
4th production year stands (n=11 site years)					
Mean	85	86	93	70	78

<u>Forage Quality</u>

Forage quality, although extremely important, is not the primary focus of this project. However, it is impossible to evaluate changes in management to maximize yield and persistence without considering the impact on forage quality. Total season mean Relative Forage Quality (RFQ) in 2014 was 162, nearly 10 points higher than 2013 but below 2012 and 2011 (Fig. 4). Second-cut was the most problematic harvest in 2014; this is reflected in the 144 RFQ for that cutting. There was also an unusually large cutting interval between first and second cuttings in 2014 (Table 1). In contrast, third-cut had an average RFQ of 192, the highest for that cutting of any previous project year.

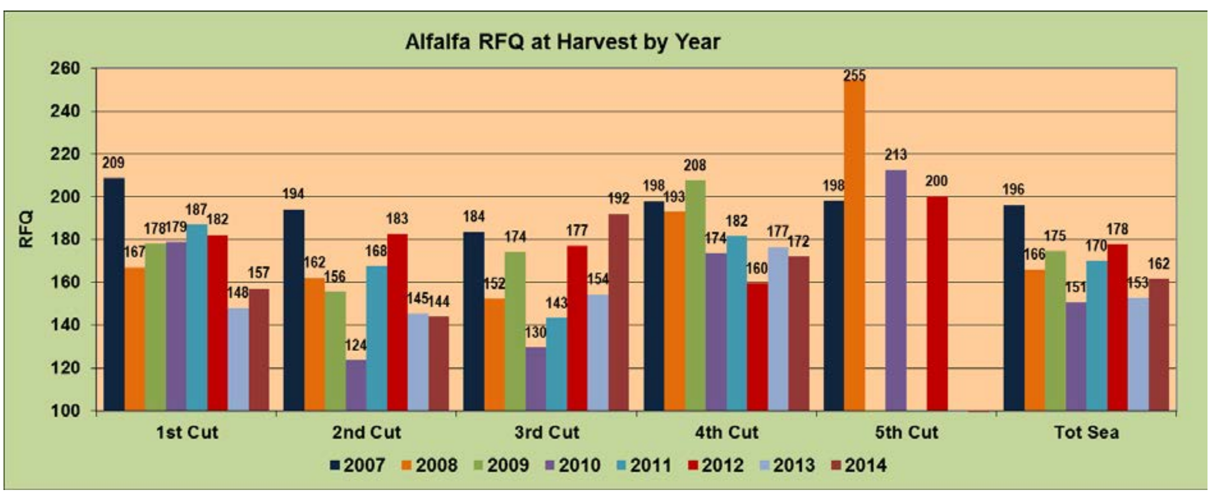

Figure 4. Average alfalfa Relative Forage Quality (RFQ) by cutting and for the total season (2007-2014).

Summary

The Wisconsin Alfalfa Yield and Persistence Program is designed to provide forage growers and agricultural professionals a unique look at what is happening at the farm level. As more fields are entered and years pass, the reliability of information will increase. It's important to keep in mind that only 8 years of data have been collected. Environmental conditions have a profound influence on both yield and quality and during the course of the past 8 years there have been no two exactly alike.

More detailed information and analysis is available in the 2014 project summary available on the UW Team Forage web site at http://fyi.uwex.edu/forage/alfalfa/

Acknowledgments

First and foremost, UW-Extension Team Forage wishes to thank the producers who took the extra time and effort to obtain weights and forage samples for the project fields at each cutting. The Midwest Forage Association is also acknowledged for providing funding for this project.

Past and Present UW Field Coordinators for this Project

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EFFECT OF ANNUAL GRASS WEEDS ON ALFALFA ESTABLISHMENT, YIELD AND FORAGE QUALITY

Mark J. Renz[1]

Weeds can affect alfalfa establishment, productivity and forage quality but the magnitude of the impact has not been thoroughly studied. Over the past three years we have established studies to evaluate the impact of all of these factors during the establishment year as previous research has shown this to be the most sensitive to weed populations. While previous experiments have been conducted throughout the state, research in 2014 was focused at the Arlington research station to determine the impacts of annual grasses on alfalfa establishment.

Methods. Alfalfa was planted on Planted May 28 at 15 lbs/A PLS with a brillion seeder to a tilled field with a prepared seed bed. This field was known to have a high seedbank of annual grasses, particularly giant foxtail. Planting was delayed due to spring precipitation and soil moisture. As the goal was to obtain a range of weed populations we applied herbicides POST with a range of grass (Poast Plus, Select) and broadleaf (Butyrac) specific herbicides applied at several rates. To avoid potential injury and yield reduction, herbicides with extended residual activity were NOT utilized (e.g. Pursuit, Raptor). Applications were applied when alfalfa was at the 1-3 (6/16/14) or 4-6 (7/2/14) trifoliate leaf stage respectively. Applications were replicated three times within the field. Due to the delayed planting, wet spring, and competitive environment alfalfa was not harvested until 8/15/14 when alfalfa was at 10% bloom. A second harvest was taken on 10/15/14 to alfalfa that was 8-10 inches tall.

Measurements. Cover of alfalfa and weed species were periodically estimated throughout the experiment. Forage yield was taken from the same square meter area within the center of each plot at each harvest. Forage yield was separated into alfalfa, grass weeds, and broadleaf weeds and dried and weighed. After weighing samples were combined for each plot, ground and analyzed for relative forage quality (RFQ) with NIRS. Alfalfa plant density was also counted for each harvested area during each harvest.

Effect of Weeds on Forage Production. Weed species increased production of total forage. The highest yielding plots summed across the establishment year were nearly all grass weeds (3.9 T DM/A), with the lowest yielding plots 75% alfalfa (1.7 T DM/A). While the first harvest on average contributed 80 % of the total yield for 2014, weed species were only common in the first harvest as on average weed species made up 80% of the biomass compared to 12% in the second harvest.

Effect of Weeds on Forage Quality in the first harvest. The primary weeds present (75%) were annual grasses (primarily giant foxtail and barnyardgrass). RFQ from treatments with 50% or less weed biomass had RFQ values > 165 (dairy quality) with estimated reductions in RFQ by 5% for for every 10% weeds in the total forage biomass.

Effect of Weeds on Forage Quality in the second harvest. Weed species were much less common in the second harvest and consisted of both annual grass and broadleaf (pigweed spp., common ragweed) weed species. Only three samples (5%) had an RFQ < 165, indicating feed was of high quality. No relationship was found between RFQ and percent of weed biomass between forage.

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Effect of Weeds on alfalfa establishment. Alfalfa plant density was 5.6 and 6.2 plants per square foot at the first and second harvest respectively. Low alfalfa plant counts are likely due to the late planting date and competitive environment and are likely underestimated by visual counts. While populations are low, no relationship was found between alfalfa plant density and weed biomass.

In summary, the majority of the weed impact to establishing alfalfa is from reductions in forage quality. While forage biomass is maximized when weeds are not controlled, forage quality drops as weed biomass increases. Forage quality can drop below dairy quality with moderate to high weed populations. While the impact on forage quality can vary depending on the weed species, our results suggest that RFQ will be reduced by 3-5% for every 10% of forage biomass that consists of weeds. The impact of weeds on forage quality is only seen in the first harvest, however. Contrary to popular belief, weeds do not affect alfalfa establishment in Wisconsin. This research confirms results from 2012 and 2013 and suggest that other factors are drivers in alfalfa plant establishment and survival, and weed management does not improve alfalfa establishment. Based on these findings I recommend that any management costs associated with weed control while establishing alfalfa should be recouped during the first harvest as one can expect minimal to no benefits after this timeframe.

FARM POLICY UPDATE: COUNTY ARC OR PLC+SCO

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{This page provided for note taking}

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GRAINS PRICE OUTLOOK

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AERIAL APPLICATION OF COVER CROPS INTO CORN AND SOYBEAN

Jim Stute [1/]

Interseeding cool-season grasses: annual ryegrass (*Lolium multiflorum*); barley (*Hordeum vulgare*) or winter rye (*Secale cereal*) alone or in combination forage legumes or radish (*Raphanus sativus*) into standing row crops is an increasingly common practice in the upper mid-west for corn and soybean producers who otherwise could not grow cover crops because of insufficient time for growth if planted after harvest. Perceived soil quality benefits: species diversity and impact on the soil biological community; return of vegetative (green) biomass to soil (including roots) and enhanced over-winter soil cover are all responsible for this interest and the belief that it will result in long-term improvement of crop yield and economic return (CTIC, 2013). Additional ecosystem services in this intensified system include the potential to increase infiltration and the retention of residual applied nitrogen when growing season conditions prevent corn from achieving its full yield potential. Increased infiltration is important for soil and nutrient retention as well as water capture and storage to mitigate increasing precipitation variability induced by climate change

Aerial broadcast seeding is the most common method of establishment in standing corn although industry has responded to grower demand and several equipment manufacturers are developing high capacity "high-boy" ground application equipment which could increase capacity over aerial application alone and result in greater planted acreage. This addresses a major barrier to cover crop adoption (Stockwell, 2012). Use of drop-tubes may also improve seed distribution on the soil surface improving cover crop efficacy. Aerial application offers advantages of rapid planting, frees the client's time for other pursuits and can be done when soil conditions are unfavorable for equipment operation.

Broadcasting seed offers challenges for successful stand establishment including downslope seed movement with run-off water (Bich et al., 2014), seed predation (Wilson et al., 2014) and fluctuations in temperature and surface moisture compared to incorporated seed (Fischer et al., 2011). In Minnesota, Wilson et al. (2013) determined that adequate soil moisture was critical for stand establishment, including rainfall within a week of application. These authors also found soil temperature had no effect on germination and establishment success, but also that their model looking at soil type, moisture and temperature only accounted for 43% of the variation in cover crop biomass production. Other authors (Ball-Coelho, 1997; Feyereiesen et al., 2006; Whitmore and Schroeder, 2007; Baker and Griffis, 2009) suggest light interception by the canopy is an important determinant in cover crop performance, at least with winter rye.

Timing is critical not only to prevent yield reduction or harvest interference in the target crop but also to obtain satisfactory cover crop performance. Cover crops seeded during the Critical Weed

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Free Period (Knezevic et al., 2002) have the potential to reduce yield by competition for light, nutrients and moisture. In corn, numerous studies have reported yield reduction for early interseeding but recently Bich et al. (2014) reported no yield reduction after V5 (Ritchie et al, 1989). Data for conventional soybean is lacking, presumably because of the potential for harvest interference and seed application at leaf-yellowing provides a longer period for competition free cover crop growth compared to corn.

Common practice among aerial applicators is to time application in corn using a specific phenological indicator: stalks browned to the ear-leaf (Damon Reabe, Personal communication). Applicator experience suggests that this is a satisfactory guideline for stand establishment with our current understanding canopy light penetration and its impact on cover crop establishment, but more work is needed to improve success rates. Informal investigation has indicated that in cases of establishment failure, plants are often etiolated, suggesting insufficient light penetration of the canopy and plants succumb to a lack of moisture from underdeveloped roots. Research is needed to determine the optimum level of light reaching the soil surface for successful cover crop establishment. This would mitigate factors such as stand density, leaf architecture and plant height which influence light penetration and are independent of the phonological target currently used.

Literature Cited

Baker, J.M. and T.J. Griffis. 2009. Evaluating the potential use of winter cover crops in corn-soybean systems for sustainable co-production of food and fuel. Agric. For. Meteorol. 149:2120-2132. doi:10.1016/j.agrformet.2009.05.017

Bich, A.D., C.L. Reese, A.C. Kennedy, D.E. Clay and S.A. Clay. 2014 Corn yield is not reduced by mid-season establishment of cover crops in northern Great Plains environments. Crop Management doi:10.2134/CM-2014-0009-RS

Conservation Technology Information Center (CTIC). 2013. 2012-2013 cover crop survey. http://www.northcentralsare.org/Educational-Resources/From-the-Field/Cover-Crops-Survey-Analysis (verified 5 Sept. 2014).

Ball-Coeho, B.R., and R.C. Roy. 1997. Overseeding rye into corn reduces NO_3 leaching and increases yields. Can. J. Soil Sci. 77:443-451. doi:10.4141/S96-072

Feyereisen, G.W.., B.N. Wilson, G.R. Sands, J.S. Strock, and P.M. Porter. 2006. Potential for a rye cover crop to reduce nitrate loss in southwestern Minnesota. Agron. J. 98:1416-1426. doi:10.2134/agronj2005.0134

Fisher, K.A., B. Momen and R.J. Kratochvil. 2011. Is broadcasting seed an effective winter cover crop planting method? Agron. J. 103:472-478.

Knezevic, S.Z., S.P Evans, E.E. Blankenship, R.C. Van Acker and J.L. Lindquist. 2002 Critical period for weed control: the concept and data analysis. Weed Science 50:773-786.

Ritchie, S.W., J.J. Hanway, and G.O. Benson. 1989. How a corn plant develops. Special report No. 48. Iowa Stute University of Science and Technology Cooperative Extension Service. Ames, IA.

Stockwell, R. 2012. Roadmap to increased cover crop adoption. National Wildlife Federation. www.nwf.org

Wilson, Melissa L., John M. Baker, and Deborah L. Allan. 2013 Factors affecting successful establishment of aerially seeded winter rye. Agron. J. 105:1868-1977. doi:10:2134/agronj2013.0133

Wilson, M.L., D.L. Allan and J.M. Baker. 2014. Aerially seeding cover crops in the northern US Corn Belt: limitations, future research needs and alternative practices. J. Soil Water Cons. 69:67-72.

Witmore, A.P., and J.J. Schroder. 2007. Intercropping reduces nitrate leaching under field crops Without loss of yield: a modelling study. Eur. J. Agron. 27:81-88. doi:10.1016/j.eja.2007.02.004

INTERACTION OF FGD GYPSUM, TILLAGE AND SOIL TYPE ON CORN PRODUCTION IN WISCONSIN

Elyssa McFarland, Francisco J. Arriaga[1], and Richard Wolkowski[2]

Introduction

Flue gas desulfurization (FGD) gypsum is a by-product of the process that removes sulfur from the gas emissions stream of coal fired electric power plants. FGD gypsum is currently being soil in Wisconsin to producers as a soil amendment and sulfur source. Most of the current work on FGD gypsum for row crop production in the Midwest is taking place in Ohio on soils that are very different from those in Wisconsin (Chen et al., 2008). The goal of this study was to better understand the effect of gypsum on corn production and soils under no tillage and conventional tillage cropping systems with six different rates of nitrogen fertilizer in Wisconsin.

Materials and Methods

This study was established in 2010 at the Arlington Agricultural Research Station on a Plano silt loam. In 2013, this study was expanded to include a site near Lancaster on a Fayette silt loam and near Marshfield on a Withee silt loam. Treatments included tillage (fall chisel with spring finisher and no-till), FGD gypsum application (0 and 1 ton/ac), and N rate (0, 50, 100, 150, 200 and 250 lb N/ac), set up as a split-split plot design with three replications.

A mid-season check of the corn nutrient status was taken by collecting ear leaf samples, digesting the tissue, and analyzing them using ICP-OES. The nitrogen and sulfur contents were then used to calculate a nitrogen to sulfur ratio. A N:S ratio of twelve or higher can be indicative of a yield response to sulfur (Weil and Mughogho, 2000). Grain yield was measured with a 2-row plot combine and stover yield manually. Nitrogen use efficiency (NUE) was calculated by subtracting the yield of a zero nitrogen applied plot from the yield of a nitrogen applied plot and dividing by the amount of nitrogen applied. Stover yield was calculated on a dry weight basis. Stover and grain samples were collected and analyzed for total nitrogen. Analysis of variance analysis was conducted using mixed models for a split-split plot design with an $\alpha = 0.10$.

Results and Discussion

The ear leaf N:S ratio improved with the application of FGD gypsum at each of the locations in both years (Fig. 1); however this did not translate to statistically significant increased yields in grain or biomass (Fig. 2). The main effect of FGD gypsum application on nitrogen content of harvest samples was only statistically significant for the grain samples from Lancaster in 2013 (data not shown).

Interaction effects of gypsum and nitrogen rate on yield were observed in 2013 at Arlington and in 2014 at Marshfield. A weak interaction was observed at Lancaster in 2013 and 2014. The interaction between nitrogen rate and gypsum was statistically significant for the nitrogen content of the grain and silage at Marshfield. Though the interaction between nitrogen rate and gypsum was observed at all locations for various measurements there was not a consistent trend. Similarly, the interaction between gypsum and tillage has not been shown to have a consistent trend.

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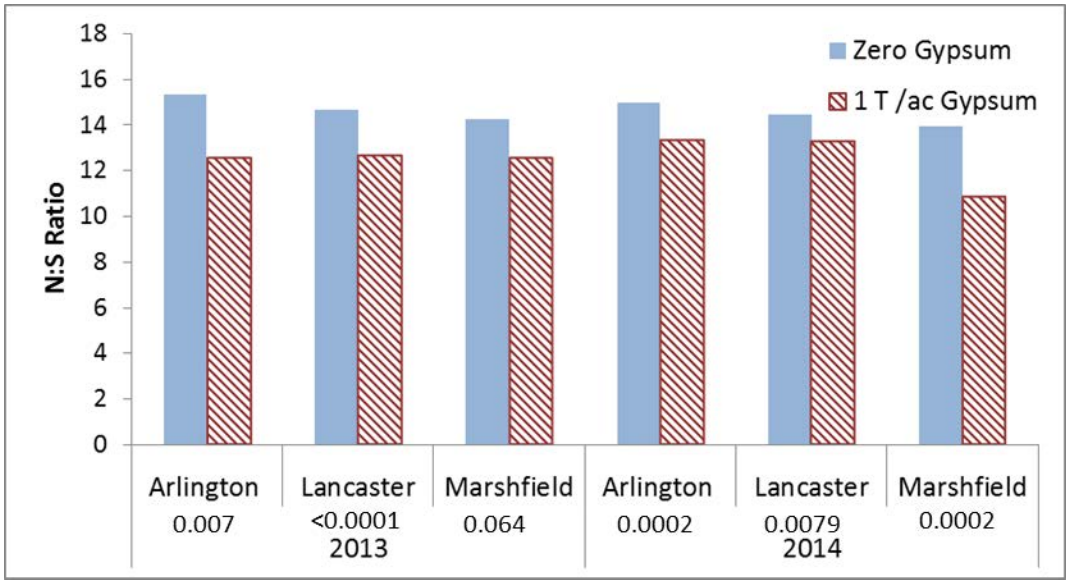

Figure 1: N:S ratio for three locations in 2013 and 2014. Values under each location represent the P-value between treatment at each location.

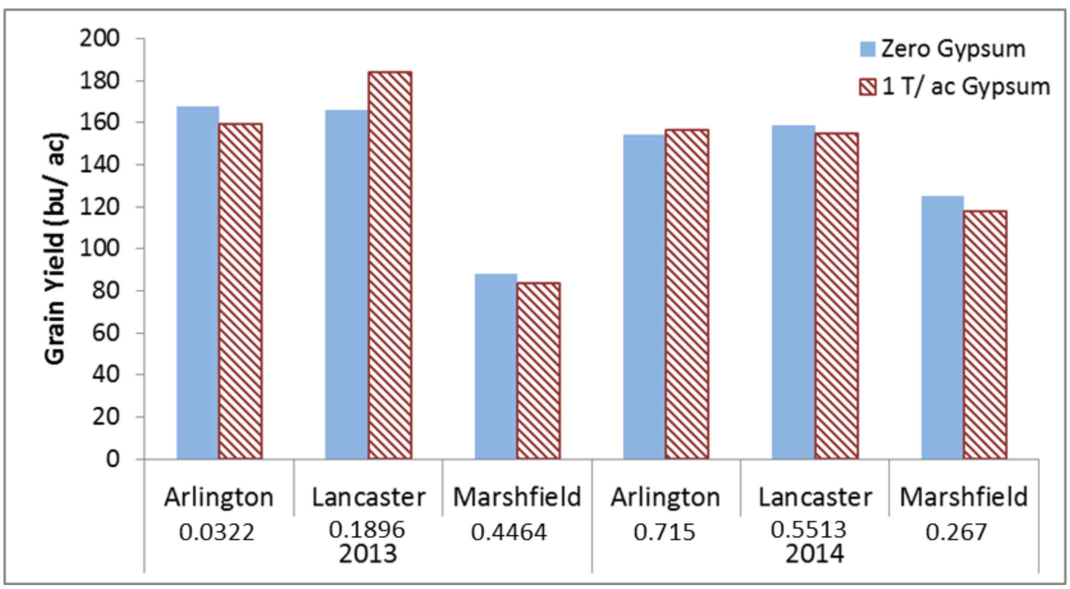

Figure 2: Grain yield for three locations in 2013 and 2014. Values under each location represent the P-value between treatment at each location.

NUE was not significantly improved by the main effect of gypsum. Similarly, there were no interaction effects in NUE at any of the sites in any of the years studied. Although the effect on FGD gypsum application has not been consistent among the three sites, work continues to further investigate long-term impacts and interaction effects with tillage and N rate application. A fertilizer recovery NUE will be calculated using the nitrogen contents of harvest samples to further explore impacts on NUE (Varvel and Peterson, 1990). Soil physical properties will be measured in the fall of 2015 at the end of the expanded 3-year study.

References

Chen, L., D. Kost, and W.A. Dick. 2008. Flue gas desulfurization products as sulfur sources for corn. Soil Sci. Soc. Am. J. 72(5):1464.

Varvel, G.E., and T.A. Peterson. 1990. Nitrogen fertilizer recovery by corn in monoculture and rotation systems. Agron. J. 82(5):935–938.

Weil, R.R., and S.K. Mughogho. 2000. Sulfur nutrition of maize in four regions of Malawi. Agron J 92(4):649–656.

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