Proceedings of the 2009 Wisconsin Crop Management Conference

13-15 January 2009

Exposition Hall, Alliant Energy Center
Madison, Wisconsin

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Appreciation is expressed to the Wisconsin fertilizer industry for the support provided through the Wisconsin Fertilizer Research Fund for research conducted by faculty within the University of Wisconsin System.

The assistance provided by Carol Duffy and Bonner Karger in preparation of this document is appreciated.

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2009 Wisconsin Crop Production Association Distinguished Service Awards

Distinguished Organization Award
Countryside Cooperative
{For Exemplary Industry Professionalism}

Education Award
Dr. Craig Grau, UW-Madison
{For Leadership & Commitment
to Educational Excellence}

Outstanding Service to Industry
Mike Turner, Wis. Crop Production Association
{For Dedication & Support to WCPA and Its Members}

Board Member Service Award
Greg Seffrood, Greg's Feed & Seed, Inc.
{For Full-Term Board of Director Service}

President's Service Award
Jim Sutter, Bullseye Ag Service, Inc.
{For Dedication, Service, & Leadership}

CropLife IRON'S Product of the Year Award
Winner to be announced

2008 – 2009
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Adam Kolb and Bradley Birzer
Fox Valley Tech

Jean Burger
Chippewa Valley Tech

Benjamin Henderson
Western Wisconsin Tech

R.D. Powell Memorial Scholarship

Shannon Earhart
UW-Madison

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MORE OF THE SAME ISN'T ENOUGH

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IMPACTS OF 2008 FLOODING ON AGRICULTURAL LANDS IN

ILLINOIS, MISSOURI, AND INDIANA

Kenneth R. Olson[1]

Introduction

The 2008 spring rains in Illinois, Missouri, and Indiana delayed planting, drowned corn and soybean plants and resulted in significant re-planting. From May 30, 2008 to June 12, 2008, the previously saturated soils could not retain any more rainfall and the wetlands, potholes and depressions in the upland landscape filled with water and then began to runoff through waterways and into small streams. As much as 30% of the upland soils in south central Illinois, northern Missouri, and southern Indiana were affected by ponding. Approximately 1/3 of that ponded acreage was not re-planted in 2008. As overland flow started to occur so did sheet, rill and gully erosion. Where significant topsoil loss occurs, it can eventually result in the erosion phase change of the soil. Any soil erosion phase change from slightly to moderately or severely eroded can reduce the crop yield potential from 5 to 15 bu/ac depending on whether the soils have favorable or unfavorable subsoils for rooting. One year's erosion events do not change the erosion phase of the soil unless gullying occurs. However, the 2008 soil loss, when added to the soil loss from erosion in previous years, could eventually result in a soil erosion phase change.

Corn and soybean planting in Illinois and Indiana was more than 3 weeks behind schedule by May 30, 2008 due to the wet and cool weather conditions. Many of the soils remained near saturated conditions (soil water in both the air and water pores) at that time. During the next 2 weeks, much of southern Indiana and south central Illinois received 8 to 12 inches of rain with little being stored in the soil. This resulted in local flooding by mid-June of 2008 with levees breaking on the Embarras, White, and Wabash rivers which drain into the Ohio River. Towns affected by flooding and levee breaks included Maysville, IN, Meyers and Lawrence, IL. Thousands of acres of agricultural lands were impacted. Much of the 2008 corn crop planted by June 8, 2008 on floodplain soils was lost due to flooding and many areas did not dry out sufficiently for crop planting until after July 15, 2008 making it too late to re-plant. In these areas the 2008 crop loss was total.

The areas that were not protected by levees and flooded only received a thin layer of silt and clay. The 2008 crop was lost but soils did not suffer permanent damage. This was not the case where levees failed. Water removed hundreds of feet of the levee embankments, eroded thousands of cubic feet of soils and underlying outwash parent material to depths of 10 to 20 feet below the base of the earthen levee when the levees broke. The force of the rushing water uprooted trees growing between the river and the levee prior to the break and deposited them on the previously protected floodplain. The 2008 crop on the floodplain soils behind the broken levees was a total loss.

This situation happened at two levee breaks southeast of Sainte Marie, IL. About 300 feet of levee was lost at each break. Blow-out holes or craters were created that were 1 to 3 acres in size and held water. Five- to 10-foot deep gullies extended a few hundred feet into the previously protected floodplain and hundreds of 70 foot high trees were transported hundreds to thousands of feet onto the previously protected floodplain. Deltaic sand deposits up to two feet thick covered

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80 acres or more on the floodplain at each site with an additional 200 acres covered with a few inches of sand. The remaining hundreds or thousands of acres of previously protected floodplain soils received a thin coating of silt and clay and remained under floodwaters long enough to drown out this year's crop if it was planted and not already removed by the wall of advancing water. The road and drainage ditches on the previously protected floodplain were also filled with sand more than a mile from the levee break. By June 23, 2008 the water had drained from the floodplains and back into the Embarras River sufficiently for the local farmers to hire contractors with bulldozers, pans, graders, back hoes, and buckets to begin the task of moving the trees from near the blow-out holes and floodplain and to begin filling in the craters and gullies. In addition, they began creating temporary levee embankments either around the blow-out hole or across it to prevent any future flooding. The material for the temporary levee was obtained from the thick sand deposit beyond the blow-out holes, transported to the edge of the blow-out hole or crater and then compacted by a bulldozer. Other equipment was used to scrape and pile the sand for use either in the temporary dam or to fill in parts of the craters and gullies. Tillage equipment, such as chisel plows and moldboard plows, were used on the areas with thin sand deposits (<6 inches) in an attempt to mix the sand into the underlying silty and clayey topsoil.

The first question raised by an equipment operator was: "Where did all the sand come from?" He seemed to know that most of the surrounding Illinois soils were low in sand content. In fact, most of the upland soils formed in loess, have less than 3% sand and even the bottomland soils in the area have less than 15% sand. Apparently, the sand came from sand bars that may have developed in the river as the fine silts and clays were carried beyond where the sand dropped onto the river bed. Also the area is just south of the Wisconsin terminal moraine that was also topped thousands of years ago by rising water moving rapidly and depositing sandy outwash in the existing Embarras River valley. This underlying outwash is higher in sand and may have been used to create the levee embankment in the 1920s and 1930s. It is the parent material under the current alluvial soils at depths from 4 to 20 ft. The levee itself contained a higher sand content than the soils in the area and significant sections of the levee were removed in addition to soil from the deep blow-out hole. When the current Embarras River cut through the levee and dissipated sufficient energy to slow the water flow down, the sand dropped out and the remainder of the finer soil materials were carried further out into the valley floodplain.

Land owner questions included: "Are the current soils in the flood plain without levees or with levees that broke damaged by flooding?" and if so "How can they be restored? When water flows over alluvial soils not protected by a levee the rising water level does not normally cause significant soil erosion damage in the form of sheet, rill or gully erosion. The unprotected alluvial soils often receive a thin layer of sediment which can usually be mixed into the underlying topsoil with tillage equipment. However, when a levee fails a several acre blow-out hole becomes a pond resulting in the permanent loss of floodplain soils and agricultural land. Additional damage can be caused by the adjacent thick sand deposits burying the underlying soils with up to two feet of sand and creating a deposit or delta which can cover 80 acres or more. This sand deposit has to be removed or the soils will remain too droughty for growing row crops in future years. The area that receives less than 0.5 foot of sand can often be mixed with the underlying silty and clayey soils and farmed in future years. Future crop yields may or may not be affected depending on the success of the mixing.

During the same May 30, 2008 to June 12, 2008 time period, 8 to 12 inches or more of rain also fell on all of Iowa, southern Wisconsin, northern Illinois and southeastern Minnesota and northern Missouri. Most of the national news coverage focused on Iowa where Cedar and Iowa rivers flooded the towns of Cedar Rapids and Iowa City. Later, the Mississippi and Missouri Rivers flooded farmland not protected by levees and where levees broke during the next few weeks as floodwaters peaked down river. The Mississippi River peaked at St. Louis, MO (near the point where the Missouri River flows in) on July 1, 2008 but at a lower height than during the 1993 flood. In 2008, there were no levee breaks on the Mississippi River south of St. Louis but there was flooding of agricultural lands and local roads in the floodplain. The raising floodwaters on the Mississippi River did cause evacuation of residents in towns such as Winfield, MO, Meyers, IL and Keithsburg, IL, closed many local roads and bridges and flooded adjacent agricultural lands. These levee breaks had the same effects on adjacent floodplain soils as noted above in the Ohio River tributaries discussion.

How did various soil conservation practices fare? During the last 30 years many soil and water conservation practices and structures were no longer utilized and soil erosion standards were met using conservation tillage and no-till systems. Most remaining terraces, contour farming, strip cropping and waterways were effective. However, many waterways were filled above capacity and were eroded by fast moving water or had significant sediment deposition. Culverts and other drainage structures were often plugged by soybean and corn residue, primarily from no-till systems residue. No-till systems did reduce raindrop impact and erosion but once overland flow started on sloping lands the residue was transported into the streams, blocked drainageways and structures and resulted in local flooding of fields and even highways. Water storage structures, such as retention ponds, filled quickly with water and in some cases were covered by floodwaters. Risers and tile outlets were often insufficient to drain crop areas within 24 or 48 hours resulting in significant numbers of corn and soybean plants lost. Some areas were eventually re-planted to corn or soybeans.

Floodwaters in 2008 on floodplains without levees resulted in 100% crop loss and floodplain soils often received thin silt, sand or clay deposition which could be mixed with tillage equipment into the topsoil prior to planting the 2009 crops. Floodplains with levees that held usually had little 2008 crop loss except where tributary streams ponded water behind the levees. However, floodplains with levees that broke lost both the 2008 crops and agricultural land. Lands adjacent to levee breaks were subject to rushing water which often created blow-out holes or craters resulting in total loss of soil profiles as the area became a pond. Thick sand deposits often tens of acres in size occurred adjacent to the blow-out hole in the form of a sand delta. These deposits could lower future yields of buried alluvial soils and resulted in up to 100% crop loss in 2008. Thin sand and silt deposits on hundreds of thousands of acres in floodpain (alluvial soils) will probably have limited impact on future soil productivity if sediment is tilled into the topsoil despite 2008 total crop loss.

Why were Illinois, Missouri, and Indiana vulnerable to flooding in 2008? The Mississippi River received a lot of floodwater from Wisconsin, Minnesota, and Iowa at a time when there was also a lot of local (Illinois and Missouri) runoff. Both sources contributed to levees breaking north of St. Louis. Indiana was obviously not affected directly by the Upper Mississippi River flooding event but was affected by Ohio River tributary flooding. Central Indiana, northern Missouri and south central Illinois received 5 to 12 inches of rain in the 2 weeks at the end of corn and soybean planting season (late May and early June) when the nearly level soils were already saturated. Other watersheds had a high slope gradient with even greater runoff potential. The hydrologic soil groupings in some watersheds also affected the runoff rate. The crop rotation in Illinois, Missouri, and Indiana is up to 90% corn and soybeans with limited acreage in small grains and forages. Further, urban and highway development in floodplains within the Mississippi, Missouri and Ohio River watersheds contributed to flooding problems. Drainage systems in the upland designed to remove excess water to open outlets in 24 hours reduced crop plant loss but contributed to higher flooding levels on floodplain soils. Currently fewer soil conservation structures and retention ponds are being built and maintained than in the past. Many levee breaks occurred despite efforts to rebuild, raise and strengthen the Mississippi and Missouri levees following the 1993 flooding. In Missouri, significant acreage of unprotected agricultural lands was converted to fish and wildlife use. Agricultural lands were permanently lost when adjacent to levee breaks. In some situations, the land owners are currently patching the private levees, filling in the craters and gullies, removing the thick sand deposits, and tilling the thin sediment deposits into the topsoil to prepare for the next year's planting season.

Recommendations

If one only focused on agricultural land and perhaps what could have been done to reduce the flooding impact, it would be important to separate watersheds with well drained soils and high slope gradients from watersheds that are relatively flat with poorly drained soils. In flat watersheds with poorly drained soils such as the Embrarras River watershed (Illinois) most soil and water conservation practices only include waterways, conservation tillage and no-till systems. Historically, the biggest management problem was soil drainage. Many of the soils were too wet to grow row crops. This was addressed with the 1879 Illinois drainage law which permitted digging drainage ditches, channelization, surface drainage, and subsurface tile drainage with the goal of removing surface ponding within 24 hours to prevent corn plants (soybeans had not yet been introduced) from drowning and to permit cropping. The only measures taken to reduce flooding in wet years were to build private levees near the banks of the streams and rivers which reduced the width of the floodplains but protected, in most years, the adjacent agricultural cropland on the floodplain soils from crop loss. Significant crop loss and damage to floodplain soils only occurs when levees break. Potential solutions to reduce the flooding impact on agricultural lands in flat watersheds with poorly drained soils could be the creation of temporary water storage structures (which would take additional agricultural lands out of production), change the crop rotation in the upland to include more forages rather than row crops, convert more of the agricultural land to timberland or grassland that can utilize or store more water, build higher and stronger levees that are located farther from the river banks to widen the river flow channel, accept periodic levee breaks and associated damage as a consequence of agricultural production in the floodplain, consider removal of existing levees or stop using the floodplain soils for agricultural crop production (land ownership might have to be transferred from private to public) and convert land to conservation use (wildlife, prairie, and timber) and restore the periodic water storage function to the natural floodplain.

In more sloping watersheds, such as the Iowa and Cedar River watersheds (Iowa) or similar ones in Missouri, southern Indiana, and southern Illinois, most of the soil and water conservation practices have focused on soil erosion control and have included terraces, waterways, contour farming, strip cropping, grass waterways, and upland water storage dams, conservation tillage and no-till systems. Soil drainage is not required for most well drained soils in the upland and drainage systems (drainage tile and waterways) have been used to safely remove water from the upland without soil erosion. Terraces usually drain to a tile outlets or waterways. In the sloping watersheds, the heavy rains create both soil erosion and flooding problems. Ways to reduce the impact of flooding on agricultural lands on the floodplains would be to slow the runoff and land drainage rate, temporarily store more water on the uplands, change the upland crop rotation to include more forages rather than row crops, convert additional agricultural land to pasture, timber, or forages so the soils can infiltrate, use or store more water, build stronger and higher levees on the floodplains but further away from the streams and rivers to widen the stream or river channel or stop farming the floodplain soils and change the land use to ones that do not sustain damage during periodic flooding.

In conclusion, the 2008 flooding severity within the Mississippi River basin depended on where the watershed was located. In Southern Wisconsin or Iowa, it was the worse flooding in 500 years, in the Embarras River watershed (Illinois), it was the worse flooding in 100 years and near St. Louis on the Mississippi River, it was the most severe flooding in past 15 years. The NOAA weather map of the May 30, 2008 to June 14, 2008 time period clearly shows where 10 inches of rain fell on already saturated soils the result in Upper Mississippi River and tributaries was flooding, crop loss, erosional damage to levees and adjacent agricultural bottom lands. However, as these waters moved southward during the month of July it was a rather uneventful period for the Lower Mississippi River south of Illinois, Missouri and Indiana.

WISCONSIN EXPERIENCES WITH EXTREME FLOODING
{Panel Discussion — Space below for notes}

Dick Wolkowski (Moderator), Mike Stanek, Randy Puttkamer,
Steve Huntzicker, and Kevin Semke [1/]

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STORM IMPACT ON CONSERVATION

Judy Derrick [1/]

Planning for normal rainfall events has been part of doing business on Wisconsin farms for centuries. In recent years, we are observing more intense rainfall events on localized areas of the state sometimes approaching rainfall factors that should only occur every 100 years. Dealing with those intense storm events are very challenging and not planning for them results in amazing damage from erosion and offsite deposition of soil and nutrients. Natural Resource Conservation Service has several suggestions on reducing risks caused by unexpected rainfall events.

What does it mean to design for a ten year event? What is a 100 year storm event? What are the engineering design issues associated with those excessive rainfall events? We will explore how to assess the value of a grassed waterway and buffers, how to evaluate the structural integrity of a Grade Stabilization Structure following a major rain event, methods to repair gulley erosion created from excessive rainfalls.

Identifying ways to slow water flow down on croplands and prevent massive gulley erosion on cropland acres is vital in conservation planning. Practices such as using cover crops to protect soil surface have increasing value in reducing flood damage. The use of common conservation practices on uplands greatly reduces cropland degradation. This session will explore the value of true no tillage capturing the concepts of soil consolidation factors. We will look at how soil reacts to saturated conditions and how that reaction may influence management decisions?

Anticipating heavy erosion potential creates new conservation planning options. The design and use of upland buffers, field edge buffers, surface water buffers. Treatments for headlands provide added protection. Cover Crops added into row crop scenarios are increasing in popularity. The value of grasses for erosion control remains critical. The value of keeping soil in place and staying in compliance is always important to economic bottom line.

This session is designed to explore soil reaction to excessive storm events, define why soils become vulnerable, and look at basic engineering concepts as they relate to soil erosion protection. The goal of this presentation is to provide options to producers to help them protect their soil from excessive rainfall factors and reduce risks from offsite sedimentation and runoff events.

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WATER IN THE VALLEY: FLOOD OF 2008

Madeline Gotkowitz[1]

In June 2008, overland flow of storm water and a rise in groundwater levels contributed to flooding 4,380 acres in Spring Green, Wisconsin. The affected area, which is located over a mile from the Wisconsin River floodplain, remained flooded for 5 months.

Groundwater elevations measured in Spring Green, in a shallow sand and gravel aquifer, show a rapid water table rise in response to spring snowmelt and precipitation events. This region experienced record snowfalls the previous winter, receiving twice as much precipitation as normal from December 2007 through February 2008. Over 5 feet of water table rise occurred following snowmelt in early spring. Intense rainstorms followed in late spring and early summer; 15.2 inches of precipitation fell in Spring Green during a 15-day period in May and June, corresponding to an additional 3.4 feet in water table rise.

Conceptual and numerical hydrogeologic models were useful to determine the role of groundwater to flooding in this region. Spring Green is located on a broad outwash terrace about 25 feet above the river, and is bordered to the north by a 200-foot-high sandstone and dolomite escarpment. Surface water from Big Hollow, a small valley lined with fine-grained sediment, drains onto the terrace. This geologic setting results in enhanced groundwater recharge to the shallow aquifer from runoff along the base of the bedrock escarpment and at the base of Big Hollow. Transient groundwater flow model simulations indicate a 12-foot rise in water table elevation may have occurred at some locations following spring snow melt and June rainfall. Water table rise above the land surface required drainage of the aquifer in order for flood waters to recede.

Groundwater-induced flooding explains the extensive and long-lasting nature of the flood, and its location far from the floodplain of the Wisconsin River. Modeling results indicate that a shift in climate in the mid-western U.S. towards increased frequency and magnitude of precipitation may cause water table rise sufficient to require adaptations in infrastructure and land use.

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SNAP-PLUS UPDATE

Sue Porter [1/] and Laura Ward Good [2/]

Snap-Plus version 1.128 was released in December, 2008. It can be downloaded from the Snap-Plus website (www.snapplus.net). This version includes many improvements requested by users. One of the major changes is implementation of an on-line Help system. Press F1 on any Snap- Plus screen to bring up the Help system window. You can use the Help system to learn about the new features listed below.

- ❖ You can now enter manure and fertilizer applications for the whole rotation for multiple years through the Rotation Wizard.
- ❖ You can update all crop, tillage, applications and other management information entered in Snap-Plus for multiple fields and multiple years in the Rotation Wizard.
- ❖ Snap-Plus now includes lime recommendations.
- ❖ You can save a copy of the farm database you are working in by using the new Snapshot feature on the File menu. Later, if you want to "undo" changes you have made, you can select "Revert" to return to your saved database.

Many more improvements are listed under the Help file.

We are working to make the Snap-Plus web site (www.snapplus.net) as informative and useful as possible for Snap-Plus users. The "Important News" section contains important current information about the latest release. A description of "Known Problems" and their workarounds is on the web site, along with tips for managing nitrogen and calculating P Index and soil loss in Snap-Plus. We have also instituted a Discussion Forum; you can post observations or questions for the programmers or other users. The web site will always have the most up-to-date information on nutrient management planning with Snap-Plus.

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[2] Snap-Plus Project Coordinator, Dept. of Soil Science, Univ. of Wisconsin-Madison.

KARST AND SHALLOW CARBONATE ROCK IN WISCONSIN

Kenneth R. Bradbury[1]

Carbonate rocks (rock formations composed primarily of limestone or dolomite) underlie about one-third of Wisconsin. These formations occur in a U-shaped belt beginning in southern Polk County in the northwest, extending through most of southern Wisconsin, and covering the entire eastern side of the state from the Illinois border to the Door Peninsula. These rocks are fractured, and vertical and horizontal fractures are the primary pathways for groundwater movement. These rocks are also soluble, and percolating water from precipitation can enlarge some fractures to form conduits, caves and sinkholes that are the hallmarks of a karst landscape.

Carbonate formations form important aquifers in Wisconsin, and these aquifers supply water for homes, farms, cities, industries, and other human uses as well as maintaining water levels in lakes and wetlands and flows in streams and springs. Carbonate aquifers can be extremely vulnerable to contamination for two reasons. First, groundwater flow in fractured rocks and karst can be extremely rapid - tens to hundreds of feet per day. Second, carbonate rocks have little attenuation capacity for filtering or otherwise removing contaminants. There are numerous examples of groundwater contamination of carbonate aquifers in Wisconsin. Consequently, land use activities in areas of carbonate rock must be carefully managed to avoid the release of contaminants to groundwater.

Carbonate aquifers are particularly vulnerable where overlying soils are thin or absent, as they are in parts of northeast Wisconsin. In 2007, a task force report addressed shallow bedrock conditions related to manure management in part of northeast Wisconsin (NE WI Karst Task Force, 2007). This report outlines management recommendations primarily intended to reduce "brown water" contamination incidents and secondarily intended to reduce contamination from nitrate. It strongly recommends the concept of carbonate bedrock management zones, in which land-use and practice management would be tailored to the unique hydrogeologic characteristics of carbonate-rock settings.

Water- and land-use management in carbonate-rock settings should always include approriate hydrogeologic mapping and analysis in the development of policies to protect groundwater quantity and quality.

Reference

Erb, K., R. Stieglitz (ed.). 2007. Final Report of the Northeast Wisconsin Karst Task Force. UWEX Pub. G3836. Univ. of Wisconsin-Extension, Madison, WI. 46 p.

[1]Hydrogeologist, Wis. Geological and Natural History Survey, Univ. of Wisconsin-Extension, 3817 Mineral Point Rd. Madison, WI, 53705.

WATER QUALITY IMPACTS OF POULTRY MANURE HEADLAND STACKING

Paul T. Kivlin[1/], Dennis R. Frame[2/], and Fred Madison[3/]

Abstract

Wisconsin is one of the nation's leading poultry producers. Manure generated by poultry has the potential to negatively impact the state's water resources if not properly managed. A common management practice associated with poultry manure handling is "headland stacking". Headland stacking involves temporarily storing poultry manure on field edges until the field is available for manure spreading (after the crop is harvested). As defined by a Wisconsin Department of Natural Resources (WDNR) WPDES permit for a poultry operation, headland stacking occurs when poultry manure is piled in fields for 11 to 365 days prior to spreading. In practice, most headland manure stacks remain in place fewer than 3 months.

In 2003, the UW-Discovery Farms Program began an investigation to determine whether the practice of poultry manure headland stacking poised a significant risk to surface or groundwater. Two studies were designed in cooperation with the WDNR, the United States Geological Survey, the University of Wisconsin's Geological and Natural History Survey, and the UW-Nutrient and Pest Management (NPM) Program.

The study examining the threat to surface water involved determining whether precipitation shed off the manure stacks had potential to carry pollutants from the stacking site. A 100 ton "typical" (100 feet long, 12 feet wide and 6 feet tall) headland manure stack was monitored over a period of 1 year to measure any water runoff. Over a 12-month period, no runoff events from the pile occurred. While this might not seem intuitive, some observations may help explain the lack of runoff. Poultry litter has an extremely high water holding capacity. Earlier laboratory work showed poultry litter held 37% of its weight in water. This ability to hold water meant the stack absorbed, and did not shed, the precipitation that fell. Additionally, heat created through the manure-composting process helped drive off moisture between rainfall events. The headland stack was, in effect, a large sponge and was able to maintain absorbency through the year. Based on the results of this study, poultry manure headland stacks pose minimal risk to surface water if they are sited away from areas of concentrated flow and severe slopes.

The study examining the threat to groundwater involved drilling monitoring wells around two "typical" headland poultry manure stacks to determine whether the stacks leached nutrients into groundwater. The two stacks were located on Rosholt silt loam soils with a groundwater depth of 12 feet (at the MM site) and 24 feet (at the RM site) and were in place for 1 year. The wells surrounding the stack sites were monitored for a period of 3 years (1 year with the stacks in place, 2 years following stack removal). The groundwater monitoring results from the two sites varied greatly and were probably most influenced by rainfall events. At the RM site, relatively

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[2/] Co-Director, UW Discovery Farms Program, P.O. Box 429, 40195 Winsand Drive, Pigeon Falls, WI 54760.
[3/] Co-Director, UW Discovery Farms Program, WGNHS, 3817 Mineral Point Road, Madison, WI 53705.

relatively "normal" rainfall patterns existed over the three year monitoring period and no elevated nutrient levels were detected as a result of the poultry manure headland stack. At the MM site, a 10.5-inch rainfall event occurred within a 24-hour period while the manure stack was still at the site. Large portions of the stack became saturated and elevated nutrient levels in groundwater were later detected as a result. The design criteria for most conservation practices use the 25-year/24-hour storm event (4.66 inches) as an upper limit. The 10.5-inch storm far exceeded not only the 25-year design parameter, but also the 100-year storm event (5.8 inches). Under normal rainfall conditions, properly sited poultry manure headland stacks appear to pose minimal risk to groundwater.

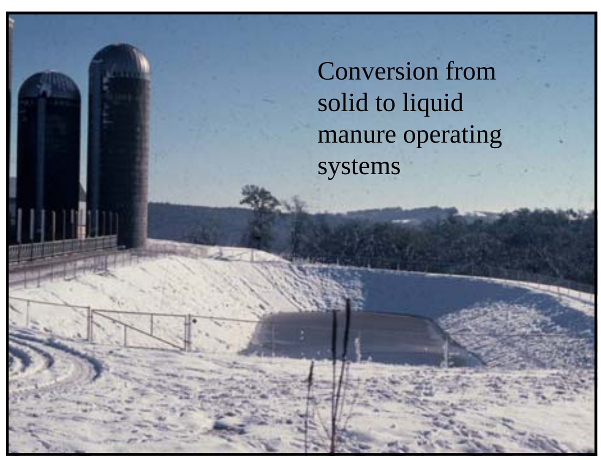
Complete reports of both studies can be obtained from Judy Goplin, UW Discovery Farms, P.O. Box 429, 40195 Winsand Drive, Pigeon Falls, WI 54760 (jgoplin@wisc.edu) or the authors.

Dane Co. Liquid Manure Ordinance for Winter Applications…or “Where To Go When It Snows”

Patrick J. Sutter, County Conservationist
Dane County Land & Water Resources Department
Land Conservation Division

Outline

- Dane County Winter Spreading Ordinance was amended to existing storage ordinance 12/12/05.
- Why Dane County opted to go the ordinance route versus the voluntary approach.
- Winter Spreading Plan Requirements.
- Highlights and challenges of having a Winter Spreading Ordinance at the County Level.
- Conclusions



Historical Events

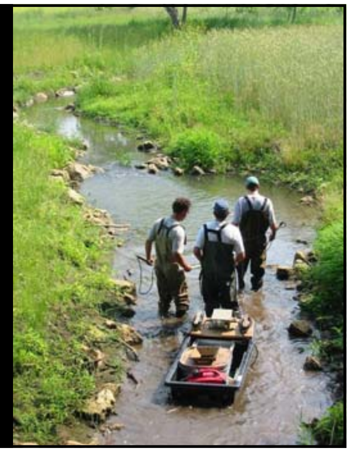
- 2 major manure runoff events in February 2005
  - Fish kill, West Branch Sugar River
  - Significant amount of nutrient loading the Lake Mendota and other local streams & lakes.

February 2005 Manure Runoff from Winter Spreading

Manure Task Force Convened

- Dane County Land Conservation Committee and Lakes & Watershed Commission established a 9-member task force committee shortly after those two incidents.
- The group met 6 times during the months of April and May, 2005. Final report was completed July 7, 2005.
- Task Force developed recommendations which ultimately were incorporated into the county ordinance.
- Members consisted of a mixture of Farmers, Environmental Interest Groups and County Board Supervisors

Monitoring & Accountability



Winter Spreading Manure Permit

Applies to agriculture producers who apply stored, pumpable liquid manure on snow-covered, frozen or ice-covered cropland

Winter Spreading Plan

1) Emergency Plan
2) Conservation Practices
3) Spreading Log
4) Maps

Emergency Action Plan for Manure Runoff/Spills

Farm Name: ______

Owner/Operator: ______

Farm Address: ______

Farm Location (T.R.1/4 Section): ______

Emergency Responder	Name	Telephone
Farm Contact		
Manure Hauler		
Off-farm Equipment Operator		
Land Conservation Staff		

Manure Runoff/Spills Emergency Steps:

1. **Stop the flow**
   - Incorporate manure if possible
   - Till ground ahead of manure flow to increase infiltration
   - Divert manure away from streams, ditches, waterways, concentrated flow areas, lakes, ponds, tile inlets, sinkholes and wells
2. **Contact DNR Spill Hotline at 1-800-943-0003.** Make sure you talk to a person. If you are unable to locate a person, contact the County Sheriff.
3. **Contact Dane County Land Conservation at 608-224-3730.**
4. **Clean up all accumulated manure.**
5. **Document your actions on the back of this page.**

Documented Actions for Emergency Plan for Manure Runoff/Spills

Action Taken	Comments
1. When manure was applied? *(date/time)*	
2. What was manure application rate? *(gallons/acre)*	
3. Where was manure applied? *(e.g. closest road name, field description/location)*	
5. Steps taken to stop runoff? *(for examples, see Manure Runoff/Spills Emergency Steps on front of this page)*	
4. Who was contacted and when? *(name, agency, date/time)*	
6. List any personnel that authorized manure clean up steps *(name, agency)*	
7. Other comments and/or actions?	

Conservation Practices:

a) **Install a grassed buffer, at least 30 feet wide, along a stream, drainage ditch, or lake**

b) Install a grassed buffer in a field

c) Install contour strip

d) Employ contour farming practices and leave all residue on the surface

e) Employ no-till practices with all crop residue from the previous year

f) Create and maintain terraces or diversions to reduce slope length

g) Chisel plowing the field prior to the ground freezing

h) Other conservation practices such as, but not limited to, intermittent strip spreading, approved by Land Conservation Department Staff

Manure Application Log

Date	Tract and Field	Acres	Conservation Practice in Place	Manure Type	Application Rate	Total Amount Applied

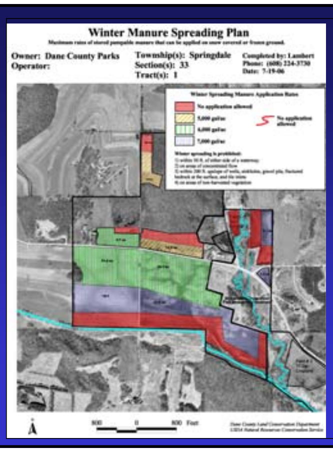
Winter Manure Spreading Plan Maps

Spreading Rates Based on Slope:

0-2% slope	**7,000 gal/acre application rate**	**(Blue on the Map)**
3-6% slope	**6,000 gal/acre application rate**	**(Green on the Map)**
7-12% slope	**5,000 gal/acre application rate**	**(Orange on the Map)**
>12% slope	**Spreading Prohibited**	**(Red on the Map)**

Areas Where Spreading is Prohibited:

- **Waterways or other channelized flow**
- **Non-harvested vegetation**
- **Within 30 feet on either side of a waterway**
- **Within 200 feet upslope of a well, tile inlet, sinkhole, gravel pit or fracture bedrock at the surface**
- **Within 300 feet of a stream or drainage ditch**
- **Within 1,000 feet of a lake**



Pros & Cons

Cons:
- > Timing – November 1, 2006
- > Other Commitments

Pros:
- > Education
- > Farmers taking the time to think where and when they spread manure

Dane County Web Site

http:www.danewaters.com/management/ManureTaskForce.aspx

MANURE MANAGEMENT ADVISORY SYSTEM-
RISK ASSESSMENT MODEL

Sara Z. Walling[1]

On-farm nutrient management begins with a good understanding of field-specific soils and their ability to accept nutrients and manure for optimal crop production while protecting water quality. DATCP is partnering with several federal and state agencies to develop two new tools to help farmers protect water resources when land spreading manure.

The first is online WI "590" Nutrient and Manure Application Restriction Maps which all of the mappable "590" spreading restrictions including slope and nitrogen restricted soils, and surface water quality management areas. These maps are currently available at http://www.datcp.state.wi.us/arm/agriculture/land-water/conservation/manure-mngmt/index.jsp.

The goal of the second tool, currently under development is a Manure Management Risk Assessment Model and website that will help alert farmers to the likelihood of runoff events occurring based on weather, landscape and soil conditions. While this tool is still in its initial development phase, it will include consideration of soil moisture, rainfall, snow, and snow melt forecasts. When completed, we expect this model will provide farmers with the ability to predict the risk of runoff for any particular day and will greatly assist farmers when making decisions about when to land apply manure or other nutrients. DATCP, NRCS, USGS, NOAA, NWS, UW (Soil Science, Ag Engineering, Discovery Farms, Pioneer Farm, Extension, and NPM), and others are collaborating to provide the surface runoff event data, models, and weather forecasting necessary to build and maintain this comprehensive assessment model that will identify when the likelihood for surface runoff may be greatest and therefore, when the spreading of nutrients on agricultural fields should be avoided.

[1] Wis. Department of Agriculture, Trade, and Consumer Protection, Div. of Agricultural Resource Management, Bureau of Land and Water Resources.

STORIES FROM THE FIELD: IMPLEMENTING NUTRIENT MANAGEMENT
{Panel Discussion — Space below for notes}

Scott Sturgul (Moderator), Greg Kerr, Paul Knutzen and Paul Sturgis [1/]

[1/] Outreach Program Manager, NPM, UW-Madison; Kerr Agronomics, Inc., River Falls, WI; Knutzen Crop Consulting, New London, WI; President, CropTech Agronomics, Vesper, WI.

SPECIES SELECTION FOR PASTURE

Dennis Cosgrove[1]

Species selection is an important first step in obtaining high yielding, long lasting pastures. There are a large number of productive pasture grasses and legumes to choose from. Each has advantages and disadvantages. Below is a brief description of the most common pasture grasses and legumes in Wisconsin.

Grass Species Descriptions

Festulolium is the result of a cross between meadow fescue (Festuca) and Italian ryegrass (Lolium). It has better forage quality than tall fescue and better winter hardiness than ryegrass. It has vigorous growth and recovers quickly after grazing. While winter hardiness is improved it is still less than optimum and stands may be lost in harsh winters.

Kentucky bluegrass is a sod-former with excellent winter hardiness. It has superior grazing tolerance and is able to persist is overgrazed pastures. Bluegrass productivity is limited due to its intolerance to hot, dry conditions. In addition, palatability is reduced as grass matures. Bluegrass is not a good choice for high producing pastures particularly in Southern Wisconsin.

Meadow bromegrass is a winter hardy bunchgrass well adapted to dry conditions. It has earlier growth in spring than other grasses and faster recovery from grazing than smooth bromegrass.

Meadow fescue has greater winter hardiness and improved palatability compared to tall fescue. It is persistent and has good grazing tolerance. It is not infected with the same endophtye and so does not contain the toxins found in tall fescue. It is a vigorous grass with rapid recovery rates.

Orchardgrass is a very productive bunchgrass. It recovers rapidly from grazing so can be grazed frequently. It is only moderately winter hardy and stands tend to thin over time and become "clumpy". Inclusion of a second, sod forming grass such as bromegrass or reed canarygrass will help avoid this but care must be taken not to overgraze them. Select late maturing orchard grass varieties.

Perennial ryegrass is a very high quality grass tolerant of close, frequent grazing. It lacks sufficient winter hardiness to be used as the only grass species in a pasture. More winter hardy grasses should be included in a mixture or, if the only grass, acreage should be limited.

Reed canarygrass is a persistent, sod-forming grass. It is high yielding and tolerant of both dry and wet soils. It recovers rapidly from grazing but cannot tolerant close grazing. Older varieties contain alkaloids that reduce palatability. More recent varieties are free of these compounds and should be selected for pasture seeding. Reed canary grass is invasive and should not be planted near waterways. Care should be taken to not let seeds form.

Smooth bromegrass is a sod forming species with excellent winter hardiness. Under proper management (proper grazing heights and rest periods) bromegrass pastures are long lasting and

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productive. Bromegrass is slower to recover from grazing than other grasses. If not managed properly, bromegrass pasture production suffers and stand longevity is severely reduced.

Tall fescue contains an endophytic fungus that produces compounds that reduce performance of animals consuming it. In addition, it has stiff, jagged-edged leaves that reduce palatability and intake. It is only moderately winter hardy. For these reasons endophyte infected tall fescue is not a good choice for pasture. Recently, improved varieties of tall fescue have become available.

Endophtye free tall fescue varieties do not contain the toxic compounds and so animal performance is increased.

Soft-leaf tall fescue varieties have shown increased intake by grazing animals. Leaves have a softer feel which increases palatability.

Novel entophyte tall fescue is infected by the endophytic fungus but doesn't produce toxic compounds. Intake and rates of gain are improved over the infected types.

Timothy is a winter hardy bunchgrass. Under proper grazing management it can be productive but lacks persistence, is intolerant of dry conditions and has long recovery periods after grazing. It is also susceptible to overgrazing. Due to these drawbacks it is not widely used by grazers desiring high producing pastures.

Table 1. Characteristics of some common pasture grasses.

Species	Ease of establishment	Grazing tolerance	Winter hardiness	Drought tolerance	Regrowth potential	Persistance
Festulolium	Excellent	Good	Fair	Fair	Excellent	Fair
Kentucky bluegrass	Good	Excellent	Excellent	Fair	Good	Good
Meadow bromegrass	Good	Fair	Excellent	Good	Good	Good
Meadow fescue	Excellent	Good	Excellent	Fair	Excellent	Good
Orchardgrass	Good	Good	Fair	Fair	Excellent	Good
Perennial ryegrass	Excellent	Excellent	Poor	Fair	Excellent	Poor
Reed canary grass	Poor	Good	Excellent	Excellent	Good	Excellent
Smooth bromegrass	Good	Fair	Excellent	Fair	Fair	Good
Tall fescue	Excellent	Good	Fair	Fair	Excellent	Fair
Timothy	Good	Fair	Excellent	Poor	Fair	Poor

Adapted From 'Pastures for Profit" UWEX Pub. A3529, Univ. of Wisconsin-Extension.

Legume Species Descriptions

Alfalfa is the most widely grown forage legume in Wisconsin. It is less popular among grazers due to higher cost and somewhat reduced grazing tolerance. Alfalfa requires a higher soil pH than most other pasture legumes which adds to the production cost. Alfalfa tends to become somewhat stemmy and so intakes are reduced if pastures are not well managed. Grazing types of alfalfa are available that reduced this effect.

Birdsfoot trefoil is the only commonly grown pasture legume that does not cause bloat. It is difficult to establish but extremely persistent due to natural reseeding. It is a high quality legume but is intolerant of dry soils and is easily overgrazed. Prostrate or semi-prostrate varieties are the best for grazing.

Kura clover is a rhizomatous legume that is winter hardy and persistent. Its growth habit makes it tolerant of frequent grazing. It is difficult to establish, particularly when interseeded into an existing pasture. Care must be taken to provide an adequate seedbed and control competition to allow kura clover time to establish adequately.

Red clover is the most widely used legume in Wisconsin pastures. It is tolerant of low pH soils and can be easily frost seeded or interseeded to maintain stands. This is important as red clover lacks long term persistence.

White clover is very tolerant of close grazing and is one the most common legumes in poorly managed, over grazed pastures. While individual plants do not persist, stands are long-lived due to natural reseeding and new plant establishing from stolons. It is relatively low yielding.

Table 2. Characteristics of some common pasture legumes.

Species	Ease of establishment	Grazing tolerance	Winter hardiness	Drought tolerance	Regrowth potential	Persistance
Alfalfa	Good	Good	Good	Excellent	Good	Good
Birdsfoot trefoil	Poor	Good	Excellent	Poor	Fair	Excellent
Kura clover	Poor	Excellent	Excellent	Good	Excellent	Excellent
Re d clover	Excellent	Good	Good	Poor	Fair	Fair
White clover	Excellent	Excellent	Excellent	Good	Good	Excellent

Adapted From 'Pastures for Profit" UWEX Pub. A3529, Univ. of Wisconsin-Extension.

Species Mixtures and Seeding Rates

A frequently asked question is "What species should I plant in my pasture?" There is no one simple answer to this question. The answer depends on animal species, soil types, grazing systems, level of management and other factors. In general, inclusion of a number of difference species helps even out production and makes the pastures able to respond to environmental changes.

There are two approaches to achieving this kind of diversity. One is to include a large number of species in a pasture mix and plant that mixture throughout the farm. Different species will excel in different areas of the farm or at different times of the year. Many complex mixtures are prepackaged and sold this way. This has the advantage of ease of planting. The disadvantage of this approach is that species with very different grazing requirements will be mixed together making for difficulty in management.

A second approach would be to plant a number of different mixtures in different paddocks through out the farm. This allows for more specific and easier pasture management. The disadvantage of this approach is more complexity in obtaining pasture mixes, calibration and planting. Table 1 lists several important characteristics of many common pasture grasses and legumes. Use this table to select similar species, particularly in regard to grazing tolerance. This will allow the use of simple (one grass + one legume) or complex mixtures with the advantage that all species will be able to be managed similarly. Table 3 lists recommended seeding rates for these species.

Table 3. Recommended seeding rates for common pasture grasses and legumes.

Species	Seeding rate (lb/acre)	Species	Seeding rate (lb/acre)
Festulolium	4	Tall Fescue	4
Kentucky bluegrass	8	Timothy	2-4
Meadow bromegrass	3-6	Alfalfa	8
Meadow fescue	4	BirdsfootTrefoil	6
Orchardgrass	2-4	Kura Clover	6
Perennial ryegrass	15	Red Clover	6-8
Reed canarygrass	5	White Clover	1-2
Smooth bromegras	3-6		

Adapted From ‘Forage Variety Update for Wisconsin” UWEX Pub. A1525, Univ. of Wisconsin-Extension.

IMPROVING PASTURE WEED MANAGEMENT

Mark Renz [1/]

[1/] Extension Weed Scientist, Dept. of Agronomy, 1575 Linden Dr., Univ. of Wisconsin-Madison. mrenz@wisc.edu

SEED CERTIFICATION AND QUALITY ASSURANCE

William F. Tracy [1/]

Legal seed certification processes and organizations developed around the turn of the previous century. The goal of such laws and organizations was to protect farmers by assuring them that the seed they purchased was clean and viable and the variety it was purported to be. These processes also protected plant breeders and reputable seed companies. For many crops most notably corn, over time quality assurance was assumed by the seed companies who's reputation and business would depend on the quality of the product. Today the traditional purpose of seed certification is still going strong especially for small grains and also newer crops such as prairie plant seeds. But a new dimension has been added to insure that the crop seed meets the claims regarding the presence or absence of transgenes or as they have become known "traits".

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WHAT HAVE TRANSGENIC CROPS MEANT TO FARMERS?

Joe Lauer [1]

Transgenic corn has dramatically changed the way Wisconsin farmers produce corn. The amount and cost of pesticides used for corn production has decreased, while weed and insect control has improved. Fewer nontransgenic hybrid options are available to farmers (Figure 1). Early adopters of transgenic hybrids have often perceived lower yields, and in general for most transgenic events this observation is accurate. But, within a short period of time transgenic hybrids yield above the average of nontransgenic hybrids more frequently. This "yield drag" or "yield lag" as it has been called by farmers is a major obstacle limiting early adoption of transgenic hybrids.

Several factors have contributed to early lower yields in transgenic hybrids. The conversion of normal corn to a transgenic hybrid requires numerous cycles of back-crossing. The time that is required to complete the back-cross process has resulted in transgenic hybrids lagging behind that of the normal hybrid from which it is derived for performance. Second, the conversion of normal hybrids is not always "clean." Plant breeders spend time and resources making sure that transgenic traits work. Sometimes undesirable agronomic characteristics are strongly linked to the gene that conferred the transgenic trait and this "linkage" decreases yield performance. Yield drag and yield lag is real and costly. Finally, yield performance variability exists among transgenic hybrids. Transgenic hybrids are often at the top of the list for yield, but they are just as frequently at the bottom of the list as well.

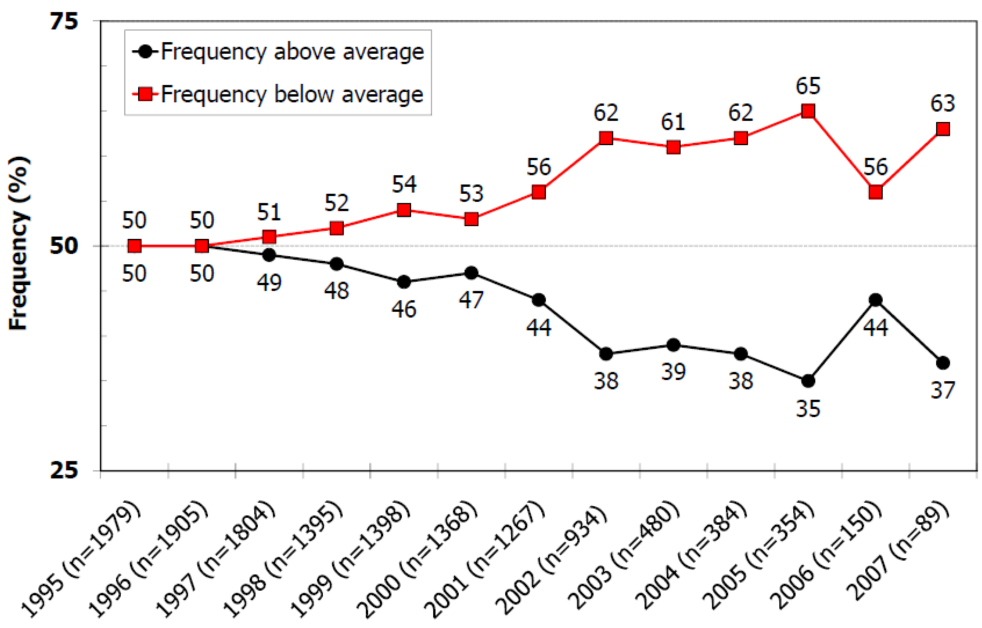

Figure 1. Frequency (%) of 'Non-Transgenic' Corn Hybrids Yielding Above and Below the Trial Average in UW Trials. The N value equals the number of normal G*E tests in each year.

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Bt-CB and Bt-CR Corn hybrids

"Bt" is an abbreviation for the bacteria, *Bacillus thuringiensis*, which is found in the soil. Bt forms a crystal protein that is toxic to caterpillars (lepidopterans, e.g. European Corn Borer), beetles (e.g. Corn Rootworm and Colorado potato beetle), and aquatic flies (e.g. black flies and mosquitoes). After the insect eats Bt, the crystal dissolves to release a toxin that attacks the gut lining. Feeding stops within a few hours. The insect gut wall breaks down within 24 hours. Bacterial spores germinate and invade the body cavity of the insect. The insect dies from toxins attacking the gut wall, by a general body infection (septicemia) which is present within 48 hours, and food deprivation. Over 70 different toxins are formed from Bt crystal proteins. The activity of the toxin in an insect depends on gut pH, the presence of enzymes and reducing agents, and the presence of binding sites on cell membranes. Production of the Bt protein in corn continues as long as the corn is actively growing and declines after ear fill begins. Different plant parts will express differing levels of the Bt protein. A number of questions need to be addressed regarding long term economics, since European Corn Borer outbreaks do not occur every year. In addition, special resistance management strategies are required.

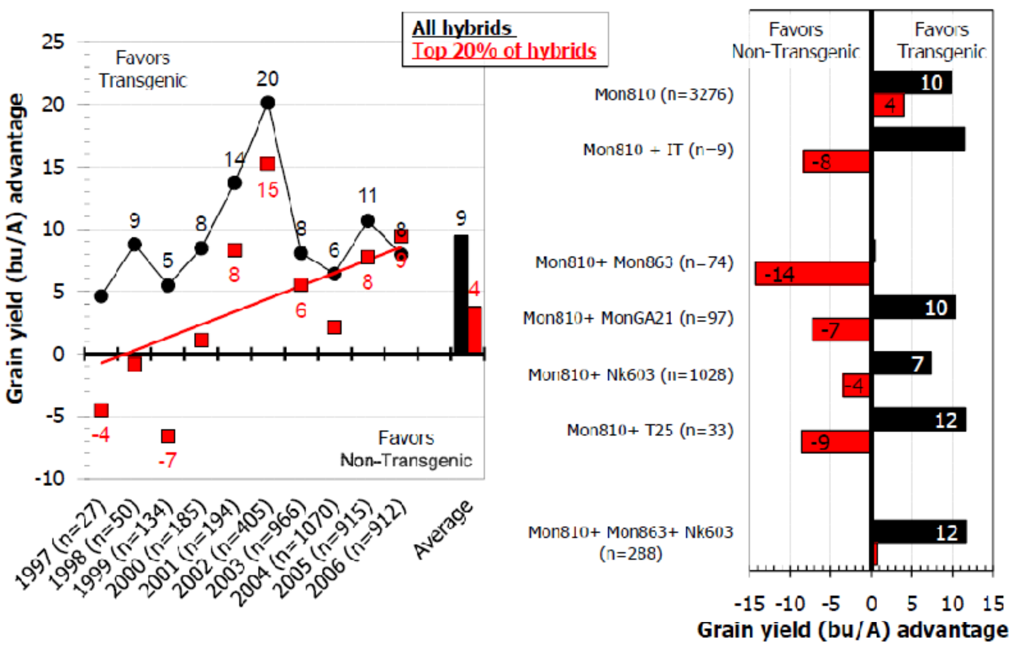

Figure 2. The yield advantage of the transgenic Bt-CB Mon810 event (n= 4858) compared to non-transgenic (n= 8767) corn hybrids when grown in the same trial. The left graph shows performance of all hybrids with the event present. The right graph shows performance of "stacked" hybrids. N= the number of G*E tests involving the transgene.

Numerous transgenic events for controlling the European Corn Borer have been available to farmers including Event 176, Mon810, Bt11, Bt413, and TC1507. An example of the relative performance of Bt-CB event (Mon810) is shown in Figure 2. All hybrids with this Bt-CB event have had greater yield than all nontransgenic hybrids every year tested. Within the top 20% of the hybrids for yield, this Bt-CB event was similar to the top 20 % of the nontransgenic hybrids when it was first released in 1997, and in 2006 was 8-9 bu/A better. Mon810 by itself yields 4-10 bu/A more than non-transgenic hybrids (all and top 20% groups), but when stacked, yields generally were less than nontransgenic hybrids in the top 20% group.

Three transgenic events for controlling the Corn Rootworm have been available to farmers including Mon863, DAS591227 and Mon88017. An example of the relative performance of Bt-CR event (Mon863) is shown in Figure 3. All hybrids with this Bt-CR event had lower yields than nontransgenic hybrids in 2003, but by 2006 this Bt-CR event had 6 bu/A more yield than a nontransgenic hybrid. Within the top 20% of the hybrids for yield, this Bt-CR event was 22 to 24 bu/A lower yielding than the top 20 % of the nontransgenic hybrids when it was first released in 2003, and in 2006 Mon863 hybrids were 7 bu/A better. Mon863 by itself did not yield any differently than non-transgenic hybrids in the all group and was 10 bu/A lower in the top 20% of the hybrids. When stacked with other traits, grain yield was usually lower in the top 20% of the hybrids, except for the "triple stack" hybrids with the combination of Bt-CB, Bt-CR and Roundup-Ready.

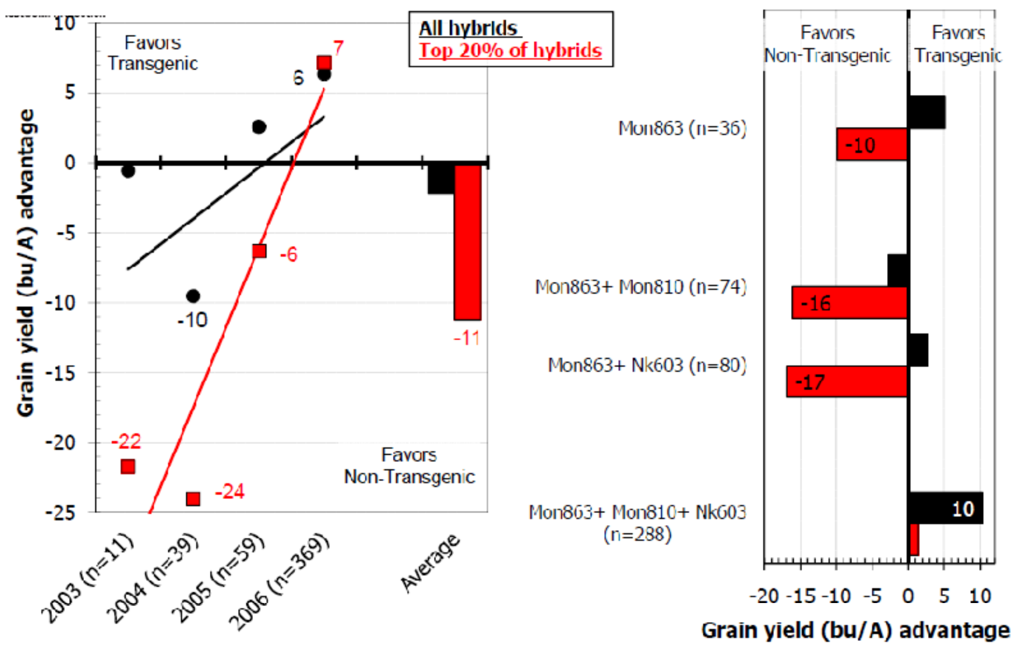

Figure 3. The yield advantage of the transgenic Bt-CR Mon863 event (n= 478) compared to non-transgenic (n= 1011) corn hybrids when grown in the same trial. The left graph shows performance of all hybrids with the event present. The right graph shows performance of "stacked" hybrids. N= the number of G*E tests involving the transgene.

"Liberty Link" Corn

Liberty Link corn is tolerant to broadcast applications of Liberty herbicide, glufosinate ammonium. The gene that gives resistance to glufosinate came from a naturally occurring soil bacterium, *Streptomycin hygroscopicus*. Glufosinate is a fast acting, post-emergent, foliar applied, non-selective contact herbicide that controls a broad spectrum of weeds. It has no translocation or root uptake. It is most effective on small weeds but less effective on lambsquarters, drought stressed velvetleaf and large annual grasses.

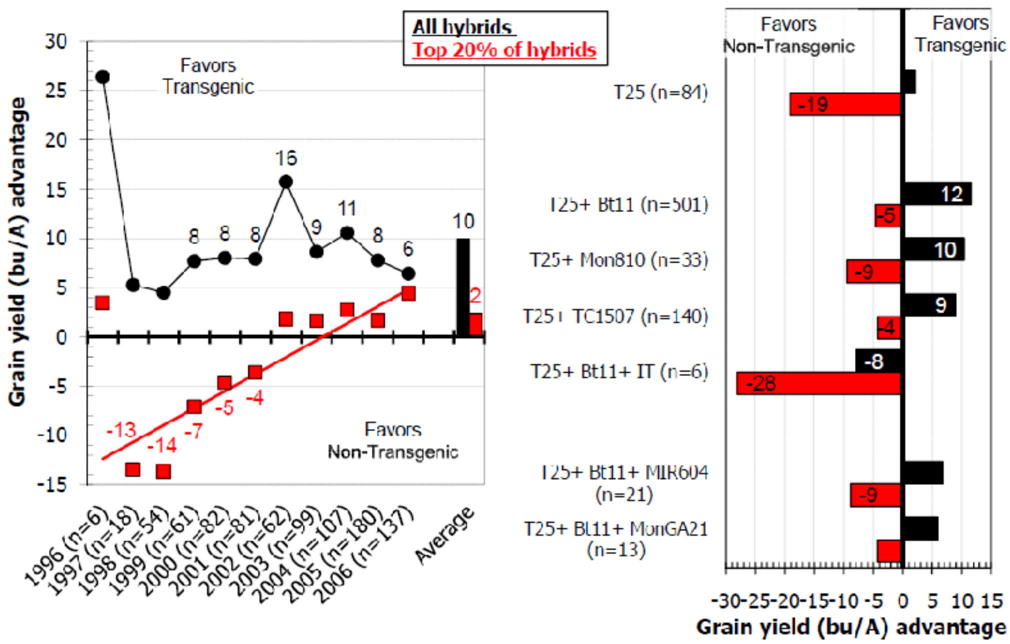

Figure 4. The yield advantage of the "Liberty Link" T25 event (n= 887) compared to non-transgenic (n= 9909) corn hybrids when grown in the same trial. The left graph shows performance of all hybrids with the event present. The right graph shows performance of "stacked" hybrids. N= the number of G*E tests involving the transgene.

Within the all group, hybrids with the Liberty Link gene had better performance in all years of testing (Figure 4). The top 20% of Liberty Link hybrids had less yield than nontransgenic hybrids in 1996 and have generally improved over time so that in 2006 there were no differences between Liberty Link and nontransgenic hybrids. Mixed performance is measured among traits stacks. Stacks involving Bt-CB hybrids (Bt11, Mon810, and TC1507) perform better within the all group.

"Round-up Ready" Corn

Corn that is resistant to the herbicide glyphosate, a post-emergent, foliar applied, non-selective herbicide that controls a broad spectrum of weeds. It was first made available to farmers commercially in 1998. The transgene was isolated from a soil fungus. Two events have been commonly used in corn, MonGA21 and Nk603. Figure 5 describes the yield changes over time and stacked for the Nk603 event. Within the top 20% group, hybrids with Nk603 yielded 2 to 20 bu/A less than nontransgenic hybrids. Yield has continued to improve and in 2006, hybrids with the Nk603 transgene were yielding 11 bu/A more than nontransgenic hybrids.

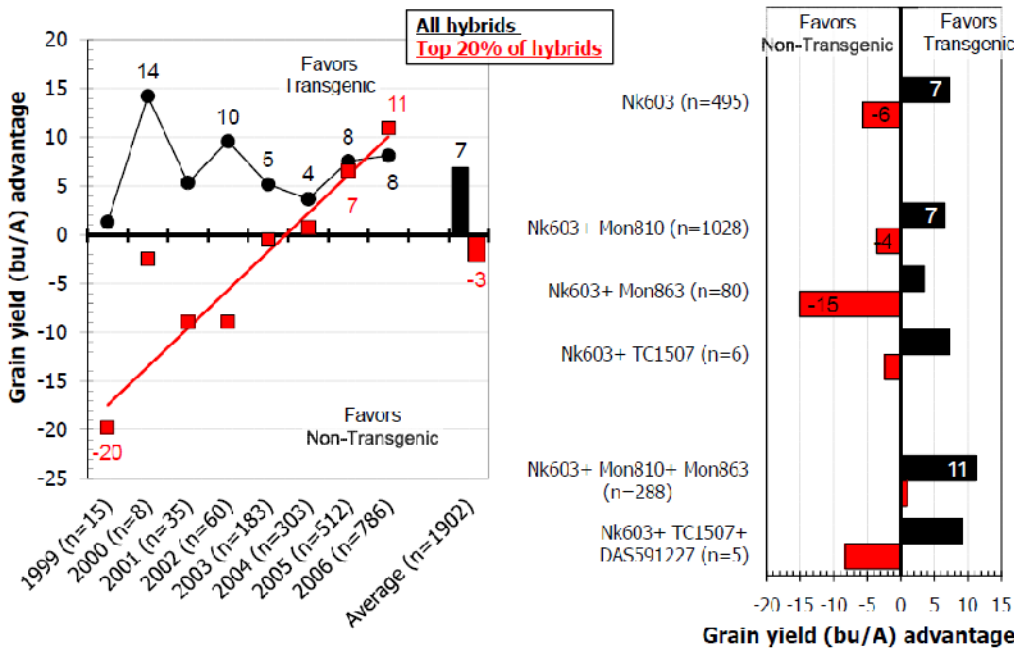

Figure 5. The yield advantage of the "Roundup Ready" Nk603 event (n= 1902) compared to non-transgenic (n= 3703) corn hybrids when grown in the same trial. The left graph shows performance of all hybrids with the event present. The right graph shows performance of "stacked" hybrids. N= the number of G*E tests involving the transgene.

"Clearfield" IMI Corn ("IT/IR")

Corn that is resistant or tolerant to imidazolinone family of herbicides (Pursuit and Scepter) due to a single semi-dominant allele. To produce IT corn inbreds, corn with the IT allele is back-crossed to a recurrent inbred parent. Hybrid corn is sold as IT or IR. IT hybrids have the gene from one inbred parent, while IR hybrids have the tolerant gene from both inbred parents. Scientists at American Cyanamid Company discovered the imidazolinone herbicides in the 1970's. In 1982, American Cyanamid began collaborating with Molecular Genetics, Inc. to develop imidazolinone tolerant corn. By 1984, Molecular Genetics, Inc. had successfully regenerated corn with imidazolinone tolerant (IT) genes which then allowed back-crossing to inbred lines. In 1992, the first corn hybrids were produced for commercial sale. These hybrids had a 2X to 4X crop safety level compared to imidazolinone herbicides. In 1993, Pursuit (imazethapyr) herbicide was labeled for use in corn. IMI corn may be good insurance where herbicide carryover is suspected. Numerous IMI hybrids with a wide range of maturity are available.

Grain yield has steadily improved with this group of hybrids (Figure 6). When first released, IMI hybrids yielded 29 to 30 bu/A less than nontransgenic corn among the top 20% of each group of hybrids. Stacked versions have not done as well as nontransgenic corn.

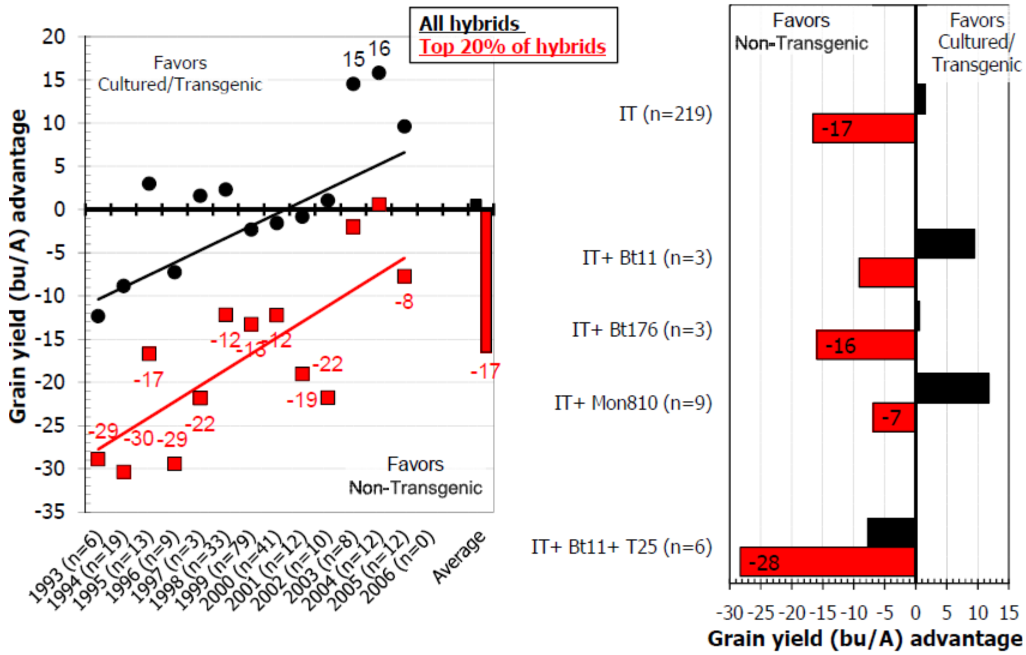

Figure 6. The yield advantage of tissue cultured "Clearfield" IMI-IT/IR (n= 257) compared to non-transgenic (n= 8658) corn hybrids when grown in the same trial. The left graph shows performance of all hybrids with the event present. The right graph shows performance of "stacked" hybrids. N= the number of G*E tests involving the transgene.

Management needs of transgenic corn

The cultural practices that are required for successful transgenic corn production are similar to those used to optimize performance of normal yellow dent corn. Growers should follow recommended agronomic practices, including the maintenance of good soil fertility and pest control to minimize stress and maximize yield potential.

The following are some key management practices when producing transgenic corn.

1. Select fields with high yield potential. Usually transgenic corn seed is more expensive. Plant transgenic corn on the most fertile well-drained soils to maximize yield and reduce stress. Avoid droughty as well as poorly drained soil conditions.
2. Use crop rotations. For best results plant transgenic corn hybrids after soybean or forage legumes. Grain yields of rotated corn will typically be about 10% higher than corn following corn. This yield advantage is much more pronounced when stress occurs during the growing season. Another benefit of rotated corn is less pest pressure. Rotated corn will also minimize volunteer corn, which can cause contamination problems during pollination in waxy, high-oil, high-lysine and high amylose corn

3. Select transgenic hybrids adapted to your growing conditions. Chose the transgenic hybrid best suited to your farming system. The decision should be based on yield potential and stability, maturity, lodging resistance, and pest resistance.
4. Prepare a seedbed that will promote uniform seed emergence and crop development.
5. Follow recommended seeding rates. Transgenic hybrids have different optimum seeding rates than nontransgenic corn.
6. Plant on optimum planting dates to optimize grain yield. Planting early will help extend the grain filling period and reduce the likelihood of stress during pollination. However, avoid wet, cold soils that may cause emergence problems.
7. Scout fields for potential pest problems throughout the growing season.

The issue of seed cost

Seed costs of transgenic hybrids are significantly higher than nontransgenic hybrids. Relative performance needs to be considered when purchasing transgenic hybrids. Looking at past results, we typically find yield differences averaging 70 bu/A between the top- and bottom-performing hybrids in a trial. Predicting into the future, we only measure about a 20 bu/A difference between top- and bottom-performing hybrids. So, at best we can only reasonably predict that any hybrid will be about 10-12 bu/A better than an average hybrid. These 10-12 bu/A must pay for the more expensive seed and/or there has to be some other advantage such as reduced pesticide costs or lodging. Yet, many transgenic hybrids are $50 to $150 more than nontransgenic hybrids. So, not only is relative performance for grain yield important, but the issue of seed cost is important to weigh as you consider your hybrid seed purchases.

SOYBEAN SEED COSTS: TIME FOR THE BIN?

Shawn P. Conley [1/]
State Soybean and Wheat Extension Specialist

Dramatic increases in soybean seed costs for 2009 (25 to 109%) have many growers rethinking their soybean seed options. The most drastic alternative being floated in the coffee shops is brown bagging or planting "saved" soybean seed. Before a grower considers this option we must revisit the legal issues and agronomic considerations associated with this practice.

First, we will address the legal issues surrounding planting saved seed. In Wisconsin alone 90% of the soybean crop planted in 2008 was herbicide tolerant (USDA -ERS, 2008). Herbicide tolerant varieties are classified as patented varieties or possess patented genes. "*If the variety is patented or has a patented gene, no seed may be saved for planting purposes and no farmer seed sales are permitted*" (Spears and Weisz, 2004). It is likely given the economic climate we are under that field monitoring procedures will be ramped up in 2009 to "catch" growers that plant patented varieties. It is also apparent that those growers that are caught will be prosecuted and fined to the legal extent of the law to discourage other growers from attempting this practice.

The remaining 10% of the soybean crop planted in Wisconsin that was not identified as herbicide tolerant will likely fall under the umbrella of either a patented variety (please see above for legal disclaimer) or under the 1994 Plant Variety Protection Act (PVPA) and Title V. *"Under this act, a grower may save seed of a protected variety for planting purposes. However, the amount of seed a grower can legally save is limited to the amount needed to plant his or her own holdings. Holdings are land owned, rented, or leased. If farm plans change that saved seed may be sold. The total of the amount planted and the amount sold, however, cannot exceed the quantity of seed needed to plant back on the farmer's own holdings"* (Spears and Weisz, 2004).

If a grower has established the legal right to plant saved seed, we must next address the agronomic considerations associated with planting saved seed. Essentially the "saved" soybean seed will be genetically identical to that they purchased. Therefore yield losses associated with saved seed will likely be due to seed quality issues related to harvest timing, storage conditions, and handling procedures. In a perfect world a grower would plan in advance which fields they intended to harvest for seed and implement the appropriate procedures to insure maximum seed quality (i.e., early harvest, proper dry down procedures and storage temperatures, etc.). Most growers that are considering planting saved seed in 2009 likely did not plan this activity in advance; therefore significant yield losses can be expected.

Most of the data related to planting saved seed was collected in the late 1980s and early 1990s. Significant advances in seed technology have been developed since this time so the yield differences listed below will likely be greater today. In North Carolina, Dunphy and Ferguson (1991) provided data on 204 saved vs. professional grown seed comparisons (16 locations, 6 years, 35 varieties). Dunphy and Ferguson found a 1.9 bushel advantage to certified seed over saved seed. In this paper, Dunphy also sites Wisconsin data that indicated a 2.2 bushel advantage to certified over saved seed.

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One strategy that growers may employ to improve the quality of their saved seed is to have the seed custom cleaned or conditioned. Remember *"it may be a violation to custom clean or condition seed of protected varieties"* (Spears and Weisz, 2004). If you offer this service, make sure you are certain you know the origin of the seed you are working with. If you suspect you are cleaning RR® seed, keep in mind there is an ImmunoStrip that can quickly verify the presence of this trait.

Given the legal risks associated with planting saved seed coupled with the expected yield loss linked with this practice and the likelihood that most growers did not plan on saving seed, I would strongly discourage growers from this practice in the 2009 growing season.

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2008 WISCONSIN CROP DISEASE SURVEY

Anette Phibbs[1], Adrian Barta[2]

Plant Pathologists at the Department of Agriculture, Trade & Consumer Protection (DATCP) survey Wisconsin's agricultural crops for plant diseases and nematodes. They check for newly introduced problem organisms and monitor levels of known diseases and nematodes. Samples are tested at DATCP's Plant Industry Laboratory, providing diagnostic services to facilitate export certification, inspections and surveys. In 2008, field surveys focused on the following crops and diseases: Early Season Diseases of Soybeans and Winter Wheat; Soybean Viruses; Potato Cyst Nematode; Soybean Cyst Nematode and Viruses and Stewart's wilt of Seed Corn.

Spring Soybean Disease Survey

In response to flooding and unusual weather conditions, a spring survey of 50 soybean fields in the V2 and V3 stages was conducted from June 23rd to July 7, 2008. Fields were randomly chosen but surveyors targeted and collected whole plants that exhibited symptoms such as wilting, chlorosis and stem lesions. Samples were tested at Plant Industry Laboratory for early season fungal pathogens and nematodes (Fig. 1).

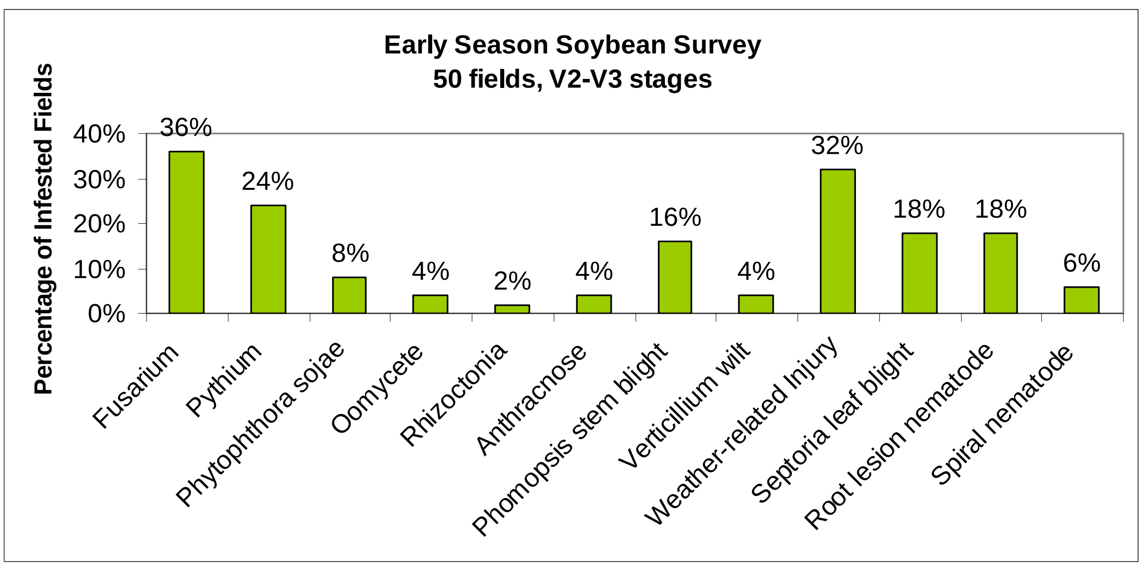

Figure 1

Seedlings from 37 of 50 fields (74%) tested positive for a variety of root diseases. The following root rot diseases were diagnosed from total 50 samples: *Fusarium* sp.: 36%, *Phytophthora sojae*: 8%, *Pythium* sp.: 24%, unspecified Oomycetes 4%, *Rhizoctonia* sp.: 2%. Some isolates of Fusarium and Pythium probably represent secondary infections. Soybean plants from 12 of 50 sites (24%) exhibited diseases of the lower stem. Based on the total 50 fields sampled, *Phomopsis* sp. accounted for 16%; Anthracnose and *Verticillium* wilt each infected 4% of declining plants. Weather related injuries (flooding, frost, high winds) injured soybean

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seedlings at 32% of surveyed sites. Root lesion nematodes (*Pratylenchus* spp.) directly were infesting 18% and spiral nematodes (*Helicotylenchus* spp.) 6% of root samples. Nematodes were observed emerging from root lesions of fine roots. Soil testing for soybean cyst nematode (SCN) was deferred to summer and fall.

Soybean disease survey continued through the growing season and early fall with an emphasis on collection of foliar samples for virus testing and a survey for Asian Soybean Rust (*Phakopsora pachyrhizi*). Two hundred and thirty-eight foliar samples were collected for laboratory analysis. Root rot and suspect foliar symptoms were observed at 36 surveyed sites. These plants were sampled and tested for pathogens at the laboratory. Two additional fields tested positive for *Phytophthora sojae* and 4 fields each tested positive for *Phomopsis*, *Anthracnose* and *Fusarium*. Asian Soybean Rust was not observed in Wisconsin in 2008. The most common foliar disease was Brown spot (*Septoria glycines*).

Soybean Dwarf Virus of Soybeans

Soybean fields for sampling were chosen using Visual Sample Plan statistical software designed by the US Department of Energy and Arc Map. Sample numbers were based on relative soybean acreage by county with a desired actual sample size of 230 fields visited. The latter number of fields would allow for 90% confidence of detection with a 1% detection threshold. In each field, plant pathologists stopped at 4 sites and took 5 leaflets from plants in the R2 to R6 life stage. The leaves were kept on ice until delivered to Plant Industry Laboratory for testing. Foliage was tested using a molecular method, reverse transcription (RT) - polymerase chain reaction (PCR) (1). Figure 2 shows the location of 16 fields throughout the state that tested positive for Soybean dwarf virus (SbDV). 6.7% of visited fields were infected with SbDV in 2008 compared to 3.1% in 2007.

SbDV was found for the first time in soybeans in Wisconsin in 2003 (2). Since then the number of infected fields has been slowly increasing. To the best of our knowledge symptoms of dwarfing or chlorosis attributable to SbDV have not been observed in Wisconsin soybean fields.

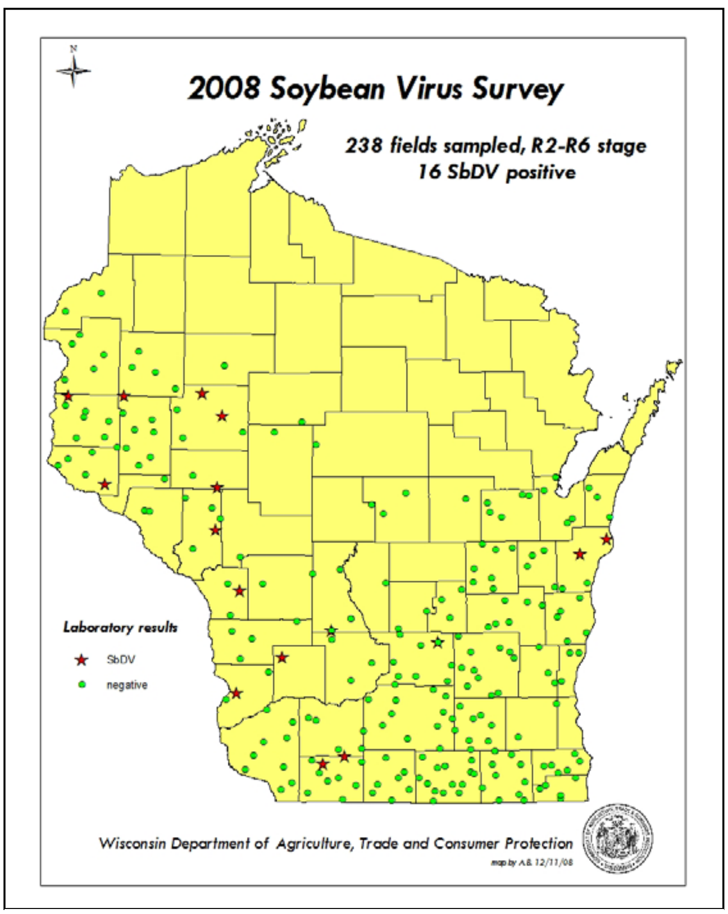

Figure 2

Early Season Winter Wheat Survey

DATCP Pest Survey specialists conducted a disease survey of winter wheat fields in the state between 5/8/2008 and 6/19/2008, sampling 106 fields in 11 counties, comprising 50 % of the wheat acreage in the state. Figure 3 shows the location of sampled fields. Wheat fields ranged in maturity from Feekes Stage 8.0 (flag leaf visible) to Feekes Stage 10.5.3 (flowering complete to base of spike). Leaf samples were collected for laboratory confirmation of diagnosis (Fig. 4).

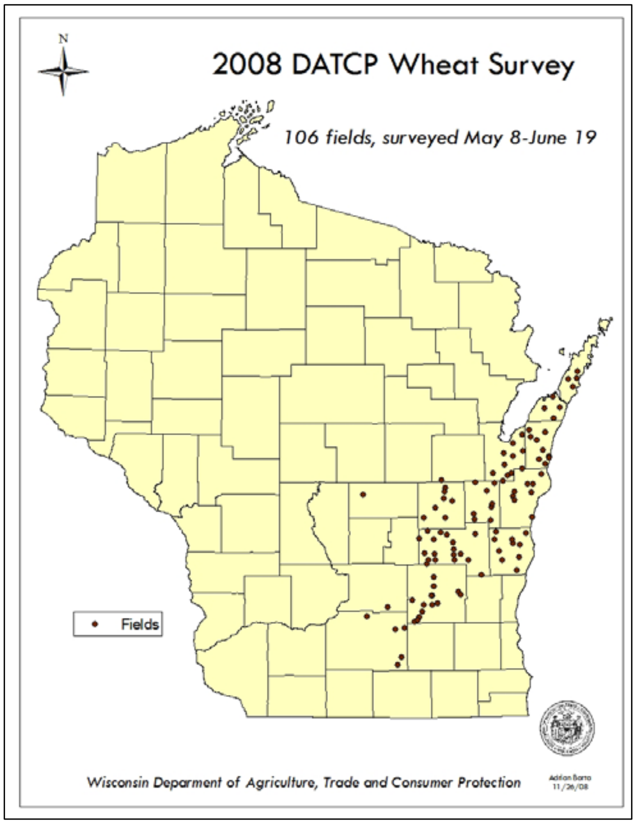

Figure 3

Powdery mildew (*Blumeria graminis*) was the most widespread disease encountered, occurring in 79 of the 106 fields surveyed or 75%. Incidence (the percentage of plants with symptoms in a field) ranged from 1 -100%. Severity (the average percentage of leaf area affected) ranged from a trace to 20%. Generally, severity was low.

Sooty molds (caused by a range of mostly saprophytic fungi) were widespread throughout the sampled fields, always confined to the lowest leaves buried in the canopy. Sooty molds are rarely a problem for wheat in Wisconsin, unless harvest is delayed and the infections move to the heads. 26% of all fields checked, tested positive for Septoria leaf blotch (*Septoria tritici and S. nodorum*). Incidence and severity are difficult to estimate in the field because of the similarity of field symptoms with other foliar diseases. Septoria leaf blotch can be troublesome during wet growing seasons. Fond du Lac (6) and Door (5) had the highest number of infected fields.

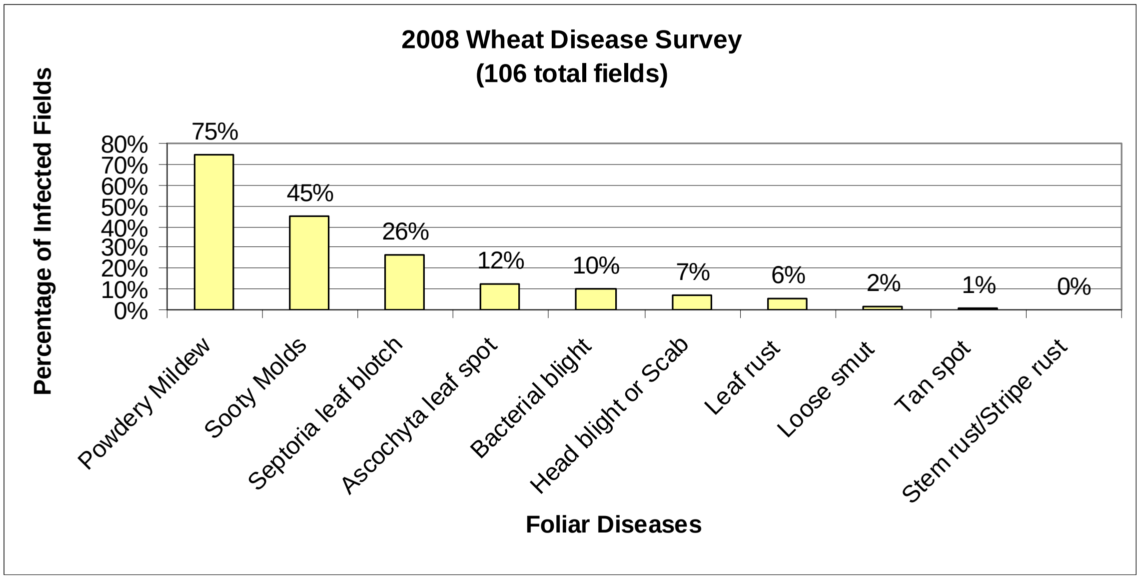

Figure 4

Ascochyta leaf spot (*Ascochyta tritici*) was laboratory-confirmed in 12% of fields. No control measures are generally required for this minor disease. Wheat leaves from 10% of fields tested positive for Pseudomonas leaf blight (*Pseudomonas syringae*) in the laboratory. 7% of fields displayed the bleached-head symptoms of Scab or Head Blight, caused by *Fusarium* spp. The incidence in fields was low.

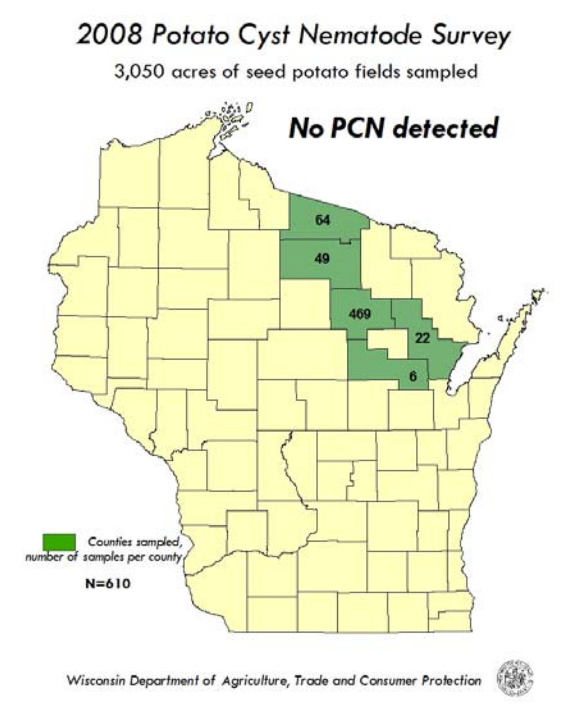

Figure 5

Leaf rust (*Puccinia triticina*) was found in 6% of fields at trace levels. Loose smut (*Ustilago tritici)* was found in 2% of fields which was less than expected in most Wisconsin wheat seasons. The incidence within fields was far below 1%. No stem rust or stripe rust was detected by DATCP personnel. One sample from a field in Dodge County was determined to have Tan spot, caused by *Pyrenophora tritici-repentis*. The severity was below 2%, with infection limited to the lowest leaves.

Potato Cyst Nematode Survey

An intensive soil testing effort of Wisconsin seed potato fields in 2008 continues to show that fields are free from potato cyst nematodes (*Globodera rostochiensis* and *G. pallida*) (Fig. 5). These microscopically small worm-like creatures can cause significant damage to potato production. Female nematodes form durable pinhead sized resting stages called cysts that can survive in the soil for decades and still infect potatoes. Potato cyst nematodes (PCN) have never been found in Wisconsin.

In 2008, a total of 610 soil samples were collected from 3050 acres of potato fields; see Figure 5. This represents over 1.3 tons of soil screened for cysts by Plant Industry Laboratory staff. Field sampling and testing focused on seed potato fields to facilitate export of seed potatoes to Canada. Potato cyst nematodes would be a serious threat to potato production and trade if found in this state. 2008 was the second year of a very intensive nation wide survey funded by USDA Animal and Plant Health Inspection Service (APHIS). In Wisconsin DATCP staff has been collecting soil samples from fields and potato storage facilities since 1982. These surveys varied in scope and were funded by the USDA's Cooperative Agricultural Pest Survey Program. A total of 6336 samples have been screened for PCN over the course of 27 years, see Figure 6. No suspect cyst nematodes have been found in Wisconsin.

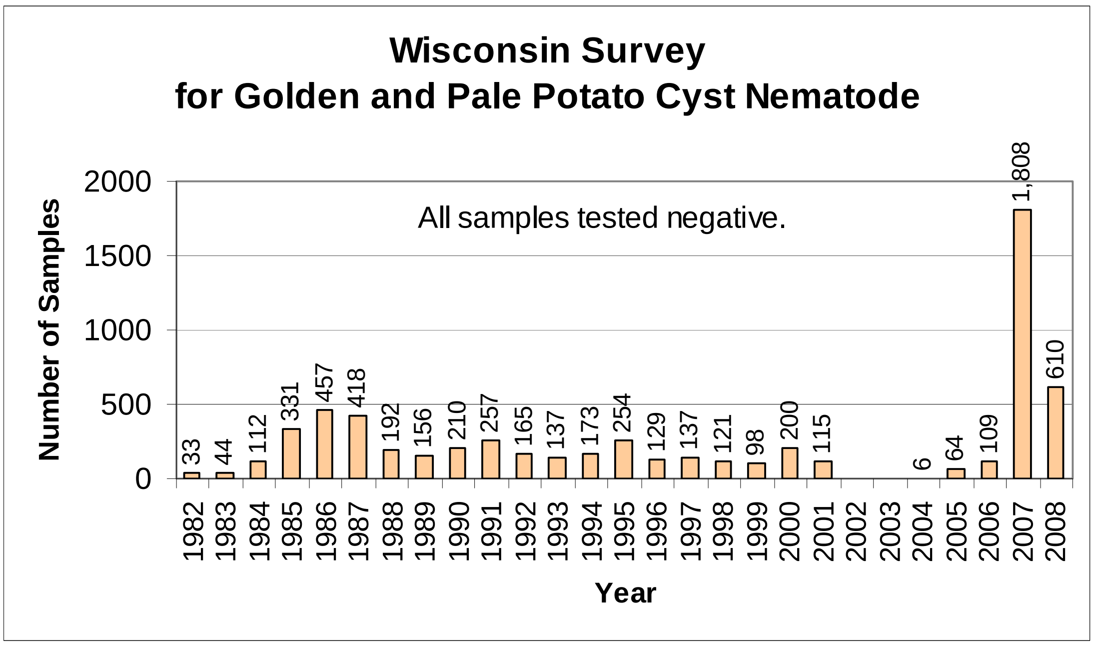

Figure 6

Soybean Cyst Nematode Survey

The year 2008 marks 30 years of annual state-wide survey for Soybean Cyst Nematode (SCN) by DATCP and University of Wisconsin staff (Fig. 7). Soybean cyst nematode (*Heterodera glycines)* was first detected in the U.S. in 1954, in Hanover County, North Carolina. Survey efforts in 1957, 1958 and 1962 did not find the nematode in Wisconsin; the first report in the state was made in 1981, in Racine County. In 2008 SCN was detected in two new Wisconsin counties (Monroe and Calumet), bringing the total number of counties where the nematode has been found to 46 (Figure 8). Soybean acreage in the counties where SCN has been detected comprises 85.5% of the soybean crop in the state.

SCN is the greatest yield reducing pest and disease problem in the U.S. In 2007 SCN reduced yields in the U.S. by an estimated 94 million bushels (Wrather & Koenning). This is three times the loss attributed all seedling diseases combined, or Phytophthora root rot, or Sudden

Death Syndrome. Soybean growers in all parts of the state are urged to sample their fields for SCN. Testing is available through the UW Plant Disease Diagnostics Laboratory at http://www.plantpath.wisc.edu/soyhealth/scnsamp.htm or private laboratories. Fields may be sampled at any time that the soil is not frozen.

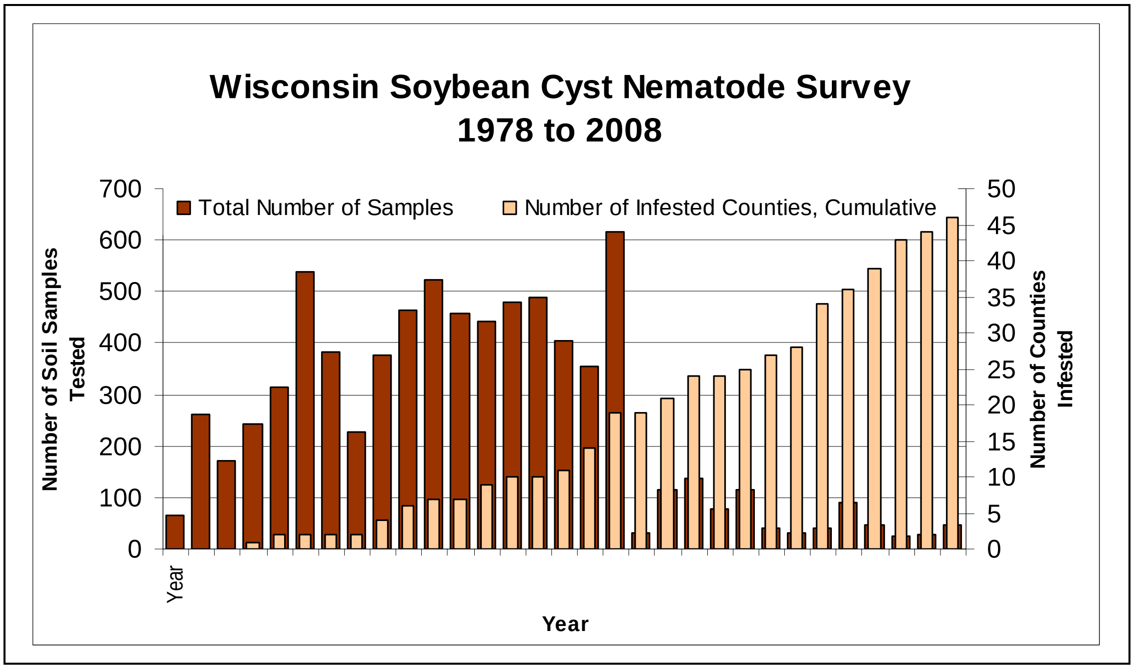

Figure 7

Seed Corn Survey

In 2008 DATCP personnel inspected 95 seed corn fields in 9 counties (2,416 acres) and tested foliage samples from 84 of the sites for *Pantoea stewartii*, the causal agent of Stewart's wilt. Stewart's wilt has been documented in various locations throughout the state over the last 8 years. The Plant Industry Laboratory confirmed 2 positive cases of Stewart's wilt in Rock County. To meet the import requirements of foreign trading partners, all samples were also tested for three viruses: High plains virus (HPV), maize dwarf mosaic virus (MDMV) and wheat streak mosaic virus (WSMV). No HPV or WSMV were detected. HPV, WSMV, and their vector the wheat leaf curl mite (*Aceria tosichella*) are not known to occur in Wisconsin. Two samples from Columbia County tested positive for MDMV which is known to occur in Wisconsin.

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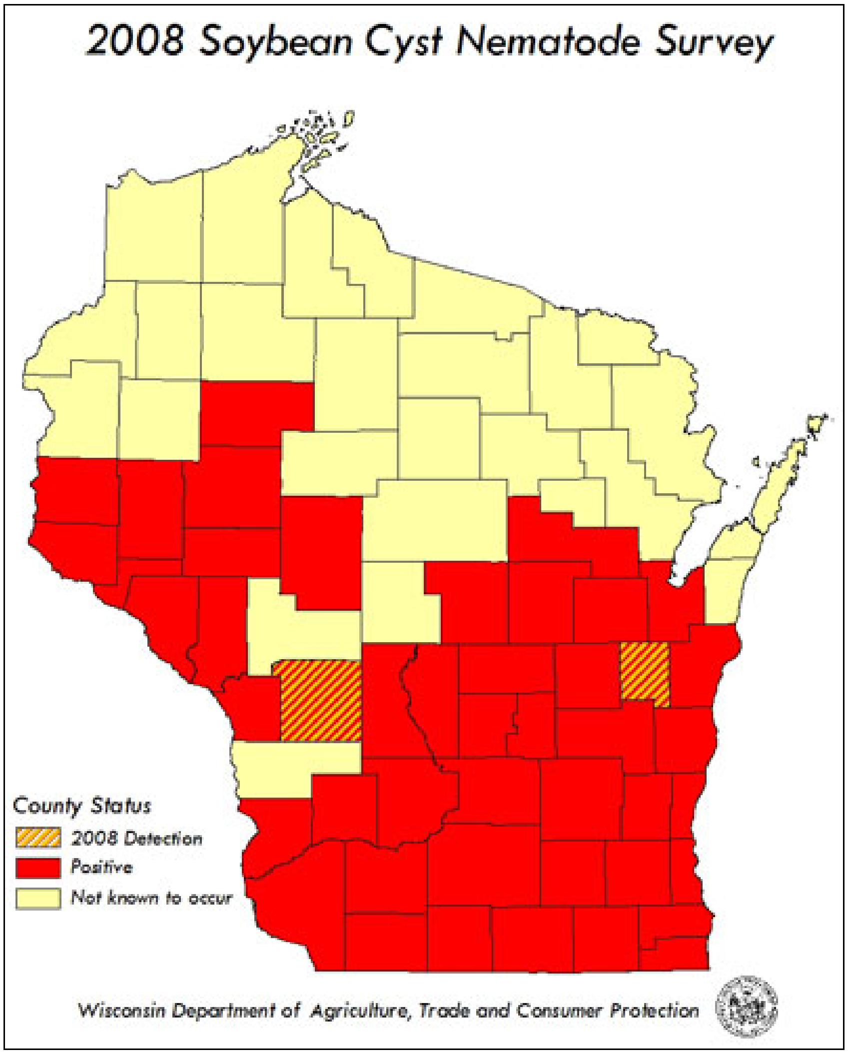
2008 Soybean Cyst Nematode Survey
County Status
2008 Detection
Positive
Not known to occur
Wisconsin Department of Agriculture, Trade and Consumer Protection

Figure 8

INTEGRATED MANAGEMENT FOR WHEAT DISEASES

Paul Esker[1] and Shawn Conley

As wheat production continues to increase in Wisconsin (Fig. 1), the management of wheat diseases, especially with the use of foliar fungicides, has become an even more important topic of discussion (Fig. 1). With estimated foliar fungicide prices in the $25-30/acre range (application cost plus fungicide cost) for 2009, an integrated management approach for controlling wheat diseases is important. What does it mean to take an integrated management approach for controlling wheat diseases? This is a multi-step process of decisions (Esker et al., 2008a; Hollier and Hershman, 2008) and includes: (i) scouting fields, (ii) identifying the growth stage, (iii) knowledge of the disease risk, (iv) knowledge of the disease reaction of the variety planted (Conley et al. 2008), (v) stand quality coming out of dormancy, (vi) crop development, (vii) weather, (viii) knowledge of the types and differences in foliar fungicides, and (ix) wheat prices.

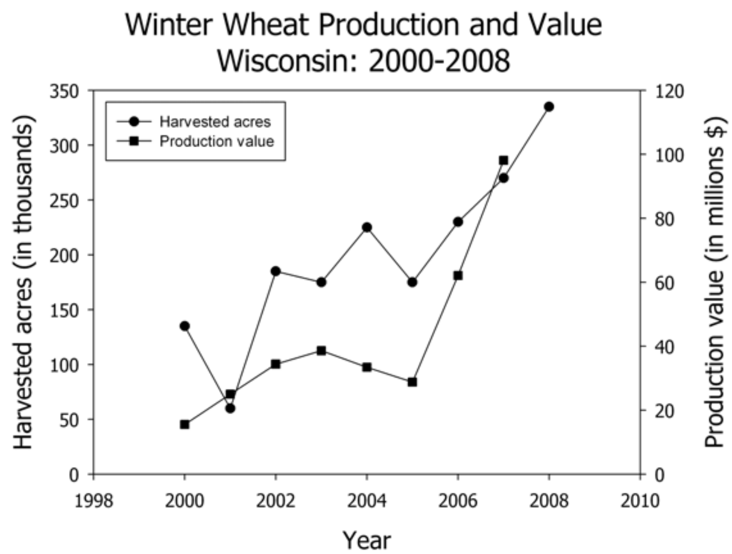

Figure 1. Winter wheat production in Wisconsin (in harvested thousands of acres) since 2000 and the corresponding of value of that production (in million $) (Source: USDA-NASS).

Most decisions for the application of a foliar fungicide for wheat will be made when the growth stage is Feekes 8 (flag leaf emergence). Why? The flag leaf is the most important leaf in terms of yield, as upwards of 50% or more of the final yield depends on its health. When scouting for wheat diseases, there are steps that should be taken to make the most appropriate estimate of the disease level. This includes scouting the entire field and making assessments from different locations. Our recommendation is to scout in at least 10 areas of the field and examine 10 plants. This provides for an estimate of disease levels on 100 plant samples. Avoid field edges when scouting.

Most critical for determining the need for a foliar fungicide for wheat disease management is the proper identification of the different wheat diseases (Esker et al., 2008b). In Fig. 2, there

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are pictorial representations of some of the most common wheat disease that might be seen in Wisconsin in a given season. Yearly occurrence of each disease is highly dependent on many factors, especially variety resistance and weather. Also, occurrence of each disease will not be at the same growth stage, as some like powdery mildew and Septoria leaf blotch can be seen around flag leaf emergence, while one like Fusarium head scab is a flowering disease. For the rust diseases and Fusarium head, there are some very useful sites that can be consulted to determine the risk of disease occurrence in Wisconsin each growing season. These include the USDA's Cereal Rust Laboratory website (http://www.ars.usda.gov/Main/docs.htm?docid=9757) and also the Fusarium Head Blight Prediction Center (http://www.wheatscab.psu.edu) (Esker and Conley, 2008).

Also, in the past few years, there has been an increase in black point disease reports around the state. Black point disease is caused by a fungal complex that includes (but is not limited to) the following fungi: Alternaria, Fusarium, and Helminthosporium. Affected kernels will appear black-pointed and dockage can occur. Conditions that favor development of black point include warm, humid or wet weather during grain maturation.

Summary of 2008 Foliar Fungicide Trials

The 2008 winter foliar fungicide trials illustrated that knowledge of multiple factors is required to most effectively control wheat diseases and improve yields. At the Arlington ARS trial, the most effective fungicide treatment was the application of Proline® at Feekes 10.5.1, where there was a higher level of Fusarium head scab. Yield was 8% higher with this treatment, compared to the untreated check (95 bushels per acre versus 87 bushels/acre). In contrast, at the West Madison ARS trials, results were different depending on the trial. In the variety by fungicide timing trial, there was a main effect of variety as Pioneer 25R47 had a 15% higher yield over Kaskaskia (119 bushels/acre versus 104 bushels/acre). However, no effect of foliar fungicide was observed. In a second trial that had only Kaskaskia as the variety, with 15 different fungicide treatments, applications of Headline and Quilt at Feekes 9 (early boot stage) had yields that were 8 to 12% higher than the untreated check. Powdery mildew was the primary disease observed in this trial.

Changes in Fungicides in 2009

In the Pest Management in Wisconsin Field Crops (UWEX, A3646), there have been changes to Table 5-5 about fungicides for control of foliar diseases of small grains (Boerboom et al., 2008). Products that have been added because of new registrations or changes to their label include: Bumper 41.8 EC (propiconazole), Caramba (metconazole), Folicur 3.6 F (tebuconazole), Proline 480 SC (prothioconazole), and Prosaro 421 SC (propiconazole and tebuconazole). Also, consult the label carefully, especially to determine the growth stage for the last allowed application. In 2007, there were reports of grain loads being held at elevators to test for fungicide residues.

Powdery mildew (*Blumeria graminis*)

Septoria leaf blotch (*Septoria tritici*)

Wheat leaf rust (*Puccinia triticina*)

Wheat stripe rust (*Puccinia striiformis*)

Wheat stem rust (*Puccinia graminis*)

Fusarium head scab (*Fusarium graminearum*)

Tan spot (*Pyrenophora tritici-repentis*)

Glume blotch (*Stagonospora nodorum*)

Figure 2. Pictorial representation of some of the most common wheat diseases that can be controlled with foliar fungicides in Wisconsin. Image Sources: C. Grau and P. Esker (UW-Plant Pathology) and the APS Digital Image Collection.

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MANAGEMENT DECISIONS FOR FOLIAR FUNGICIDES IN CORN

Paul Esker[1], Bill Halfman, and Bryan Jensen

Interest in using foliar fungicides continues to increase. Foliar fungicides have always been considered an effective management tactic when disease pressure warrants the application (Boerboom et al., 2008). Recently, however, foliar fungicides are being marketed for things like Plant Health® or Plant Performance®. Therefore, it is critical to further our understanding regarding if and when a foliar fungicide is effective for corn production in Wisconsin.

Estimates for 2008 indicate that the number of acres in Wisconsin that received a foliar fungicide increased over 2007, when approximately 10% of the acreage was sprayed (400,000-500,000 acres). Across the U.S., management of corn diseases is a process that requires decisions at multiple hierarchies (Table 1), including decisions made both pre- and post-planting. In this hierarchy is the use of foliar fungicides. The same factors that are used for managing corn diseases can be applied to determine the relative efficacy of an application of a foliar fungicide. Hybrid susceptibility is the number one factor to consider, followed by production practices like continuous corn and no-tillage corn, and having a high risk for leaf diseases.

Table 1. Hierarchy of integrated pest management (IPM) decisions for managing corn diseases.

Hierarchical level	IPM decision and/or knowledge
Primary level: pre-plant knowledge	Hybrid susceptibility to specific corn disease
	Previous cropping history (rotation)
	Previous disease history and pressure (e.g., severity)
Secondary level: environmental conditions	Conditions conducive for disease development: relative humidity, leaf wetness, temperature
Tertiary level: cultural and chemical management	Fungicide seed treatments, tillage, rotation, foliar fungicides

Disease Pressure in 2008

Overall, weather greatly influenced the occurrence of corn diseases in 2008, as initially, there appeared to be an increase in common rust during June. However, once the flooding rains in many parts of the state ceased, late season weather was very dry, reducing the development of many corn diseases. Disease pressure was determined to be (in order from most common to least common): common rust, anthracnose, common smut, eyespot or northern corn leaf spot, and northern corn leaf blight.

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Economic Considerations for Using a Foliar Fungicide

Currently, it is being estimated that the cost of spraying a foliar fungicide in 2009 will be in the $25-30/acre range (application cost plus fungicide product cost). With the current corn commodity prices quite variable and hovering in the $3 to $4/bushel range, Table 2 is provided to show the necessary return in bushels per acre needed to cover the cost of foliar fungicides at different application and fungicide costs as well as different corn commodity prices.

Table 2. Estimates on the number of bushels needed to cover the cost of a foliar fungicide application at different combinations of application and fungicide cost as well as different corn market values.

Application	Fungicide	Corn market value ($/bu)		
cost	cost	2	4	6
6	10	8.0	4.0	2.7
6	15	10.5	5.3	3.5
6	20	13.0	6.5	4.3
6	25	15.5	7.8	5.2
8	10	9.0	4.5	3.0
8	15	11.5	5.8	3.8
8	20	14.0	7.0	4.7
8	25	16.5	8.3	5.5
10	10	10.0	5.0	3.3
10	15	12.5	6.3	4.2
10	20	15.0	7.5	5.0
10	25	17.5	8.8	5.8
12	10	11.0	5.5	3.7
12	15	13.5	6.8	4.5
12	20	16.0	8.0	5.3
12	25	18.5	9.3	6.2

Small Plot Trials – 2008

Small plot foliar fungicide trials were conducted at multiple locations during 2008 and focused on general questions of efficacy as well as the role of previous crop history.

On-Farm Small Plot trials were conducted in La Crosse, Monroe, Pepin, and Trempeleau counties (6 trials) that used Headline (6 ounces per acre), Stratego (10 ounces per acre) and Quilt (14 ounces per acre), applied at the R1 growth stage. Analyses were conducted from these data. Overall, mean yield ranged from 167.0 (Quilt) to 169.1 (untreated check) bushels per acre and there was no evidence that yield was affected by the application of a foliar fungicide (P = 09684). The highest source of variation in the analysis was at the farm scale. Furthermore, there was no evidence that grain moisture was affected with foliar fungicide application (range: 20.9% (Quilt) to 21.4% (Stratego) (P = 0.7430). Lastly with the on-farm small plot trials, there was no evidence that stalk rot was reduced with a foliar fungicide application (range: 36.2% (untreated) to 39.5% (Quilt) (P = 0.7636).

Foliar fungicide efficacy trials were also conducted at the Arlington and Lancaster Agricultural Research Stations. In these two trials, comparisons of 8 fungicides (including the untreated check) were examined in small plot trials (plot size = 10 feet (4 row) by 50 feet).

At Lancaster, yield ranged from 123.7 bushels per acre (Quilt) to 156.7 bushels per acre (Evito at 2 ounces per acre), but there was no evidence of differences among the treatments (P = 0.8816). Furthermore, there was no evidence of an effect of foliar fungicide on either grain moisture (P = 0.5840) (Range: 18.6 to 19.8%) or test weight (P =0.8633) (Range: 56.5 to 57.2 pounds per bushel).

At Arlington, results were similar to Lancaster in that there was no evidence of an effect of treatment, as yield ranged from 175.7 (experimental) to 194.0 (Evito at 3 ounces per acre) (P = 0.8978), grain moisture (P = 0.6274) (Range: 22.3 to 23.6%), and test weight (P = 0.5027) (Range: 52.2 to 55.9 pounds per bushel).

Based on results from the regional trials in 2007, another study was established in 2008 at the Arlington and Hancock ARS to examine the effect of previous crop history and fungicide application timing on disease development and yield. In these trials, the previous crop at Arlington was either corn or soybean, while at Hancock, the previous crop was either corn or potato. The fungicide treatments were: (i) untreated check, (ii) Stratego at 10 ounces per acre at V12, (iii) Stratego at 10 ounces per acre at VT-R1, and (iv) Stratego at 10 ounces per acre at R2. Corn hybrids were DeKalb 57-79 at Arlington and DeKalb 46-28 at Hancock, both planted to 33,000 per acre. Overall disease severity was low throughout this study (< 1% severity of common rust on the ear leaf). A summary of the yield results is presented in Table 3.

Table 3. Summary of yield and grain moisture for trials conducted at the Arlington and Hancock ARS to examine the effect of previous crop history and fungicide timing on disease development and yield.

	Location = Arlington				Location = Hancock			
	Previous = corn		Previous = soybean[z]		Previous = corn		Previous = potato	
Treatment	Yield (bu/A)	Moisture (%)	Yield (bu/A)	Moisture (%)	Yield (bu/A)	Moisture (%)	Yield (bu/A)	Moisture (%)
Untreated	222.8	26.5	176.1	22.8	220.2	18.9	233.7	19.4
Stratego (V12)	217.3	27.0	178.4	22.4	218.4	19.0	232.5	18.8
Stratego (VT-R1)	223.3	27.1	171.9	22.6	212.8	19.9	223.3	21.1
Stratego (R2)	224.8	27.4	187.1	22.9	212.3	19.7	243.0	19.9
P-value	0.8534	0.8039	0.6952	0.8682	0.9091	0.5236	0.5819	0.1286
LSD[y]	NSD	NSD	NSD	NSD	NSD	NSD	NSD	NSD

[z] In the previous crop soybean, the fourth replication was lower in yield than all other replicate observations, however, this has been kept in the analysis initially.
[y] LSD stands for the least significant different. NSD stands for not statistically different and implies there is no evidence that there is an effect of treatment (e.g., effect of foliar fungicide application).

Summary of Regional Corn Fungicide Trials – 2008

Similar to 2007, Extension Plant Pathologist provided data for a regional summary on foliar fungicides of corn. Compiled by Greg Shaner, Purdue University, there were 68 trials compiled (to date) from 13 states and Ontario (Shaner, 2008). Within these trials, Headline was in 65 trials that were applied from VT-R1 at 6 ounces per acre, Stratego in 24 trials that applied from VT-R1 at 10 ounces per acre, Quilt in 32 trials that were applied from VT-R1 at either 10.5 or 14 ounces per acre, and Quadris in 16 trials that were applied from VT-R1 at 6 ounces per acre. For Headline, results indicated that the mean yield for the untreated check was 171.9 bushels per acre and for Headline it was 176.1 bushels per acre. While there was a difference of 4.2 bushels per acre, what was observed was that disease pressure greatly influenced yield response. In trials were disease severity was less than 5% (disease severity measured as the amount of leaf tissue infected on the ear leaf), mean yield response was 1.2 bushels per acre. However, when disease severity was > 5%, then the mean response was 10.1 bushels per acre. For Stratego, mean yield was 179.1 bushels per acre for the untreated check and 179.8 bushels per acre when Stratego was applied. The mean response when disease severity was less than 5% in these trials was -1.2 bushels per acre and it was 1.6 bushels per acre when disease severity was greater than 5%. For Quilt, mean yield was 173.2 bushels per acre for the untreated check and 176.0 bushels per acre when Quilt was applied. The mean response when disease severity was less than 5% was 0.4 bushels per acre and it was 7.4 bushels per acre when disease severity was greater than 5%. For Quadris, mean yield was 174.0 bushels per acre for the untreated check and 180.0 bushels per acre when Quadris was applied. The mean response when disease severity was less than 5% was 4.0 bushels per acre and it was 8.7 bushels per acre when disease severity was greater than 5%.

Overall, the results from the regional summary, when combined with our current knowledge from both small plot and on-farm strip and small plot studies, indicates that the most effective use of a foliar fungicide is when there is a threat of having higher severity of leaf diseases.

Acknowledgments

We thank our grower cooperators for help with conducting the on-farm research trials. We also thank the following County Agents who helped in conducting these trials: Steve Huntzicker, Jon Zander, Carl Duley, Bob Cropp, and Trisha Wagner. We also acknowledge the support of the USDA North Central Integrated Pest Program, BASF, Bayer CropScience, Syngenta, and Arysta Life Sciences, for support of both the on-farm and efficacy trials.

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SUMMARY OF THE 2008 STRIP TRIALS FOR FOLIAR FUNGICIDE USE ON CORN

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Introduction

Foliar fungicide use on corn has increased in recent years. Insufficient Midwest field data have encouraged a series of small- and large-scale research plots implemented by UW-Madison and Extension personnel in 2007 and 2008. Large-scale field plots have advantages and disadvantages when compared to small scale plots. Advantages of small-plot research include the ability to control variables such as soil type/texture, drainage, soil compaction and pest interactions. It also allows the researcher to evaluate several different treatments in a small area. However, the value of large-scale on-farm research is that the previously mentioned variables are not singled out and those results better represent "real world" scenarios. Both research methodologies should be considered vital and important steps in the research process.

The 2008 results of the large scale, on-farm plots will be reported in this paper, as will the combined results from 2007 and 2008.

Methods

On-farm, large-scale field plots were initiated during the 2008 growing season in Chippewa, Dane, Green Lake (2), Jefferson, La Crosse (3 locations), Sheboygan and Waupaca counties using the host grower's production practices (tillage, hybrids, etc.) and replicated a minimum of two times.

Foliar fungicides were applied according to labeled recommendations during the R1 stage of corn development. Foliar disease ratings were taken in most plots prior to application and again in early September by estimating the percent foliage affected. Stalk lodging was assessed in early October using a stalk nudge test by pushing 30 consecutive corn plants to a 45 degree angle and recording the number of lodged plants. A plant was considered lodged if it bent prior to reaching a 45-degree angle or if it was lodged prior to this test and anthracnose symptoms were present.

2008 Results of Individual Plots

Individual strip trial results (Table 1) indicated that 3 of the 8 field trials had a statistical difference in yield. There was no statistical difference in kernel moisture, test weight or lodged stalks in those fields where data was available.

Combined 2007 and 2008 Results

What Have We Learned? On-farm foliar fungicide strip trials in corn have now been conducted at several locations over two years (Figure 1). In Figure 2, we also show the boxplots for yield and grain moisture for the 2008 on-farm trials across all observations. In order to determine how fungicides may be recommended, it is important to conduct analyses that help to identify if there are effects of fungicide treatment, as well as identify the largest source of variation (for example, year, location (e.g., county), farm). In both 2007 and 2008, disease pressure was low and variable, with 2007 dominated by late

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Table 1. Individual field results

County (# reps)	Hybrid	Previous crop	Treatment/ (rate fl. oz/a)	Yield [a]	Kernel moisture [a] (%)	Test Wt. [a]	# Lodged stalk/30 [a]	Ave. % diseased foliage pre-application	Ave. % diseased foliage-September	Diseases present
Chippewa (3)	Renk RK438 RRYGCB	Soybean	UTC	187.25 a	-	-	3.0 a	3 %	10 %	A, NCLS
			Headline (12)	185.65 a	-	-	3.67 a		10 %	
Dane (2)	N/A	N/A	UTC	204.8 a	N/A	N/A	N/A	N/A	N/A	N/A
			Headline (N/A)	208.9 a	N/A	N/A	N/A	N/A	N/A	N/A
Green Lake Field #1 (3)	DKC 52-43	soybean	UTC	166.5 a	17.0 a	54.7	0 a	< 1%	15 %	R, ES, NCLB
			Headline (6)	190.5 b	18.1 a	54.5	0 a		15 %	
Green Lake Field #2 (3)	Croplan 388	soybean	UTC	206.9 a	20.2 a	53.7	0 a	< 1 %	8.0 %	R, ES, NCLB
			Headline (6)	212.5 b	21.0 a	53.0	0 a		3.7 %	
Jefferson (4)	Midwest 7645 VT3	wheat	UTC	163.9 a	24.0 a	N/A	N/A	N/A	N/A	N/A
			Headline (6)	160.3 a	24.5 a	N/A	N/A	N/A	N/A	N/A
La Crosse Field #1 (2)	Croplan 388	corn	UTC	146.3 a	16.0 a	-	11.0 a	1%	10%	N/A
			Headline (6)	160.2 a	16.4 a	-	9.0 a	1%	5%	N/A
La Crosse Field #2 (2)	Pioneer 37Y13	soybean	UTC	217.5 a	21.9 a	-	9.5 a	1%	2%	N/A
			Headline (6)	228.2 b	21.8 a	-	5.5 a	1%	4.5%	N/A
Sheboygan (3)	Golden Harvest 7148LL	soybean	UTC	154.0 a	23.1 a	51.3 a	10.5 a	< 1%	2	A, R
			Headline (12)	157.8 a	22.9 a	52.3 a	10.2 a		1	
Waupaca (3)	Pioneer 35F37	corn	UTC	168.5 a	35.4 a	51.8 a	N/A	N/A	N/A	N/A
			Headline (6)	171.2 a	33.0 a	52.3 a	N/A	N/A	N/A	N/A

[a] For each location, means within a column followed by the same letter are not significantly different (P=0.10), Duncan's Multiple Range Test or direct estimate of difference (contrast) for the Green Lake field trials due to unbalanced replication.
- signifies data not taken at time of harvest
N/A=data not available at this time,
A=anthracnose, ES=eyespot, NCLB=northern corn leaf blight, NCLS=northern corn leaf spot, R=rust

season stalk rots, and 2008 having initial concern about a common rust epidemic. Therefore, a combined analysis was conducted for the on-farm strip plot data. A summary of means and standard deviations for yield in 2007 and 2008 are presented in Table 2, but note that means and analyses discussed will be based on the statistical model in subsequent questions. The hypothesis that was tested was that there would be no difference in yield, grain moisture, or stalk lodging, with the application of a foliar fungicide. The level of significance was set to 0.10 for all analyses.

Yield: The analysis indicated that there was no evidence that the mean yields were different from one another in 2007 and 2008 (P = 0.1058). Yields were estimated based on the statistical model and were 183.8 (Headline), 184.5 (Quilt), and 180.4 (Untreated check). While there is a trend for higher yields when Headline and Quilt were applied, compared with the untreated check, the difference in these yields (3.4 and 4.1 bushels, respectively) may not justify the application of a foliar fungicide economically. For example, if we take the current estimated price for the application of a foliar fungicide (and including the application cost) in the $25-30/acre range, this would require corn prices to be from $6 to $9 just to breakeven.

Moisture: To date, there is no evidence from the on-farm strip trials that grain moisture is increased when the application of a foliar fungicide (P = 0.5203). Grain moisture, averaged across years, has ranged from 20.9% to 21.2%.

Lodging: Based on our combined analyses, there is evidence of reduced stalk lodging with application of a foliar fungicide (P = 0.0041). Estimated percentage lodged plants (out of sample sizes of 30 per plot) were 19.8% (Headline), 20.7 (Quilt), and 29.4% (Untreated check). Further work is needed to quantify the economics of improved efficiency in terms of harvest time and missed plants.

Sources of Variation: Our analyses identified that that two primary sources of variation were at the farm scale and also the replication within the farm scale. Of those two sources of variation, the farm was the highest source of variation. Therefore, we continue to work on incorporating information about differences in hybrids, soil types, and other overall farm management practices to further quantify if and how they affect yield response with the application of a foliar fungicide.

Table 2. Mean yield and standard deviation of yield for on-farm strip plot fungicide trials conducted in 2007 and 2008 in Wisconsin. The number of observations varies because not all treatments were used in all trials.

Year	Treatment	Total number of observations	Mean yield (bu/acre)	Standard deviation of yield
2007	Headline	10	188.1	27.7
	Quilt*	17	172.5	18.6
	Untreated	19	176.4	29.5
2008	Headline	25	181.9	25.0
	Untreated	25	179.2	25.8

* Quilt was used only in the 2007 on-farm strip trials.

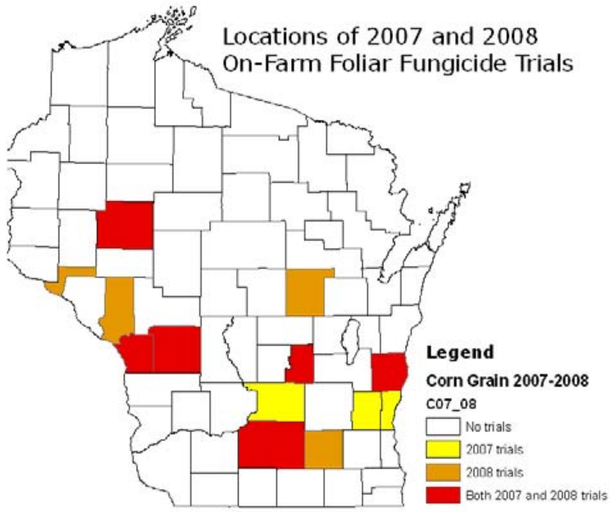

Figure 1. Locations of the on-farm foliar fungicide trials (includes both small plot and strip) in 2007 and 2008 in Wisconsin.

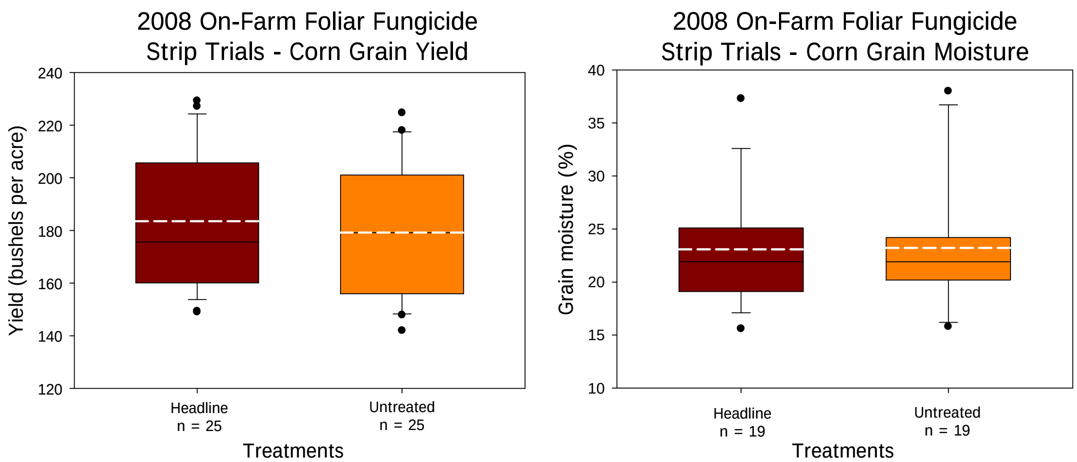

Figure 2. Boxplots of corn grain yield (bushels/acre) and corn grain moisture (%) for the 2008 on-farm large strip trials. The “n” under each treatment indicates the number of observations used to make the boxplot. The dashed white line represents mean values.

PLANNING AND CONDUCTING MEANINGFUL ON-FARM DEMONSTRATIONS AND RESEARCH

Joe Lauer[1]

Farmers today have an increasing number of tools for managing crops. New developments in precision farming technologies, biotechnology, and advancements in pesticides, equipment, and other ag inputs are converging and arriving at the farm-gate at an unprecedented rate. Sifting through the overwhelming milieu of technologies to find the tools that really work is a challenge for farmers and the consultants and agronomists that serve and support production agriculture.

Often farmers use technologies with little or no evaluation prior to use. Industry heavily invests in technology research and development, thus, "ramp-up" is fast and products are often marketed and distributed quickly in an attempt to recover investments in the early phases of technology adoption. Often farmers, usually at great expense, must learn and re-learn management of these technologies as new and improved versions are released.

The **objective** of an on-farm trial is to predict how different management options will perform compared to each other under your environment and cropping system. The process of testing a hypothesis and using the information gained in a cooperative, systematic manner has been highly successful in providing viable options for making production decisions on the farm. The process of incremental change and gradual improvements has evolved into a system of research, development and production never imagined just decades ago.

In general, there are two major categories of on-farm research trials. The first is replicated trials that try to account for field variability with repeated comparisons. Examples include trials conducted by universities and by public and private plant breeders. The other type is non-replicated demonstrations such as yield contests, on-farm yield claims, demonstration trials and farmer observation and experience.

Identifying the source of variability is a primary objective in any on-farm trial. The use of statistical methods including replication and mean comparisons improves the reliability and confidence of results. An overriding strength of on-farm evaluations is the credibility of the results in the eyes of the end user, the farmer by showing how the practice responds within his production system. Often the power of these trials can be enhanced with simple modifications such as replication within locations and across multiple sites with coordinated effort.

The advent of effective tools for collecting data related to crop production such as weigh wagons, on farm scales and yield monitors have removed many of the traditional barriers of on-farm trials. The next phase in the development of agriculture is necessary coordination of multi-site trials that will require collaborative specialists for data collection and analysis.

What is on-farm research?

What's special about "on-farm" trials? From a standpoint of actually doing trials, there is nothing special. The nature of on-farm trials limits the number of comparisons, doesn't allow some treatments that require special equipment, and requires timeliness/priority that at times can be an issue. It is, though, "real" field conditions. The main advantage for on-farm trials is that it makes

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it possible to test over a large number of sites, thus it can more easily move research from "description" to "prediction." Knowing what we want to say when the work has been completed should be a critical precondition for undertaking on-farm, applied research. If you can't even guess what such a statement might look like, you might want to hold off. A certain percentage of all on-farm research projects are wasted effort or even harmful in that they suggest the use of harmful inputs, suggest the use of useless inputs, and fail to predict (accurately) the benefit of a useful input.

Terminology

Check (Control) Plots: Your current practice is represented in the check or control plot. It does not receive the new technology being tested; rather it represents your current management style where your tillage practice, applied fertilizer, variety and/or applied fungicide is used in the usual manner. The check plot and the treated plot differ only in the specific treatment comparison being made. Aside from this treatment, plots are managed exactly the same to avoid biasing results.

In some trials, the new technology incorporates several practices. Avoid these if possible. For example, consider a trial that compares a farmer's current planting operation with another planting operation using different tillage, fertilization and row spacing systems. A fair comparison can only be made between the two complete systems, not any given part of either system. This kind of trial is difficult to interpret because of all the confounding interactions that may occur among the parts.

Replication: Replication is used to determine whether the difference between plots is due to chance variation or treatment variation. Chance variation is caused by differences in weather, soil and other factors. These factors change significantly in space (field to field) and time (year to year). Through replication in both space and time, average treatment effect values can be obtained. Replication in space means that several plots of each treatment are grown in the field (field replication) or that single plots of each treatment are placed in several fields across the farm (farm replication). Replication in time is repeating the trial over several years. Comparisons between average values are more accurate than those between single plots. Replicating your check and treatment plots at least three or more times will give you much greater confidence in your results and final conclusions about a new practice if it is made only after being evaluated over several years and/or at several locations.

Replicate 1	Replicate 2	Replicate 3
Treatment 1	Check	Treatment 2
Check	Treatment 3	Treatment 3
Treatment 2	Treatment 1	Check
Treatment 3	Treatment 2	Treatment 1

Low ----------------------------------- High

Soil Fertility Gradient (or yield potential, organic matter, pH, etc.)

Fig. 1. An example of a plot design, with a check plot and treated plots arranged in three replications. The entire trial area should be kept within a uniform soil condition. Other plot arrangements are possible.

Randomization: Randomization prevents bias of any one treatment in any way (intended or unintended). To randomize a trial, randomly assign replicated check plots and treatments (Fig. 1) by drawing numbers out of a hat or flipping a coin as you assign treatments to plots.

How can on-farm research be conducted so that it means something?

The key to an on-farm test is that it must make repeated and unbiased side-by-side comparisons of the practices in question. These repeated comparisons are called replications. With replication, we can use simple statistical formulas to decide if one practice or “treatment” differs enough from the other to be sure the difference was not due to chance.

A well conducted performance test on your farm or in cooperation with neighbors using similar management practices is an important part of deciding upon new agronomic practices for efficient and profitable crop production. Key ingredients of an on-farm testing program include:

1. Establish goals and objectives.
2. Which treatments will be evaluated and what is the check (control) plot.
3. Select a site.
4. Lay out plots on the selected site.
5. Decide who, what where, when and how measurements will be collected.
6. Determine how data will be analyzed.
7. Extending the results.

Pre-season planning

On-farm trials must have a **goal and specific objectives**. Goals are statements of the overall theme of your experiment. A goal, for example, may be to reduce soil erosion on your farm. Objectives are statements of the problem you wish to evaluate in your project. These are the ideas you want to test or questions you want to answer. Objectives are measurable and relate to your overall goals. The objectives will determine what is measured and the type of data you will collect during the project. For example, you might hypothesize that a strip-tillage system will leave more surface residue that the tillage system you now use. The trial you establish would involve a comparison between the two systems. One objective will be to determine if the reside levels are different between the two tillage systems. Residue levels would be one type of data collected as part of the trial.

Selection of treatments to be tested: Keep treatments simple. Limit the number of treatments to no more than four, including one well-known treatment as a check (control) plot. As the number of treatments increase so does the complexity of the on-farm trial. Choose treatments that you expect to be significantly different. With experience you will gain confidence in your on-farm testing abilities and you can move on to testing treatments involving minor impact, difficult to test production practices. It is very important that production inputs remain constant, except for the tested treatments.

In field planning

Field variation can mask treatment differences, so chose as uniform a field site as possible. Organize the field plot layout so that that all treatments have an equal opportunity to perform. Consider previous crop history (fertilizer rates, herbicides, tillage, etc.), drainage, soil texture, soil depth, topography, pest infestations, and bordering influences such as trees, runoff from neighboring fields, lack of fencing from animals, and other factors. Avoid placing trials in runoff areas, near fence lines or in field corners as these areas are often subject to multiple or irregular applications of fertilizer and herbicides. The characteristics of a uniform field site depend on the type of test being conducted. Pay particular attention to things that strongly influence your treatments. Use county soil survey maps of the fields being considered to help you select the site.

Consider site access when selecting a plot location. Is the site easily accessible for mid-season treatment applications and data collection? If early or differential harvest is likely (such as with an alternate crop), can you get at the site with harvest equipment without destroying other crops? Will you hold a tour of your site? If so, is there ready access for visitors and their vehicles?

Replication and Randomization: Choose a uniform area in the field. Each practice should be repeated (replicated) two or more times in the trial. Two different layouts or designs are commonly used. **Completely random designs** are used on uniform sites. In this design, all treatments have an equal chance of being assigned to any given plot including identical treatments side by side. Use a **randomized complete block design** when it is not possible to obtain a uniform test site. Arrange the plots so that each treatment is used once in each replication. Treatments should be arranged in a different order in each replication (randomized). See Figure 1. Each replication contains a complete set of treatments. Each replication is placed in a uniform area. Using such an arrangement allows all treatments to have equal potential to perform within the replication. The effects of replications can be removed or "blocked out" when analyzing the data.

Plot size: Optimum plot size for on-farm tests may vary greatly with the size of uniform land area, number of treatments and size of equipment. Adjust plot lengths so that each treatment is within a reasonably uniform area or so that each uniformly covers the field variation as discussed above. Plots should be similar in size. Avoid using field edges in plots. Field edges should be left as borders. Plot width is determined by the width of equipment used to apply treatments (e.g., planter, sprayer, etc.) and/or harvest plots. The width of the established treatment should be larger than the harvest width. This way there will be a uniform harvest width and errors in harvesting will not affect side by side treatments. Typical treatment plots are between 1/10 and 1/2 acre.

Management: Each plot should be managed exactly the same and as close as possible to the conditions which normally occur on your farm.

Data collection and record keeping

It is important to plan ahead and identify what should be measured, and when and how to take measurements. What you will measure depends on the project's objectives. If the purpose is to increase yield, then a measure of yield is required. If the objective of a new practice is to increase soil moisture, then soil water tests are needed. If the purpose is to increase net farm profit, then you must analyze costs and returns (including yield).

If you need help in deciding what to measure and how to measure it, consult your county extension agent. Without appropriate data and a method to measure treatment differences, your trial will have little value or could lead to inaccurate conclusions. Detailed written records are often required to interpret data. Written documentation preserves the details of your on-farm trial so you can share information with others. Remember, the more you plan and document, the greater confidence you will have in your results.

The following information includes the baseline data needed to document and interpret a valid, unbiased test.

Trial description: State the goals, objectives, treatments and experimental design of the trial.

Field history: Record obvious variations within the test site and the previous cropping history including crop rotation, tillage practices, previous crop and variety, and previous fertilizer and pesticides applied. Make a diagram showing the layout of the field trial.

Soil test and fertility: Sample soil using university guidelines and send samples to a laboratory for analysis. Apply appropriate fertilizer uniformly to the entire trial area.

Field notes and observations: Keep accurate and up-to-date records. Walk the area every few weeks during the season. Note obvious strengths and weaknesses of the treatments plus any general problems with the test. Record any conditions that might influence stand establishment including variety, seeding, planting date, soil temperature, type of planter, seeding depth, row spacing, and residue levels. Take notes of other field operations, such as the type of equipment, depth of tillage operations and materials applied.

Weather: Record significant weather events such as high winds, frost and hail. Precipitation is more variable than temperature between sites. If practical, place a rain gauge at the test site with a little oil in it to prevent water from evaporating and after each storm, record rainfall and empty the rain gauge.

Insects, Weeds and Disease: Record the presence and density of pest (diseases, insects and weeds) and the extent or severity of crop damage. Note differences between treatments, if any.

Crop Growth and Development: During the growing season record the crop stage at the time of treatment and management operation applications, such as pesticide spraying. When abnormal conditions occur, such as drought, note the differences in plant growth response among treatments. It is just as important to record no differences among treatments at a certain growth stage as it is to record obvious differences.

Measurements: Depending on the test, take stand counts of the crop, ratings of weed control, disease or insects. Weigh the yield of each plot, take a moisture sample, and adjust yields to the same moisture content. Yield estimates are needed to make production and economic comparisons between treatments. Measure the size of the harvest area using a measuring tape or before or immediately after you harvest each plot. These distances are then multiplied by the width of the combine head to arrive at the harvested area and yield per acre.

Harvest the middle area of each treatment plot so that border effects do not bias the results. Yields can be measured with a local truck scale, a weigh wagon, or a properly calibrated yield monitor. Harvest equipment must be completely empty and clean before each treatment is harvested. Save a sample from each treatment to determine moisture content at harvest and any other quality factors that may be important such as test weight and protein content. If moisture contents differ between the treatments, you must be corrected to constant moisture.

Data analysis and Statistics

Data analysis largely depends on how the project was designed and conducted. Simple statistical software packages are available. Microsoft Excel has a very good analysis of variance procedure.

Economics: Use a partial budget analysis where

Grower return = (Yield*Price) - [Yield * (Handling+ Hauling+ Storage+ Drying+ Trucking)]

- Price = Weighted Price per Bushel = 50% November 15 Average Cash price + 25% March CBOT Futures price ($0.15 basis) + 25% July CBOT Futures price ($0.10 basis). November 15 Average Cash price derived from Wisconsin Ag Statistics; CBOT Futures prices derived from closing price on first business day in December.
- Handling costs = $0.02 per bushel
- Hauling costs = $0.04 per bushel
- Storage costs = $0.02 per bushel for 30 days
- Drying costs = $0.02 per bushel per point of moisture
- Trucking costs = $0.11 per bushel for 100 miles

Analysis: Use averages over replicates to compare treatments. A well-conducted test will have small differences among plots of the same treatment and some large difference between treatment averages. Consider all-important traits and not just yield.

Variations in yield and other measurements because of variations in soil and other growing conditions lower the precision of the results. Statistical analysis makes it possible to determine, with known probabilities of error, whether a difference is real or whether it might have occurred by chance.

Means are often separated using a number labeled "LSD" which stands for least significant difference. LSD's at an appropriate level of confidence (usually 10%) are used. Where the difference between two selected treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure that in nine out of ten chances that there is a real difference between the two treatment averages. If the difference is less than the LSD value, the difference may still be real, but the experiment has produced no evidence of real differences.

Statistics are only a tool to help prevent us from deceiving ourselves and others. Growing conditions in any particular year can have large effects on certain practices. Two years of replicated data are a minimum for supporting most practices. Statistics, as commonly used, often describe better than they predict. But, stats used over a lot of site-years can provide a measure of the usefulness of a prediction based on data. And yet, statistical statements always involve probability, and this is not always easy to "apply" when it comes to inputs. Statistics do NOT substitute for the large amount of data (site-years) that good on-farm testing always requires.

Time: Data from one field in one year may be misleading. About two to three years of your own tests in conjunction with other reliable information should be adequate to select treatments to be practiced on larger acreage. One year's data may be adequate to discard poor treatments from the test. Replace discarded treatments with new treatments in any tests conducted next year.

Adjustments in the number site-years should be considered if expected variability due to soil type is high (then you need more soil types), if expected variability due to years (weather) is high (then you need more years), and/or if variability is expected to be high over both soils and years, (then you will need a lot of sites and years). If variability is expected to be high over varieties/hybrids, you have a problem.

Summary of results

To interpret results from your on-farm trial, carefully summarize management history, data collected, and observations made. Summary forms are provided in the back of this guide for this purpose. The summarized results should address your goals and objectives. If your objective was to reduce costs, equal or even lower yields may be an acceptable result as long as costs are reduced and the net return has improved.

Take the time to share the results with your neighbors and county extension agents. This flow of information and experience is necessary for the progress of agricultural production and management.

On-farm testing is not a quick cure for anything, but it should greatly accelerate innovation and adoption of new practices by providing reliable, quantitative answers that apply directly to a producers situation. Treatments frequently differ in performance and these differences may vary with management practices, weather patterns, soil conditions, and other environmental and management practices. Replicated trials which take into account field variability are the most reliable and need to be part of informed selection of new practices for profitable crop production.

Lessons from experience

1. If possible, include the cooperator's current practice
2. You can't over document a trial: maps, plot layout, field markers, distances, etc. A field at planting looks a lot different five months later.
3. Communicate with the cooperator early and often - planting and harvest are especially important
4. Plan multiple locations......you'll probably lose a couple
5. Be nice to people with scales and weigh wagons. You need them.
6. Have an efficient data collection system.
7. Visit the trial during the growing season. Measure distances, take stand counts, look for environmental and manmade problems. Document location of potential problems
8. Send a letter of thanks and the results to the cooperator
9. Purchase, borrow, make, or steal equipment when you can wheel, 300 ft. tape, generator, large shop vacuum, PVC stand count stick, PDA, moisture tester, sprayer, etc.
10. THE COOPERATOR can make or break a project. It helps if they're interested in the result. Be willing to accommodate the cooperator's schedule.
11. Commitment to the project......a poor trial is worse than no trial

What are the implications? How far can the research take you?

On-farm testing is not a quick cure for anything, but it should greatly accelerate innovation and adoption of new practices by providing reliable, quantitative answers that apply directly to a producer's situation. Treatments frequently differ in performance and these differences may vary with management practices, weather patterns, soil conditions, and other environmental and management practices. Replicated trials that take into account field variability are more reliable than non-replicated trials and improve the confidence of implementing of new practices for profitable crop production.

NEW FEDERAL CROP INSURANCE PROGRAMS

Paul Mitchell [1/]

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FERTILIZER SUPPLY, DEMAND, AND PRICE OUTLOOK

Joe Dillier [1/]

[1/] Plant Food Marketing Manager, Growmark.

COMMODITY PRICE OUTLOOK

Brian Doherty [1/]

Outline of Presentation

I. Introduction

II. What moved the markets last year (2008)

III. What will be market-moving forces this year?

IV. Fundamental analysis — corn, wheat and soybean supply and demand numbers

V. Price outlook

VI. Strategies to consider for 2008

[1/] Senior Market Advisor, Stewart-Peterson Group, Inc.

IMPLEMENTATION OF NTURIENT MANAGEMENT PLANS
{Panel Discussion — Space below for notes}

Jim Vanden Brook, Tom Bauman, and Pat Murphy [1/]

[1/] Wis. DATCP, Wis. DNR, and Wis. NRCS, Madiosn, WI.

RUNOFF FROM PAIRED BASINS AT THE PIONEER FARM

Dennis Busch, Randy Mentz, and Dave Owens[1]

Introduction

The paired-basin approach was developed to evaluate impacts of forestry management on water quality, and has been adopted by researchers to evaluate management practices in agricultural land use settings. The methodology requires that two basins (control and treatment) are monitored for two time periods (calibration period and treatment period). If the two basins react in a consistent predictable manner while under similar management and climate during the calibration period, an alternate practice can be applied to one basin during the treatment period, and if the relationship between the basins changes, it is due to the treatment (Clausen 1993). The University of Wisconsin-Platteville's Pioneer Farm has installed surface-water monitoring gauging stations in four agricultural basins and collected surface-water quality and quantity data for use in calibrating the basins for paired-basin research.

Methods

The University of Wisconsin-Platteville's Pioneer Farm is a 430 acre production farm located in the driftless area of Wisconsin, seven miles southeast of Platteville in sections 20, 21, and 29 of Elk Grove Township (T3N-R1E) in Lafayette County. The farm is comprised of 330 acres of cropland, 73 acres of pasture, and 27 acres in buildings, roads, and other areas associated with the farmstead. Dominant soil is a moderately eroded Tama soil series with B and C slope classes. Soils are underlain by Galena Dolomite bedrock. The seven-year crop rotation includes one year of oats followed by three years of alfalfa and three years of corn. Livestock enterprises include a Holstein dairy cow herd (125 milking), a farrow-to-finish swine herd, and a beef cow-calf herd. Manure from the dairy herd is collected from alleyways with mechanical scrapers, stored in an earthen basin, and land-applied in the fall using a towed-hose system. Manure from beef and swine facilities are handled as a solid which is composted and land applied year-round.

Surface-water runoff gauging stations and automated samplers were installed at Pioneer Farm in cooperation with the United States Geological Survey to monitor quality and quantity of runoff from agricultural basins. After installation of monitoring equipment, a two-year calibration period was conducted for paired basins 3 and 5 in the water-years (WY) 2003 and 2004, and basins 5, 10, and 11 were calibrated during the 2007 and 2008 WYs. The WY starts October 1st and ends September 31st.

Discharge (quantity) from basins was determined using a pre-calibrated flow control structure (H-flume) coupled with a nitrogen gas pressure transducer stage monitoring device. Time-based discrete samples of surface-water runoff were collected using an ISCO automated sampler. Discrete samples were then composited using a churn splitter and samples analyzed at the UW-Stevens Point Water and Environmental Analysis Laboratory (WEAL). Samples were analyzed for the following: total solids, total suspended solids, nitrate + nitrite N, ammonium, total keldahl nitrogen, total phosphorus-dissolved filtered, and total phosphorus- unfiltered.

The sample concentrations (mg l^{-1}) provided by WEAL were multiplied with USGS flow (l) data to calculate event loads (mg) and multiplied by 1,000 (kg). Event loads (kg) were then divided

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by drainage areas (ha) to determine the yield (kg ha^{-1}). The relationships between yields for basins. The sample concentrations (mg L^{-1}) provided by WEAL were multiplied with USGS flow (l) data to calculate event loads (mg) and multiplied by 1,000 (kg). Event loads (kg) were then divided by drainage areas (ha) to determine the yield (kg ha^{-1}). The relationships between yields for basins during the calibration period were examined using linear regression and analysis of variance (ANOVA). Minimal detectable differences for basin pairs were determined using the method described by Kovner and Evans (1954). Data were tested to ensure it met required assumptions: normality of regression residuals (Anderson-Darling), autocorrelation (Durbin-Watson), and equal variance (Levene). Log, inverse, square root, and cubed root transformations were used to improve the distribution of the data sets. This study determined the strength of paired basin relationships for the following parameters: runoff, total solids (TS), total nitrogen (TN), total phosphorus (TP), and dissolved reactive phosphorus (DRP).

Basins 3, 5, 10, and 11 are single-use basins, meaning that only one crop type is grown in the basin at a time. During the WY 2003-04 calibration period, cropland in basins 3 and 5 was chisel-plowed in the fall and finished in the spring prior to corn planting in late April. Field average soil test phosphorus levels ranged from 88 to 130 ppm. A light application (17 Mg ha^{-1}) of solid beef and dairy manure was applied to all of basin 3 and portions of basin 5 in the fall of 2002. In the fall and winter of 2003 of solid dairy manure (6.3 Mg ha^{-1}) and liquid dairy manure (218 L ha^{-1}) were applied to all of the cropland in basin 3 and portions of basin 5. Basin 5 also received a solid manure application of 58 Mg ha^{-1}. During the WY 2007-08 calibration period, cropland was transitioned to alfalfa production and no manure applications were made.

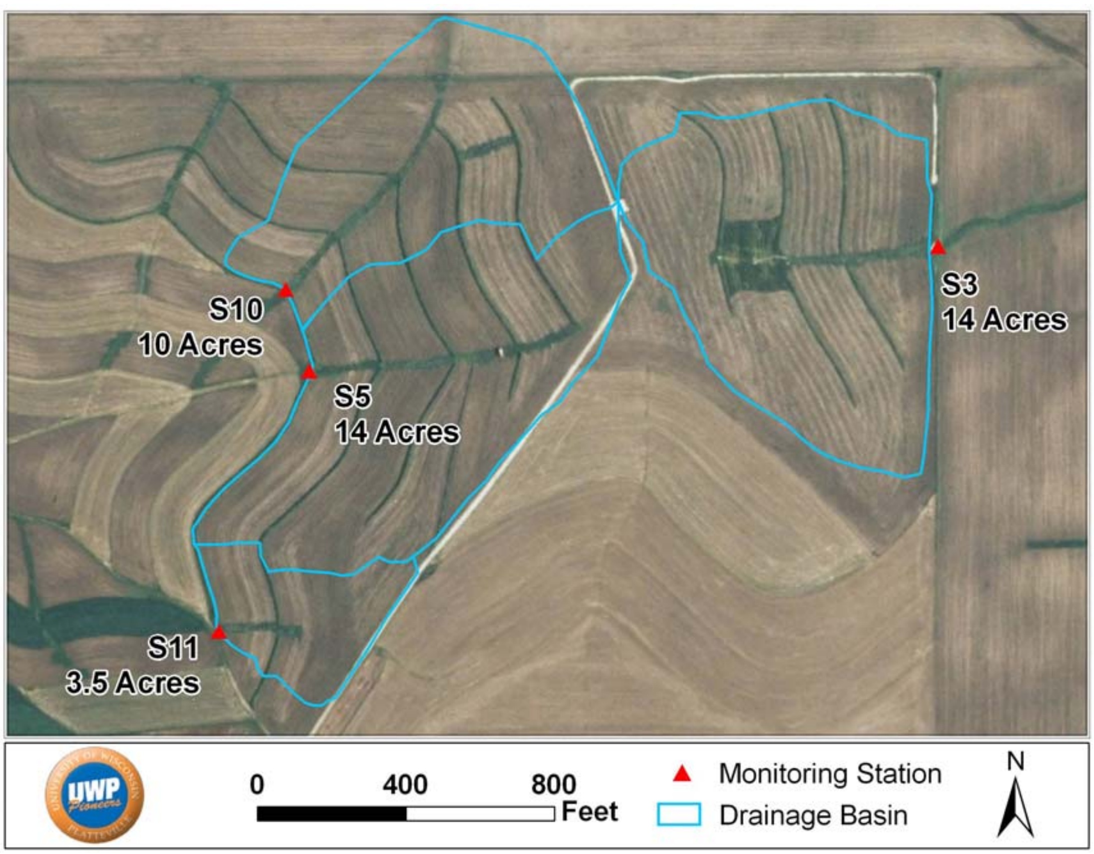

Figure 1. Monitored basins at UWP Pioneer Farm.

Results and Discussion

During the calibration period for basins 3 and 5, 9 runoff events were monitored in WY 2003 and 19 were monitored in WY 2004. The calibration period for basins S5, S10, and S11 included 11 events in WY 2007 and 27 events in WY 2008. The figures below plot total phosphorus yield for sequential runoff events from paired basins 5-10 and 5-11. The events in the shaded areas are snowmelt driven runoff events, non-shaded areas are rain driven runoff events. Figure 2 indicates a close relationship between paired basins 5 and 10 during both snowmelt and rainfall events. In contrast, basins 5 and 11 plotted in Figure 3 do not react as predictably, especially during snowmelt events. One reason for the potential weak pairing of basins 5 and 11 may be due to the slightly northern aspect of basin 11. Due to the slight northern aspect, snowmelt and snow accumulation may occur differently in this basin than it does in basins 5 or 10.

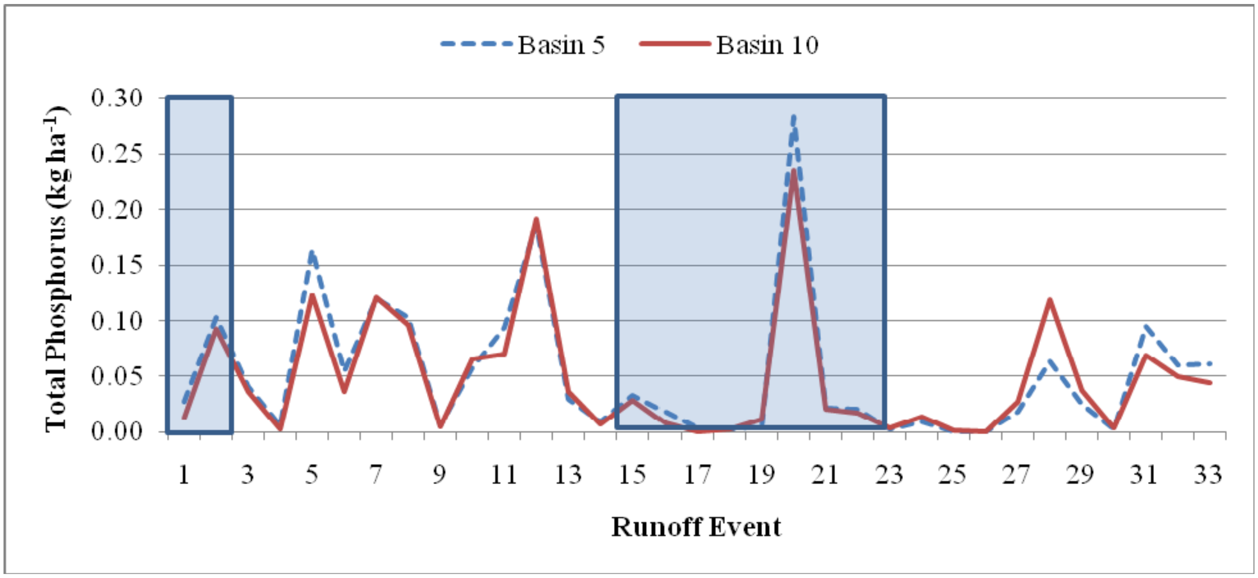

Figure 2. Total phosphorus yield event series for basins 3 and 5.

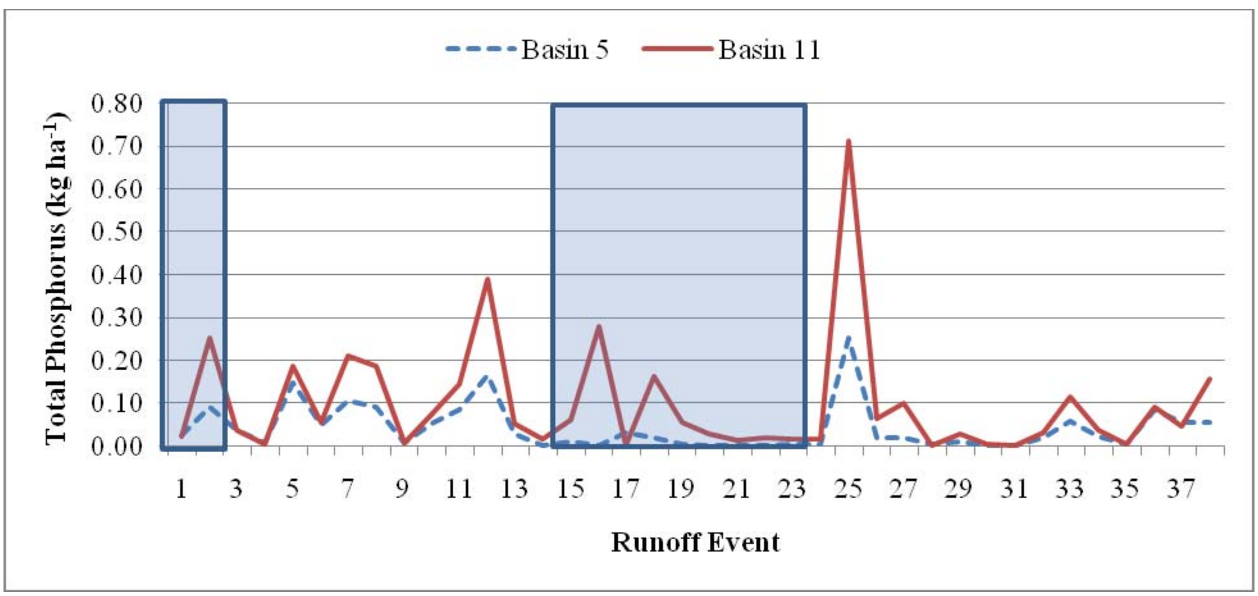

Figure 3. Total phosphorus yield event series for basins 5 and 11.

Given the calibration data that were collected, there are four possible pairs of basins: 5-3, 5-10, 5-11, and 10-11. Analysis of the calibration yield data indicates that regression equations for all parameters in all pairs were significant at the 0.05 level. However, the strength of the pairs was variable. Table 2 lists the smallest detectable differences by parameter for basin pairs. The basins that have the strongest relationship (i.e. smallest detectable difference) are 5 and 10. For this pair, an eight percent difference in the mean DRP yield would be statistically significant. In comparison, a 44% or greater change in mean DRP yield would be required in order to be detected as significant for the 10 and 11 paired basins. One possible reason for the apparent weakness in the 5-11 and 10-11 pairs may be due to the slight northern aspect of basin 11. This difference in aspect may be resulting in changes to snowmelt characteristics, which may affect hydrology. Also, the aspect may result in greater snow accumulation in this basin.

Table 2. Paired basins smallest detectable difference (expressed as a percentage of the mean).

	Basin 5					Basin 10				
Basin	Runoff	TS	TN	TP	DRP	Runoff	TS	TN	TP	DRP
			%					%		
3	20	40	34	31	34	------------------ No Data --------------				
10	14	27	21	12	8	------------------ No Data --------------				
11	46	46	63	68	42	48	43	60	49	44

Summary

Analyses of data collected from basins 3, 5, 10, and 11 at UWP Pioneer Farm indicate that the basins will be useful for evaluating the effect alternative agricultural practices and/or systems have on water quality and quantity. However, the strength of relationship between pairs of basins is not consistent. For example, basins 5 and 10 have the strongest relationship and can detect the smallest response due to the treatment- a 13% change in total phosphorus would be significant. Basins 3 and 5 also paired well, minimal detectable differences were 20 to 40% for sediments and nutrients. In contrast, the weakest pair of basins is 5 and 11 where a 68% or greater change in total phosphorus would be required in order to be statistically significant. The reason for the weak pairing with basin 11 may be due to the slight northern aspect of the basin. This may result in changes in snowmelt that alter the hydrology. Or, it may be influencing the amount of snow that accumulates in this basin.

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Kovner, J.L., and T.C. Evans. 1954. A method for determining the minimum duration of watershed experiments. Transactions, American Geophysical Union 4:608-612.

AGRICULTURAL CHEMICALS IN WISCONSIN GROUNDWATER

Jeff Postle [1/]

Between January 2007 and June 2007, 398 private drinking water wells were sampled as part of a statewide survey of agricultural chemicals in Wisconsin groundwater. The purpose of the survey was to obtain a current picture of agricultural chemicals in groundwater and to compare the levels in the 2007 survey with levels found in earlier surveys conducted in 1994, 1996 and 2001. Wells were selected using a stratified random sampling procedure and were used to represent Wisconsin groundwater accessible by private wells. Samples were analyzed for 32 compounds including herbicides, herbicide metabolites, one insecticide, and nitrate-nitrogen.

Based on statistical analysis of the sample results, it was estimated that the proportion of wells in Wisconsin that contained a detectable level of a pesticide or pesticide metabolite was 33.5%. Areas of the state with a higher intensity of agriculture generally had higher frequencies of detections of pesticides and nitrate-nitrogen. The two most commonly detected pesticide compounds were the herbicide metabolites alachlor ESA and metolachlor ESA which each had a proportion estimate of 21.6%.

The statewide estimate of the proportion of wells that contained atrazine total chlorinated residues (TCR) was 11.7%. The estimate of the proportion of wells that exceeded the 3 µg/L enforcement standard for TCR was 0.4%. Estimates of the mean detect concentrations for pesticides were generally less than 1.0 µg/L. The estimate of the proportion of wells that exceeded the 10 mg/L enforcement standard for nitrate-nitrogen was 9.0%.

Time trend analysis was performed to determine whether the proportion estimates for atrazine, TCR, nitrate-nitrogen, alachlor ESA and metolachlor ESA in private wells had changed between the 2001 survey and the 2007 survey. The results of this analysis did not show any statistically significant changes for these compounds over this time period.

The full report for this project can be obtained by emailing Jeff.Postle@Wisconsin.gov.
The report can also found at the following department web page:
http://www.datcp.state.wi.us/arm/agriculture/land-water/environ_quality/pdf/ARMPub180.pdf

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ENVIRONMENTAL PARTNERS: INDUSTRY-INITIATED STEWARDSHIP

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SOIL AND THE ENVIRONMENTAL TRANSMISSION OF PRION DISEASES

Joel Pedersen [1/]

Prion diseases comprise a family of inevitably fatal neurodegenerative diseases that affect a variety of mammalian species and include bovine spongiform encephalopathy ("mad cow" disease) in cattle, scrapie in sheep and goats, chronic wasting disease (CWD) in deer and elk, and Creutzfeldt-Jakob disease in humans. The infectious agents in these diseases, referred to as prions, lack nucleic acid and are composed predominately, if not solely, of a misfolded form of the normal cellular prion protein. Scrapie and CWD appear unique among prion diseases in that animal-to-animal transmission can be mediated by an environmental reservoir of infectivity. Among potential reservoirs for prion infectivity, soil appears the most plausible. The disease-associated prion protein binds to a variety of soil minerals and can persist in soils for years. Attachment to soil particles limits migration of the pathogenic prion protein through fine-grained soils and may increase the potential for animal exposure by maintaining prions near the soil surface. Clay mineral-bound prions remain infectious intracerebrally, and soil particle-associated agent is infectious orally. Prion sorption to clay minerals dramatically enhances oral prion disease transmission suggesting an explanation for disease transmission despite the presumably low levels of prions shed by infected animals. Soil may contribute to the environmental spread of prion diseases by increasing the transmissibility of small amounts of infectious agent in the environment. Prions released into soil environments may be preserved in a bioavailable form, perpetuating prion disease epizootics and exposing other species to the infectious agent.

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CHANGING ECONOMICS OF WEED MANAGEMENT

Chris M. Boerboom [1]

Introduction

The simplest part of weed management is selecting the right herbicide or mix of herbicides to control a specific weed complex. It is more difficult to understand and predict the timing and severity of weed competition with corn and soybeans. Given the uncertainty of weed growth and crop yields each year and the uncertainly of crop price, it becomes even more difficult to predict the most economically profitable weed management program that a grower should use in each field. I could argue that the investment in a good weed management program has the highest or one of the highest returns on investment next to purchasing seed (i.e., a given since a grower must purchase seed to get any return). Without weed management, corn and soybean yields can be reduced by 50% or more so weed management protects a substantial portion of gross returns. While it is wise to be as economical as possible with herbicide expenditures, the goal and achievement of yield protection cannot be forgotten and appropriate investments in weed management programs should be made. Even before the substantial increases in seed, fertilizer, and land input costs in 2008 and 2009, herbicide costs were a relatively small percentage of the total production costs of corn and soybean and herbicides protect a large percentage of the gross value relative to their costs (Table 1).

Table 1. Average chemical costs (predominately herbicides) and percentage of total production costs and gross crop value for cash corn and soybean as reported by the Profits through Efficient Production Systems (PEPS) program.

Crop	Year	Total production costs	Gross value	Chemical (herbicide) Cost	Chemical (herbicide) % of input costs	Chemical (herbicide) % of gross value
		$/acre	$/acre	$/acre	%	%
Corn	1997	295	491	22	7.5	4.5
	2002	288	446	20	6.9	4.5
	2007	351	633	27	7.7	4.3
Soybean	1997	201	357	30	14.9	8.4
	2002	179	319	14	7.8	4.4
	2007	220	557	16	7.3	2.9

Considering the changing economics of crop production, this presentation will review the following three aspects where weed management and economics interact.

1. Potential economic losses with postemergence weed management in corn and soybean.

2. Economics of preemergence herbicides in soybean production.

3. Interactions of weed management and nitrogen in corn: Part II.

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1. Postemergence Weed Management in Corn and Soybean

Most crop advisors recognize the potential for early-season weed competition to reduce corn and soybean yield potential. However, data to document the actual number of acres affected or the level of yield loss are lacking. The presentation “SURVEY OF POSTEMERGENCE WEED MANAGEMENT IN WISCONSIN FIELDS” at this conference documents that approximately 75% of surveyed corn and soybean fields, which are treated with postemergence herbicide programs were treated after the recommended time of weed control to prevent crop yield loss. The predicted yield loss in the corn fields based on the average weed densities and heights was 6.5%, which would equate to a $39/acre loss based on a 150 bu/acre yield potential and a $4/bu price (Table 2, see referenced presentation for more details). Economic losses would be even greater with higher yielding corn. The average predicted yield loss in soybean was similar at 6.6%, but the profit loss was not as great in soybean as corn with the yield and price used. Still, the predicted economic loss of $26/acre in soybean is substantial. This information on the potential economic losses that are likely occurring in Wisconsin corn and soybean fields is compelling justification to consider management options to improve economic returns.

Table 2. Predicted yield and profit losses using WeedSOFT predictions based on the average densities and heights of the three most common weeds in corn and soybean fields in Wisconsin. Corn yield and price were set to 150 bu/acre and $4/bu and soybean yield and price were set to 50 bu/acre and $8/bu for this example.

	Corn	Soybean
Crop stage	V5	V4
Crop yield	150 bu/acre	50 bu/acre
Crop price	$4/bu	$8/bu
Predicted yield loss	6.5% or 9.75 bu/acre	6.6% or 3.3 bu/acre
Predicted profit loss	$39/acre	$26/acre

2. Economics of Preemergence Herbicides in Soybean Production

The increased price of glyphosate in 2008 was not viewed by soybean growers as a positive development. However, one positive aspect is that it made preemergence herbicides more affordable on a relative basis. Many preemergence soybean herbicides cost in the range of $10-12/acre when applied at the reduced rates recommended in Roundup Ready soybeans. At these rates, these herbicides will control or reduce early season weed competition and allow greater flexibility in the timing of the postemergence glyphosate applications. Without the residual control provided by a preemergence herbicide, an increasing number of soybean fields are being treated with glyphosate twice.

Given the potential for yield loss from early-season weed competition, an analysis of the partial returns to seed and herbicide program costs was conducted to determine if the costs of preemergence herbicides could be economically justified (Table 3). The returns for soybeans with different seed traits were also considered. In the analysis, several assumptions had to be made. For costs, the assumptions were: conventional, Roundup Ready, Roundup Ready 2 Yield, and LibertyLink soybean seed were $30, $46, $63, and $46/unit, respectively; soybean are planted at 175,000 seeds/acre at 140,000 seeds/unit; herbicide application cost is $8/acre; branded glyphosate is $12/acre; Ignite is $11/acre; and Sonic is $13/acre for 3 oz. For soybean yield, a base yield of 50 bu/acre is used with a 2% yield reduction for conventional soybeans; a 6% reduction for single postemergence herbicide programs (based on field trial results in 2008); and a 6% yield increase with Roundup Ready 2 Yield soybeans (although university data is not available to support this claim). Soybean price was set at $8/bu. With these estimates, total seed and herbicide program costs could range from a low of $77/acre with a single application of Ignite to LibertyLink soybean to a high of $126/acre for a two pass program with Roundup Ready 2 Yield soybean. However, the range in partial returns is only $12/acre. Perhaps the most important fact is that the use of a preemergence herbicide with the herbicide resistant soybeans had a similar return to a single application of glyphosate or Ignite. Additional items to consider in this analysis are that a premium was not included in the market price for the conventional soybeans, which has the potential for an additional $1-2/bu for various non-GMO soybeans. Also, the partial return for Roundup Ready 2 Yield soybeans could be lower if the yield increase is not obtained for this trait. Overall, partial returns will be greatly influenced by the yield potential of the soybean variety regardless of trait or cost of the herbicide program, but a preemergence herbicide program could be economically justified to protect that yield.

Table 3. Potential seed and herbicide costs and net returns for soybeans with different types of herbicide traits.

Trait	Herbicide program	Seed cost	Herbicide cost	Total cost	Soybean yield	Gross return	Partial return
		$/acre	$/acre	$/acre	bu/acre	$/bu	$/acre
Conventional	Sonic/Select Max (7 oz/9 oz)	38	53	91	49	392	301
Roundup Ready	Glyphosate (0.75 lb)	58	26*	84	47	376	292
	Glyphosate (0.75 + 0.75 lb)	58	46*	104	50	400	296
	Sonic/Glyphosate (3 oz/0.75 lb)	58	47*	105	50	400	295
RR 2Yield	Glyphosate (0.75 lb)	79	26*	105	50	400	295
	Glyphosate (0.75 lb + 0.75 lb)	79	46*	125	53	424	299
	Sonic/Glyphosate (3 oz/0.75 lb)	79	47*	126	53	424	298
LibertyLink	Ignite (22 oz)	58	19	77	47	376	299
	Ignite (22 oz + 22 oz)	58	38	96	50	400	304
	Sonic/Ignite (3 oz/22 oz)	58	40	98	50	400	302

* includes $6/A for postemergence grass herbicide to control volunteer glyphosate-resistant corn.

3. Interactions of Weed Management and Nitrogen in Corn: Part II.

Weed management is certainly not the most expensive input for corn production. Rather, nitrogen may be the most costly input, but weeds and weed management are linked to nitrogen because of weed competition. At last year's 2008 conference, we described the effects postemergence weed control timing on corn yield and the interaction with optimal nitrogen rates in the paper titled "FERTILIZING YOUR WEEDS FOR PROFIT?" The data from this Arlington field study showed that weeds can compete for a significant amount of nitrogen if they are not controlled in a timely manner. The nitrogen removed by the weeds can be replaced to restore corn yield, but the cost of additional nitrogen is expensive. At the same time, the cost to control weeds with a preemergence herbicide program to prevent weed competition for nitrogen is greater than the cost of spraying glyphosate postemergence. To determine how the costs of nitrogen and weed control programs might be optimized, the corn yield response to nitrogen rates was analyzed for three weed management scenarios using a partial budget. Assumptions for the analysis were a corn price of $4/bu, a nitrogen price of $0.90/lb, a preemergence herbicide price and application of $40/acre, and a postemergence herbicide price and application of $22/acre.

Corn yields with the preemergence weed control program and when weeds were controlled at the 4-inch stage were similar in both 2006 and 2007 (Fig. 1 and 2). However, the additional 8 days of weed competition from the 4-inch timing until the 12-inch weed control timing reduced corn yield at the intermediate nitrogen rates. At the 200 lb/acre nitrogen rate, corn yields were similar for all weed control timings.

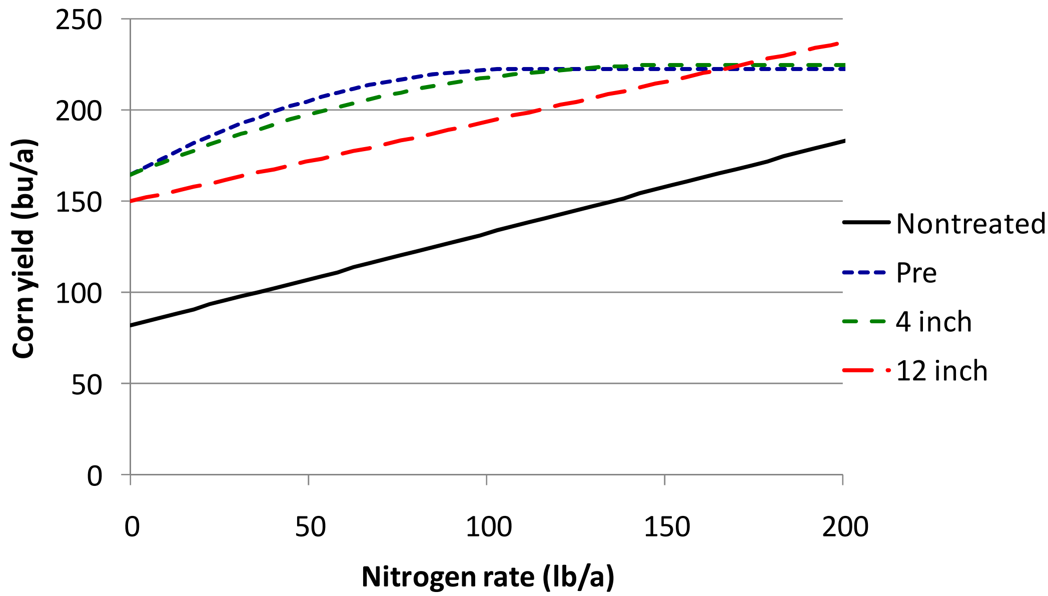

Figure 1. Corn yield response to increasing nitrogen rates when weeds were controlled preemergence or at the 4- or 12-inch growth stage in 2006 at Arlington, WI.

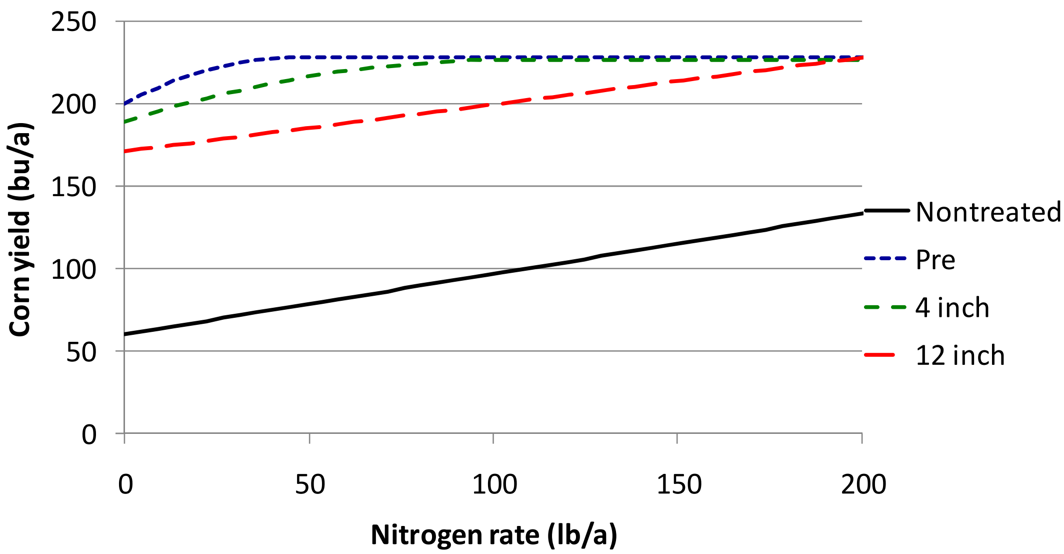

Figure 2. Corn yield response to increasing nitrogen rates when weeds were controlled preemergence or at the 4- or 12-inch growth stage in 2007 at Arlington, WI.

In 2006, the partial returns were greatest with the preemergence herbicide at moderate nitrogen rates and were very similar to when the weeds were controlled at the 4-inch timing (Fig. 3). If the preemergence weed control program was more expensive, the 4-inch weed control timing with glyphosate would have provided the highest return at the optimal nitrogen rate. At these moderate nitrogen rates, the economic return of the 12-inch weed control timing was greatly reduced, but increased with increasing nitrogen rates.

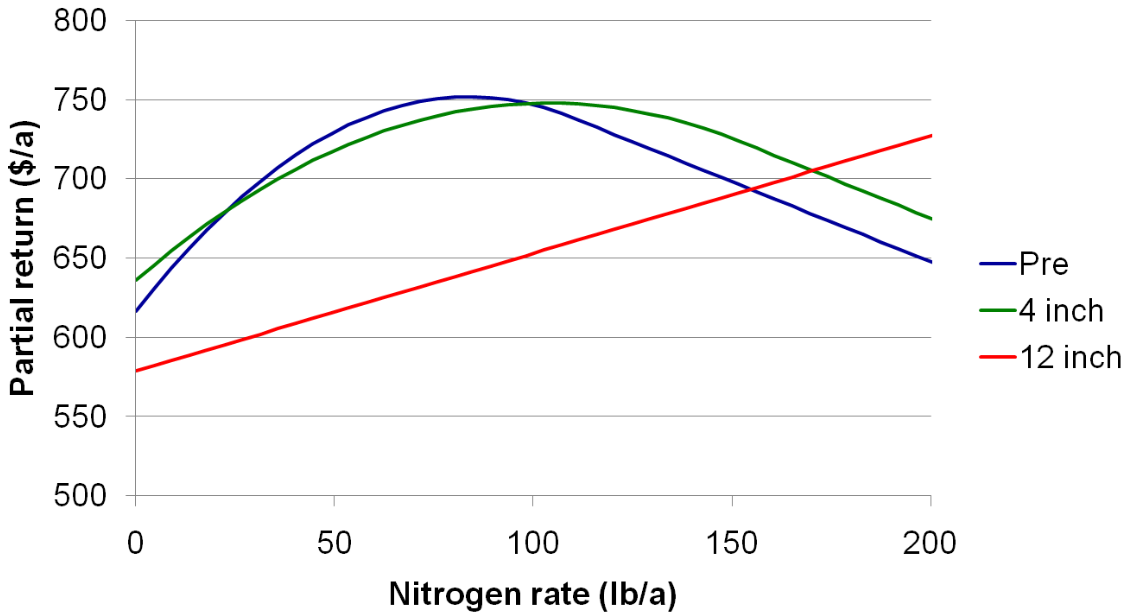

Figure 3. Partial returns for corn yield less nitrogen and weed control costs with increasing nitrogen rates when weeds were controlled preemergence or at the 4- or 12-inch growth stage in 2006 at Arlington, WI.

In 2007, the partial returns were greatest with the preemergence herbicide at low nitrogen rates because the economic optimum nitrogen rate was low (Fig. 4). The returns when the weeds were controlled at the 4-inch timing were less than the preemergence treatment over the range of low nitrogen rate and they were similar after the economic optimum nitrogen rate was reached and when the returns were declining with the cost of the additional nitrogen. The partial returns were dramatically lower with the 12-inch weed control timing even when the high nitrogen rates compensated for the extended weed competition.

These partial returns are based on high nitrogen prices which may not continue into the future. However, partial budgets based on nitrogen prices of $0.60/lb yield similar responses although the partial returns are proportionately greater at the higher nitrogen rates. Overall, this data supports that an investment in preemergence weed control may be more profitable than applying nitrogen at rates above the economic optimum rates.

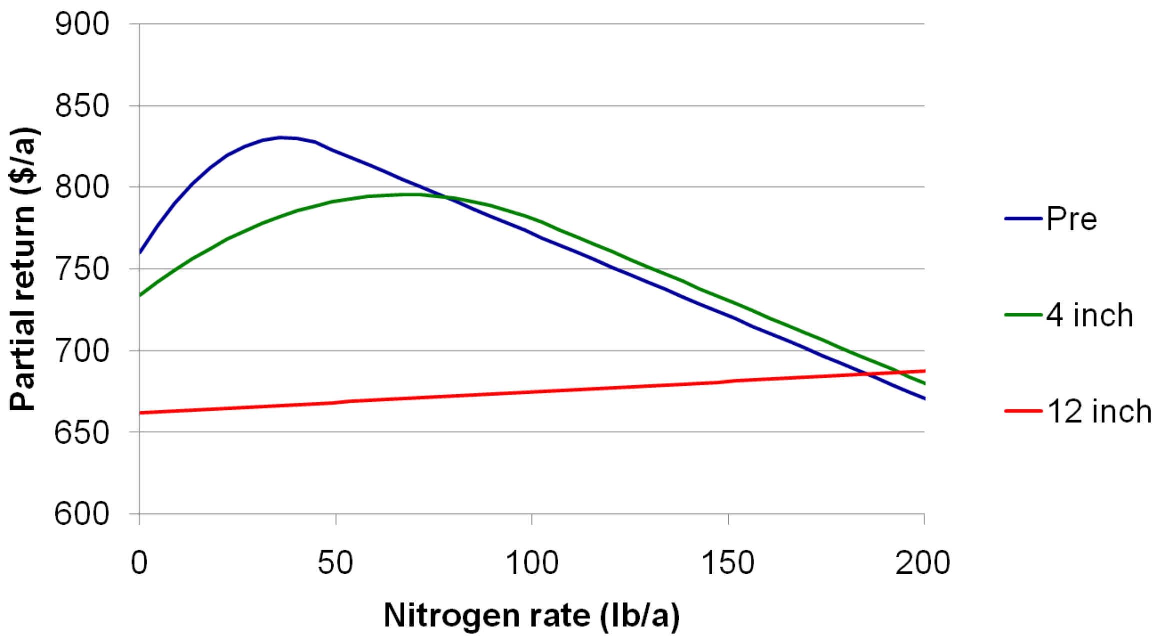

Figure 4. Partial returns for corn yield less nitrogen and weed control costs with increasing nitrogen rates when weeds were controlled preemergence or at the 4- or 12-inch growth stage in 2007 at Arlington, WI.

MID-TERM CRP LAND MANAGEMENT

Mark J. Renz, Marie L. Schmidt and Richard T. Proost [1]

The Conservation Reserve Program (CRP) was initially established as a cropland set-aside program offered by the United States Department of Agriculture in the 1985 Farm Bill. Over the past twenty years, priorities for this program shifted to support wildlife habitat, specifically nesting habitat, food and cover for upland birds. Due to this shift, many fields that are monocultures of cool season grasses such as smooth brome are now considered improper habitat for this program. Recently, the Farm Service Agency (FSA) has required owners of these properties to suppress cool season grasses and diversify the plant species present by inter-seeding the fields with desirable forbs. This management is intended to enhance wildlife habitat by increasing plant species and structural diversity as well as remove duff and control woody vegetation. While options for management are provided by the National Resource Conservation Service (NRCS), limited information exists on the effectiveness of herbicides and tillage in suppressing cool season grasses, establishing desirable forbs, and how these treatments can affect soil loss.

Experiments were conducted in Green and Dodge County, Wis. to evaluate the effectiveness of glyphosate (Roundup), sethoxydim (Poast) and fluazifop (Fusilade) in suppressing smooth brome dominated stands compared to tillage and untreated plots (see Table 1 for rates). Herbicides and tillage were applied in the spring on 4/29/08 and 5/12/08 at each site respectively. At the Greene county site, plots were inter-seeded with alfalfa (selected desirable forb) using a no-till drill 1 day after treatments (DAT) were applied.

Suppression of smooth brome and other cool season grasses was observed with treatments containing glyphosate and fluazifop at both sites during the summer. Percent control was 75-85% and 88-94% for treatments containing glyphosate and 48-58% and 84-91% for treatments containing fluazifop 97 DAT and 77 DAT at the Green and Dodge County site respectively (Table 1). Suppression did diminish with time however, and at the Green County site, only treatments containing glyphosate were able to maintain suppression of smooth brome 127 DAT, with glyphosate at 0.5, 0.75, and 1.0 lb ae/acre reducing cover of smooth brome by 84, 89, and 91%, respectively. At the Dodge County site, smooth brome remained suppressed 106 DAT with fluazifop, glyphosate, sethoxydim and tillage. Fluazifop at 0.19, 0.25, and 0.38 lb/acre reduced cover by 57, 82, and 83% compared to the untreated plots respectively, while glyphosate at 0.5 and 0.75 lb/acre and sethoxydim at 0.29 lb/acre reduced smooth brome cover 73, 60, and 51%, respectively. Differences in suppression between sites may have been due to large populations of goldenrod species at the Dodge County site in combination with no inter-seeding of alfalfa. Establishment of alfalfa was successful at the Green County site with all treatments, but only increased with glyphosate treatments. Cover of alfalfa 127 DAT with these treatments were 34-55% compared to 2% in untreated plots.

Although all methods were effective in establishing a more diverse plant community, the use of glyphosate was more effective at suppressing populations and allowing for establishment of alfalfa while also suppressing other undesirable broadleaf weeds. While disking suppressed smooth brome, results did not persist throughout the year as cover was only significantly reduced at the Dodge county site 38% 106 DAT. These data in combination with the potential for increased soil loss should cause land managers to hesitate in recommending disking for mid contract management of cool season grasses on highly erodible land.

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Table 1. Percent control and cover of smooth brome and other cool season grasses after spring treatments.

Treatment	Active ingredient	New Glarus 97 DAT †	Dodge 77 DAT	New Glarus 127 DAT	Dodge 106 DAT
product/acre	lb/acre	% control		% cover	
Fusilade (12 fl oz)[2]	fluazifop (0.19)	48	91*	71	14
Fusilade (16 fl oz)[2]	fluazifop (0.25)	53	90*	76	5*
Fusilade (24 fl oz)[2]	Fluazifop(0.38)	58*	83*	66	5*
Poast plus (12 fl oz)[2]	sethoxydim (0.10)	42	36	89	32
Poast plus (24 fl oz)[2]	sethoxydim (0.19)	37	45	84	45
Poast plus (36 fl oz)[2]	sethoxydim (0.29)	38	17	85	16*
Roundup Weathermax (14 fl oz)[3]	glyphosate (0.5 ae)	75*	88*	33*	9*
Roundup Weathermax (21 fl oz)[3]	glyphosate (0.75 ae)	80*	89*	26*	13*
Roundup Weathermax (28 fl oz)[3]	glyphosate (1.0 ae)	85*	94*	22*	22*
Untreated control		28	5	87	32
Disking		43	60*	62	20*

[2] Included 1% crop oil concentrate and 2.5 lb/acre of ammonium sulfate.
[3] Included 10 lb/acre of ammonium sulfate.
* Indicates value is different than untreated controls within the column.
† DAT = days after treatment.

Table 2. Cover of alfalfa (planted desirable forb) at the Green County site after spring treatments.

Treatment	Active ingredient	New Glarus 127 DAT †
product/acre	lb/acre	% cover alfalfa
Fusilade (12 fl oz)[2]	fluazifop (0.19)	12
Fusilade (16 fl oz)[2]	fluazifop (0.25)	18
Fusilade (24 fl oz)[2]	Fluazifop (0.38)	28
Poast plus (12 fl oz)[2]	Sethoxydim (0.10)	5
Poast plus (24 fl oz)[2]	Sethoxydim (0.19)	3
Poast plus (36 fl oz)[2]	Sethoxydim (0.29)	9
Roundup Weathermax (14 fl oz)[3]	glyphosate (0.5 ae)	48*
Roundup Weathermax (21 fl oz)[3]	glyphosate (0.75 ae)	34
Roundup Weathermax (28 fl oz)[3]	glyphosate (1.0 ae)	55*
Untreated control		2
Disking		20

[2] Included 1% crop oil concentrate and 2.5 lb/A of ammonium sulfate.
[3] Included 10 lb/A of ammonium sulfate.
* Indicates value is different than untreated controls within the column.
† DAT = days after treatment.

SMALL-SCALE, ON-FARM BIODIESEL PRODUCTION

Jerry Clark[1/], Bob Cropp[2/], Carl Duley[3/], Bill Halfman[4/], Steve Huntzicker[5/], Trisha Wagner[6/], and Jon Zander[7/]

On-Farm biodiesel production has gained interest in the past few years as volatile energy costs impact Wisconsin farmers. Dairy and other livestock production continues to be very important in western Wisconsin and on-farm biodiesel production may be one way for livestock farmers to lower their costs both of fuel and protein inputs. Very little, if any, applied research is available for farmers regarding production, costs or safety of biodiesel production. University of Wisconsin Cooperative Extension Agriculture Agents in the Western District have developed a complete system for evaluating small scale on-farm biodiesel production including growing different oilseed crops to processing the oil into ATSM quality biodiesel. On-Farm Biodiesel Options for Livestock Farms is a program the extension agents have designed to provide farmers with unbiased information to make informed decisions regarding production of biodiesel. Information gathered from the program also includes quality and economics of feeding the protein meal byproduct to dairy cattle and other livestock.

The On-Farm Biodiesel Options for Livestock Farms program combines the need for applied research on oilseed production and biodiesel production with the desire of farmers to get hands-on experience in the field. Demonstration plots and yield results of oilseed (sunflower, soybean and canola) production have been developed at three locations. An oilseed press has been purchased to demonstrate crushing needs and variability of oil output. Finally, a biodiesel processing unit is established at a local farm cooperator to provide hands-on demonstrations to small groups of farmers.

An emphasis for the project has been the safe production of on-farm biodiesel. Many farmers are attempting to produce biodiesel with equipment not designed for biodiesel production. The use and handling of methanol is a huge safety concern on the farm. A major goal of the project is to discover the true cost of producing ASTM certified biodiesel safely.

Objectives of the On-Farm Biodiesel Options for Livestock Farms:

1. Producers (crop and livestock) will understand the profitability of producing oilseed crops in western Wisconsin soils.
2. Producers will understand the basics of small scale biodiesel production including regulatory and safety requirements.
3. Producers will understand the economics of small scale on-farm biodiesel production.
4. Producers will make an informed decision on starting their on-farm biodiesel production operation.
5. Producers will have a streamlined process available to meet necessary federal, state and local regulations.

Funding for the project has been obtained from a number of sources. Start up costs for a complete system from bin to fuel tank is about $25,000.

Costs for basic equipment incurred for making biodiesel include:

Swedish Type 70 press	$7700	Biodiesel processor	$10,500
Boiler system	$5470	Donated bulk bin and Augers	

Currently, oil yields of canola, soybean, and sunflower have been collected during the 2007 and 2008 growing seasons. 2008 data are currently being processed. UW-Extension publication A3654 Wisconsin Soybean Variety Test Results provides data of variety oil content. Data from canola trials in Chippewa Falls are available at:
http://osbornlab.agronomy.wisc.edu/research/results.html

Sunflower Variety Results 2007
From 2 locations (Sparta and Alma)

Company	Variety	Yield lb/acre	% crude protein	% fat	Gallons oil/acre
Croplan	544	1550	18.4	29.4	54
Garst	4596	3001	14	38.4	141
Garst	4668	1914	18.1	32.2	73
Garst	4682	2321	16.7	35.6	99
Garst	4704	2591	16.4	34.8	108
Pioneer	63M52	2843	17.4	34.8	118
Pioneer	63M91	2392	17.3	34.8	99
Mycogen	8N358	1776	18.8	36.1	76
Mycogen	8N386	2357	20.2	36.8	103

Soybean Variety Results 2007
Across 3 locations (Sparta, Tomah, Alma)

Variety	yield	% oil	% protein	Gal/acre
Brunner 2101 rr	46.6	19.7	33.9	76
Croplan 2020	46.5	20.1	34.2	77
Dahlco 9213	47.5	19.5	33.8	76
Kruger K195 rr/scn	43.9	20.1	33.9	73
Latham E1950 r	48.4	19.5	33.2	78
NK S21-N6	57.8	20.2	33.2	96
Pioneer 92M32	48.2	19.5	33.6	77
LSD 0.10	7.9	0.3	0.7	

For more information or questions about the On-farm Biodiesel Production project contact:

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Funding sources:

UW-CALS
UW-Western District Ag Agents
Buffalo County Federated Cooperatives
Wisconsin Soybean Marketing Board
UW-Extension Farm Safety Grants
UW-Extension Western District
Badgerland Farm Credit Services
Riverland Energy Cooperative
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DEVELOPMENT OF SWITCHGRASS AS A BIOENERGY CROP

Michael D. Casler [1/]

In 1992, the U.S. Department of Energy initiated its feedstock development program by choosing two model species upon which to develop a nationwide research infrastructure. Switchgrass (*Panicum virgatum*) was chosen as the herbaceous model plant and poplar (*Populus* spp.) was chosen as the woody model plant. Switchgrass was chosen for several reasons that included: (1) broad species adaptation within the USA including suitability on a wide range of marginal lands; (2) its native status; (3) relatively high biomass yields and high drought tolerance; (4) high seed production potential, ease of processing seed, and previous existence of a viable seed industry; and (5) its value in natural resource conservation programs. The principal accomplishment of the 10-year program was a projected 25% reduction in production costs for switchgrass biomass crops, achieved by (1) selection of the most adapted varieties within many regions of the USA, (2) optimization of harvest timing and frequency, and (3) reduction of nitrogen fertilization levels to minimize nitrate losses to groundwater. Most studies have shown that two harvests per year will increase biomass yields, but generally not enough to offset the increased production costs associated with a second harvest. Optimal nitrogen fertilization rates are about 100-120 lb N/A (110-130 kg N/ha) to achieve a balance between maximizing biomass yield and minimizing nitrate leaching into groundwater. Although switchgrass can be grown from Mexico to Canada, the range of adaptation of individual varieties is much more limited. Most varieties should not be moved more than one hardiness zone north or south of their origin. Likewise, eastern and western varieties are generally best adapted within their respective regions, east or west of the Mississippi River. A system of switchgrass gene pools has been proposed as a mechanism to classify and deploy switchgrass germplasm for breeding, marketing, and conservation purposes. A number of new varieties have been developed with increased biomass yield potential and these gains will continue as new switchgrass breeding programs have been established in strategic regions of the USA and as new genetic technologies come into play.

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CROP ROTATION ECONOMICS

Paul Mitchell [1/]

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FIELD OBSERVATIONS: CROP ROTATION OPTIONS
{Panel Discussion — Space below for notes}

Paul Mitchell (Moderator), Eric Birschbach, David West, and Bill Schaumberg [1/]

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PERENNIAL COVER CROP MANAGEMENT IN PROCESSING SNAP BEAN

A.J. Bussan, Michael Copas, and Michael Drilias[1]

Cover crops play a vital role in the management of processing vegetables in the Central Sands region of Wisconsin. The use of cover crops to reduce soil losses due to wind erosion has become a common practice following the harvest of a given cash crop by producers in the region. The management of these cover crops focuses on erosion control and limits development of the crop beyond vegetative stages through tillage or herbicide control. Currently cereal rye is the most common species used in vegetable production fields as a cover crop. Cereal rye is advantageous for erosion control due to its rapid establishment and the ability to grow at cooler temperatures in fall following harvest.

The current vegetable cropping system inherently demands high fertilizer inputs, especially nitrogen. Due to economic instability in the U.S. and worldwide, the cost of chemical nitrogen products has fluctuated drastically and the potential remains for future price volatility. Exploring alternative cropping systems as a means for providing nitrogen as well as improving the sustainability of the vegetable system without limiting yield or quality of harvested crops is an area where rapid development of research is needed.

Perennial legume forage crops grown in crop rotations are common in non-vegetable systems where these crops are commonly grown in monoculture. There are several characteristics of perennial legumes, however, that limits their implementation into current vegetable crop systems as a cover crop.

1) Perennial legume crops are slow to establish.
2) Establishment of perennial legume crops is costly.
3) Perennial legume cover crops will compete with the vegetable crop for water and nutrients.
4) To utilize the full benefits of a perennial legume cover crop the land must remain in monoculture for an entire cropping season.
5) Certain species of perennial legume crops may serve as alternate hosts for vegetable crop pathogens.

These negative aspects can be minimized or even eliminated through proper management of the 'perennial cover crop' within the vegetable crop systems. By solving these issues the benefits of incorporating a perennial legume cover crop into a vegetable crop system may outweigh the drawbacks.

Two different trials were initiated at the Hancock Agricultural Research Station to address management questions related to the inclusion of perennial species in a vegetable system. The first examines different species of perennial cover crops that were established in the first season under snap bean and maintained through a following season of sweet corn production. The second experiment takes a representative legume (red clover) and determines the proper stage of snap bean growth to inter-seed the cover crop. The effects of commonly used pre-plant herbicides on the establishment of the legume cover crop were also evaluated. Hopefully this research will spur interest in the implementation of perennial cover crops into the existing vegetable crop rotation due to the potential reduction in nitrogen fertilizer inputs, and progression toward a more sustainable and profitable cropping system.

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I. Evaluation of perennial cover crop species in a vegetable crop rotation

Many previous studies have focused on either annual species of cover crop or perennial cover crops as a distinct monoculture within a crop rotation. Cover crop research has primarily focused on the potential benefits of various species in their uses as green manures, bio-fumigants, companion crops, soil compaction reducers, weed suppressors and as contributors to general soil quality. Albrecht, Zemenchek, and Affeldt have evaluated the use of kura clover in annual corn roations. Limited information is available on the implementation of perennial cover crops into an intensively managed vegetable rotation, let alone the use of perennial species grown simultaneously with vegetables. A study was conducted from 2005-2007 that compared several perennial cover crop species, and their persistence and influence on a two year system of snap bean followed by sweet corn. Five different perennial cover crop species and a no cover crop check were seeded at the time of snap bean planting and established as the snap beans matured. Harvest of the snap beans was conducted and the cover crops were maintained following the harvest and through the succeeding winter. The following spring, cover crops were sprayed with a 0.5 lb ae/A glyphosate to limit biomass production and lightly tilled to prepare the field for planting. Sweet corn was planted and the cover crops were allowed to persist under the developing corn. Harvest of the sweet corn was conducted and the cover crops were maintained into the following spring when they were plowed down as a green manure crop.

Results indicated that all five species of cover crop contained similar amounts of nitrogen in their plant material, while hairy vetch and red clover produced the highest amounts of total biomass in the fall of 2005 (Table 1). Hairy vetch also provided the lowest carbon:nitrogen (C:N) ratio. The C:N ratio is a critical component when considering cover crops as a green manure. A higher C:N ratio (greater than 24:1) in plant residues could delay mineralization of the nitrogen from the plant material after incorporation into the soil. High C:N ratios are typical in grasses and cereal crops and can range between 25:1 and 50:1 depending on the species and maturity of the crop. Low C:N ratios are common in legume crops, which are characteristically lush in growth and allocate much of their nitrogen into protein rich leaves and stems ranging from 10:1 to 25:1 depending on species and maturity. The nitrogen contribution by the cover crop species to the snap bean was assumed to be very minimal given the relatively short period of snap bean growth coupled with a longer establishment time for the cover crops.

A problem developed with the simultaneous development of the snap bean and the under-seeded cover crops, as witnessed in the yield numbers from 2005 and 2006 (Table 2). The rate of cover crop development exceeded that of the snap bean resulting in competition between the two crops for nutrients, water, and light. This was believed to be caused by the inability of the snap beans to create a closed canopy between the rows, coupled with the fast development of the perennial cover crop grown under ideal water and nutrient conditions. Yield losses by the snap beans, as well as contamination of cover crop residue in the harvested pods were substantial in all cases. Following the snap bean harvest the cover crops were allowed to persist without the additional irrigation or fertilization. A rye cover crop was planted into the no cover crop check treatments following the snap bean harvest to mimic current management practices. This step is critical for the production of biomass by the cover crop in preparation for winter, as well as a means to reduce inputs by eliminating any post-harvest tillage costs, or irrigation to supplement the cover crop.

Table 1. Total biomass, biomass % nitrogen and carbon nitrogen ratio for perennial cover crop species harvested in the fall of 2005 and spring of 2006 prior to sweet corn planting at Hancock, WI.

2005 Fall Biomass

Cover Crop	Biomass (Tons/A)		% N		C:N Ratio	
Hairy vetch	1.59	a	4.01	a	10.76	c
Alfalfa	0.92	c	3.67	b	11.55	b
Red Clover	1.26	b	3.68	b	11.81	ab
Sweet/Yellow Clover	0.94	c	3.63	b	11.77	ab
Alsike Clover	0.84	c	3.54	b	12.19	a

2006 Fall Biomass

Cover Crop	Biomass (Tons/A)	% N		C:N Ratio	
Hairy vetch	0.65	4.72	a	9.26	b
Alfalfa	0.27	4.13	bc	10.54	ab
Red Clover	0.55	3.95	c	11.06	a
Sweet/Yellow Clover	0.31	4.31	b	9.89	ab
Alsike Clover	0.45	4.19	bc	10.41	ab

Statistical difference in values denoted by different letters

Biomass production by the perennial cover crop was again measured the following spring, with alfalfa, sweet clover, and red clover providing the highest amounts of biomass (data not shown). The total nitrogen in the biomass and C:N ratios were similar to the previous measurements. Glyphosate was applied at 0.5 ae/A to the cover crops, followed by disking 7 to 10 d later to prepare the field for planting. Following sweet corn planting a pre-emergence application of Bicep Lite (atrazine + metolachlor) was applied. This addressed early season weed control and provided a second means of reducing cover crop growth during the early stages of sweet corn development.

Harvest data from the 2006 sweet corn indicated that perennial cover crops provided substantial amounts of nitrogen to the developing sweet corn crop (Table 2). The number of ears per acre in the unfertilized treatments did not differ from the ear numbers seen in the full rate treatments where cover crops were grown in 2006. This indicates that nitrogen was not a limiting factor to the sweet corn where cover crops were present during the period of ear initiation. In 2007, the unfertilized treatments did not yield a similar number of ears as fertilized treatments, but still produced more than the 0 N/A check with no cover crop. Yield of sweet corn in 2006 showed that in the presence of sweet clover, red clover, and alsike clover, sweet corn could yield 7-8 tons/A without the addition of nitrogen fertilizer. Alfalfa and hairy vetch were also able to yield well, with each producing over 6 tons/A. In 2007 yields in unfertilized cover crop treatments were less than those seen in the full fertilization treatment, but were still significantly superior to the unfertilized check. Yield numbers were suppressed in 2007 due to an early frost in September that cut short the anticipated growing season by nearly 10 days.

Table 2. Influence of perennial cover crop species, and nitrogen rate on ear number and yield of sweet corn at Hancock, WI.

2006 Sweet Corn

	Ears				Yield			
N Rate	0 N		150 N		0 N		150 N	
Cover Crop	(1000's / A)				(Tons / A)			
No Cover	15.2	b	27.0	a	1.82	f	8.36	ab
Hairy Vetch	26.1	ab	27.3	a	6.88	de	8.89	a
Alfalfa	27.4	a	28.5	a	6.46	e	8.09	abc
Red Clover	23.9	ab	28.1	a	7.32	bcde	8.82	ab
Sweet Clover	28.6	a	28.2	a	8.09	abc	8.58	ab
Alsike Clover	27.0	a	25.3	b	7.15	cde	7.86	b

2007 Sweet Corn

	Ears				Yield			
N Rate	0 N		150 N		0 N		150 N	
Cover Crop	(1000's / A)				(Tons / A)			
No Cover	11.0	c	24.8	a	1.12	e	5.79	ab
Hairy Vetch	15.7	b	25.8	a	1.62	de	5.26	b
Alfalfa	17.9	b	24.5	a	2.13	c	6.10	a
Red Clover	19.4	b	25.0	a	2.72	c	6.49	a
Sweet Clover	15.6	b	27.4	a	1.86	cd	6.01	a
Alsike Clover	18.2	b	23.6	a	3.00	c	5.84	ab

Statistical difference in values denoted by different letters

Further measurements taken during the course of this study are currently being analyzed, specifically how much nitrogen was available for plant uptake in the soil and how the nitrogen pool changed through the growing season.

The yield results of this study indicate that perennial legume cover crops can provide a substantial amount of the 150 lb of nitrogen currently recommended by the Univ. of Wisconsin to attain >7 tons/acre sweet corn yield. Several management issues that bear further research include: determining the proper timing and methods for establishment of perennial cover crops to limit their interference with snap bean yield and quality, establishing a herbicide program that will control weeds during the snap bean and sweet corn phases and limit destruction of the perennial cover crop, and finally the economic gains or losses by switching to this type of cropping system.

II. Establishment of a perennial cover crop (red clover) under snap bean

The previous study demonstrated that perennial legumes were a viable alternative to the current cover crop system by providing ample nitrogen credits to a second year crop of sweet corn when established under snap beans in the preceding season. A cost of this process was reduced yield and quality of the snap bean crop due to competition from the developing cover crops when planted in tandem with the snap beans. A research project was initiated in 2007 to evaluate if modifying the time of cover crop planting would limit its interference with the snap bean crop. By establishing the cover crop at a time later than snap bean planting, the competition with snap bean may be limited so yield and quality remain unaffected by the cover crop presence.

Red clover was chosen as a model legume species based on its success in the previous perennial cover crop study. This project will also compare the common pre-plant herbicide formulations used in snap bean production and determine their influence on the cover crop establishment and growth.

The study delineated five different stages of snap bean development including: at planting, unifoliate leaf stage, third trifoliate leaf stage, bud stage, and post-harvest, that would function as clover planting periods. Each clover planting date presented a new challenge for seeding due to the accessibility of tillage implements or planters. The first clover planting followed the pre-plant herbicide soil incorporation, but before the snap bean planting, and was conducted using a Brillion model seeder. The second and third plantings of clover, conducted at unifoliate and third trifoliate stages were air seeded over the top of the developing snap beans and followed with a row cultivator. The fourth clover planting was conducted at snap bean bud stage. Due to an inability to till the snap beans due to concerns of pod drop or crop damage and yield loss, the clover was air seeded over the top of the snap beans and immediately followed with an irrigation application. The final clover planting followed harvest and was again conducted with a Brillion model seeder. The three herbicide regimes were pre-plant soil incorporated and included Dual (1.0 pt/A) + Sandea (0.5 oz/A), Eptam 7E (3 lb/A) + Treflan (1 pt/A), and Eptam 7E (3 lb/A).

Snap bean yield was lowest when clover was planted at snap bean planting in 2007, but no response was evident in 2008 (Table 3). The highest snap bean yields were seen at the unifoliate and third trifoliate establishment dates for clover. Determining the influence of the herbicides on clover establishment and its subsequent limitations on snap bean yield will need to take into effect residue levels in the harvested beans, yield differences, and the impact of each herbicide on snap bean stand density. No distinct differences were observed in the sieve size grades across the clover planting dates. The Eptam + Treflan and the single Eptam treatments had the lowest percentage of beans grading out at a sieve size of 3 or less, while Dual + Sandea had the highest percentage. The mechanism for this response is not known at this time, but may be due to a slight delay in snap bean maturity.

The total aboveground biomass of clover was collected at the end of the growing season in 2007 and again prior to sweet corn planting in the spring of 2008 and is reported as dry weight in tons/acre (Table 4). The highest levels of clover biomass were accumulated in the first two clover plantings, at planting and unifoliate leaf stage, except in first clover planting under Dual+Sandea treatments which were lower due to herbicide damage on the cover crop. Clover planted at bud stage provided the least biomass, primarily due to the relatively short time span between clover planting and snap bean harvest. Clover germination was relatively poor in these treatments due to reduced seed-soil contact. This probably resulted from the lack of soil incorporation provided to the clover seeds at this planting date. Clover populations were also recorded prior to snap bean harvest and these numbers are synchronous with the biomass results (data not shown). The most interesting trend in the clover population numbers is that the breakdown of the Dual+Sandea mixture is reflected in the increased population of clover as the time from herbicide application and clover planting lengthened. Biomass was measured again the following spring, prior to planting of sweet corn. Clover planted at the bud stage of snap bean development showed significant improvement relative to other plantings. While total biomass in the spring of 2008 did not vary greatly, populations within the plantings differed with the post harvest plantings having the highest population densities (data not shown).

Table 3. Time of red clover planting based on snap bean stage of development and herbicide regime influence on snap bean sieve size and yield at Hancock, WI, 2007 and 2008.

2007 Beans

	Graded Beans Sieve Size						Yield					
Herbicide	Dual + Sandea		Eptam + Treflan		Eptam		Dual + Sandea		Eptam + Treflan		Eptam	
Planting Date	% ≤ 3						(Tons/A)					
At Planting	29.2	ab	25.9	c	27.8	bc	2.65	e	2.72	de	2.85	d
Unifoliate	27.3	bc	27.3	bc	24.2	cd	3.34	ab	3.26	b	3.29	ab
3rd Trifoliate	27.8	bc	24.8	cd	23.6	d	3.34	ab	3.31	ab	3.47	a
Bud	30.9	a	26.0	c	24.5	cd	3.18	bc	3.47	a	3.29	b
Post-Harvest	29.2	ab	24.9	cd	24.2	cd	3.05	c	3.00	cd	3.43	ab

2008 Beans

	Graded Beans Sieve Size						Yield					
Herbicide	Dual + Sandea		Eptam + Treflan		Eptam		Dual + Sandea		Eptam + Treflan		Eptam	
Planting Date	% ≤ 3						(Tons/A)					
At Planting	32.0	a	27.6	c	31.1	ab	3.71	b	4.11	ab	4.44	a
Unifoliate	30.4	ab	34.1	a	28.2	bc	4.34	a	4.10	ab	4.44	a
3rd Trifoliate	27.6	bc	30.7	ab	33.6	a	4.28	a	4.25	a	4.10	ab
Bud	31.0	ab	30.0	ab	29.8	abc	3.67	b	4.62	a	4.44	a
Post-Harvest	31.3	ab	35.5	a	26.0	c	4.26	a	3.81	b	4.28	a

Statistical difference in values denoted by different letters.

Table 4. Red clover total biomass production at end of season and prior to sweet corn planting as influenced by herbicide regime and planting date based on snap bean stage of development at Hancock, WI, 2007.

	Fall Clover Biomass						Spring Clover Biomass					
Herbicide	Dual + Sandea		Eptam + Treflan		Eptam		Dual + Sandea		Eptam + Treflan		Eptam	
Planting Date	(Tons/A)						(Tons/A)					
At planting	0.22	g	2.43	b	2.69	a	0.89	b	1.40	ab	1.69	ab
Unifoliate	1.03	c	2.71	a	2.70	a	1.27	ab	1.83	a	1.69	a
3rd Trifoliate	0.62	e	0.71	d	0.94	cd	1.52	ab	1.29	ab	1.34	ab
Bud	0.59	f	0.51	f	0.51	f	0.98	ab	1.21	ab	1.03	ab
Post-harvest	0.85	cde	0.84	cde	0.75	def	1.32	ab	1.24	ab	1.32	ab

Statistical difference in values denoted by different letters

The preliminary data in this study indicate that planting clover into snap beans at the unifoliate or third trifoliate stages of development may produce an adequate crop of clover, while limiting the effects of competition and residue contamination that reduce yield and quality in snap beans. Further measurements in this project will account for winter survivability of the clover as well as the effect of different levels of clover population on sweet corn yield.

Further research on perennial cover crops in a vegetable rotation is planned for the future. The research will focus on developing further management recommendations for the implementation of cover crops into a continuous vegetable rotation. We also hope to test and apply these strategies in current vegetable crop systems by developing on-farm research with cooperating growers.

SWEET CORN DISEASES AND SOURCES OF RESISTANCE

William F. Tracy [1/]

The most troublesome diseases of sweet corn in our region continue to be northern corn leaf blight (*Exserohilum turcicum*) and common rust (*Puccinia sorghi*). From central Illinois south, Stewart's wilt (Erwinia stewartii) can also be a problem. In certain environments and years maize dwarf mosaic and sugar cane mosaic virus can cause problems. With increased minimum tillage anthracnose (*Colletotrichum graminicola*) and Goss's wilt (*Clavibacter michiganense* subsp. *nebraskensis*) can occur. For most of these diseases, sources of resistance exist and commercial cultivars have been developed with resistance. However, we know from experience that for many of these diseases the casual organisms can rapidly evolve virulence in response genetic resistance. The UW sweet corn breeding program continues to screen exotic germplasm to look for more diverse sources of resistance and incorporate these genes into adapted material.

Sweet Corn Inbreds and Hybrids

The University of Wisconsin sweet corn breeding continues to develop and release sweet corn inbreds after they have been tested in hybrid combination. Occasionally we will also release hybrids. We concentrate on sugary enhancer (*su1 se1*) (Table 1) and supersweet (*sh2*) (Table 2). In both these endosperm types we focus on improved eating quality (flavor, tenderness, and texture). After many years of work we have developed sugary enhancer inbreds with high levels of se type quality (Table 3). Due to the difficulty in developing se quality we have paid less attention in this material to disease resistance. In the supersweet germplasm we have a had a strong effort in improving resistance to MDMV/SCMV, common rust (*Puccinia sorghi*) and northern leaf blight (*Exserohilum turcicum*).

Disease Resistance from Exotic x Temperate Sweet Corn Populations

We are making extensive use of tropical germplasm in our breeding program. Generally we work with populations that are 25-50% tropical and 50-75% high quality temperate sweet corn. The main breeding objective for these populations is disease resistance, but many seem to have unique quality factors and other traits such as cold tolerance. We are employing both recurrent selection and line development to develop useful germplasm. Inbreds 04030 - 04037 in Table 3. were derived from this program. They are all highly resistant to MDMV and SCMV and have high levels of polygenic resistance to common rust (*Puccinia sorghi*). They have excellent agronomic (stalk and root strength) and good quality. Hybrids using these inbreds have already shown commercial potential. We have much more tropical by temperate germplasm in the pipeline. In 2008 we found very high levels of resistance to northern corn leaf blight in some of the newest lines (Figure 1).

Figure 1

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Rust Resistant Inbreds

In 2008 we tested a new group of rust resistant inbreds. These inbreds are in both *sh2* and *se1* endosperm types. These inbreds are exciting because the source of resistance is a stack of three *Rp1* alleles developed by Scott Hulbert formally of Kansas State. The resistance was effective this year and some of the new inbreds had high table quality. This was particularly exciting for the sugary enhancer germplasm. Much of the commercial sugary enhancer germplasm is very susceptible to common rust. We believe this germplasm has great potential.

Population Releases

We have released the following populations

- **Mexican Dent sh2**
  - 50% temperate sweet
  - Excellent resistance to MDMV and common rust
- **Caribbean Flint sh2**
  - 50% temperate sweet
  - Selected for res. to NCLB
- **Hawaiian temperate bt1**
  - 50% temperate sweet
  - Excellent resistance to MDMV and common rust
  - Poor NCLB resistance
- **Red su1 (temperate)**
  - Excellent rust resistance

Table 1. UW-Madison 2008 advanced sugary enhancer hybrid trial.

Inbred	Tester	Flavor	Tenderness	Ear appearance	Overall	Pollen	Silk
		--------1 to 5 scale,1 worst 5 best------				Days	
05407	A	4.3	4.0	3.3	3.7	47	49
05408	A	4.3	4.0	3.7	3.7	46	48
05411	B	4.3	4.0	3.3	3.7	46	48
05416	B	4.0	3.3	3.3	3.3	46	48
04834b	C	4.0	3.7	3.3	3.3	49	51
05410	D	4.0	3.7	4.0	4.0	46	48
05412	A	4.0	3.7	3.7	3.7	46	48
04401	C	4.0	4.0	3.7	3.7	46	48
03418a	D	4.0	4.0	4.0	4.0	54	56
A	**05401**	4.0	4.0	3.7	3.7	48	50
05405	A	4.0	4.0	4.0	4.0	46	48
05405	B	4.0	4.0	3.5	3.5	46	48
05406	D	4.0	4.0	4.0	4.0	50	52
05410	B	4.0	4.0	4.0	3.7	45	47
05415	B	4.0	4.0	3.3	3.3	46	48
05421a	C	4.0	4.0	3.3	3.0	46	48
02404	E	4.0	4.3	4.0	4.0	53	55
04823	B	4.0	4.3	3.0	3.0	46	48
04834a	C	4.0	4.3	3.3	3.7	51	53
05416	D	3.7	3.7	3.3	3.3	56	58
04806	B	3.7	4.0	3.7	3.7	45	47
05405	D	3.7	4.0	3.3	3.3	50	52
05407	D	3.7	4.0	3.7	3.7	50	52
05421b	C	3.7	4.0	3.3	3.3	44	46
04819	B	3.7	4.3	4.0	3.7	50	52
05404	D	3.7	4.3	3.3	3.3	48	50
05402	D	3.3	3.0	4.3	4.0	50	52
05404	B	3.3	4.0	3.0	3.0	48	50
04802	B	3.3	4.3	4.0	3.3	46	48

Table 2. UW-Madison 2008 advanced supersweet hybrid sweet corn trial.

Inbred	Tester	Flavor	Tenderness	Ear appearance	Overall	Pollen	Silk
		--------1 to 5 scale,1 worst 5 best------				Days	
05081b	1	4.7	4.0	4.0	4.0	55	57
01001	6	4.7	4.0	3.7	3.7	50	52
05047a	1	4.3	4.0	3.7	3.7	55	57
05047b2	1	4.3	4.0	4.3	4.0	54	56
05054	1	4.3	4.0	3.7	3.7	57	59
05063	1	4.3	4.0	3.3	3.3	57	59
05066a	1	4.3	4.0	3.0	3.0	59	61
05070b	2	4.3	4.0	4.0	3.7	57	59
05075	3	4.3	4.0	4.3	4.0	54	56
03031	4	4.3	3.7	3.7	3.7	56	58
05047b1	1	4.3	3.7	4.0	3.7	55	57
05081a	3	4.3	3.7	3.7	3.7	53	55
05042	3	4.3	3.7	3.7	3.7	54	56
05081a	1	4.3	3.3	3.7	3.7	53	55
05032b	1	4.0	4.3	3.3	3.3	52	54
05069b	2	4.0	4.3	3.7	3.7	54	56
05069b	3	4.0	4.3	3.7	3.7	58	60
05070a	2	4.0	4.3	4.0	3.7	54	56
05032a1	2	4.0	4.0	4.0	4.0	53	55
05032a2	2	4.0	4.0	4.0	4.0	52	54
05032a1	1	4.0	4.0	3.7	3.7	54	56
05032a2	1	4.0	4.0	3.3	3.3	54	56
05042	3	4.0	4.0	3.3	3.3	57	59
05051	1	4.0	4.0	3.7	4.0	55	57
05054	2	4.0	4.0	4.0	4.0	54	56
05069a	2	4.0	4.0	3.3	3.3	61	63
92054	5	4.0	3.7	3.7	3.7	54	56
05016	4	4.0	3.7	3.7	3.7	54	56
05050a	2	4.0	3.7	4.3	4.0	54	56
05050b	2	4.0	3.7	3.7	4.0	54	56
05051	3	4.0	3.7	3.7	4.0	57	59
05081b	3	4.0	3.3	3.7	3.7	54	56

Table 3. University of Wisconsin advanced sweet corn inbred performance.

Inbred	Endosperm	Pollen	Silk	Height	% rust	MDMV/SCMV	
02404	sugary enhancer	*	*	*	*		
04401	sugary enhancer	63	65	105	50		Good to excellent sugary enhancer quality
04802	sugary enhancer	64	66	105	50		Good to excellent sugary enhancer quality
04806	sugary enhancer	64	66	110	20		Good to excellent sugary enhancer quality
04819	sugary enhancer	66	68	95	50		Good to excellent sugary enhancer quality
04834a	sugary enhancer	*	*	*	*		Good to excellent sugary enhancer quality
04834b	sugary enhancer	*	*	*	*		Good to excellent sugary enhancer quality
05401	sugary enhancer	61	63	90	50		Good to excellent sugary enhancer quality
05405	sugary enhancer	NA	NA	NA	NA		Good to excellent sugary enhancer quality
05406	sugary enhancer	59	61	85	60		Good to excellent sugary enhancer quality
05407	sugary enhancer	61	63	85	100		Good to excellent sugary enhancer quality
05408	sugary enhancer	63	65	80	80		Good to excellent sugary enhancer quality
05410	sugary enhancer	60	62	125	80		Good to excellent sugary enhancer quality
05411	sugary enhancer	64	66	130	90		Good to excellent sugary enhancer quality
05412	sugary enhancer	61	63	125	100		Good to excellent sugary enhancer quality
05415	sugary enhancer	62	64	125	90		Good to excellent sugary enhancer quality
05416	sugary enhancer	64	66	110	40		Good to excellent sugary enhancer quality
03418a	sugary enhancer	66	68	95	20		Good to excellent sugary enhancer quality
9261	supersweet	63	65	105	60		Early excellent germination fair quality
98032	HQ supersweet	69	71	145	30		nice ears and kernel color very high quality poor germination
01001	supersweet	68	70	165	30		Large ear high row count good flavor fair tenderness
03031	supersweet	62	64	100	20		Mediium size ear high row count good flavor fair tenderness
05051	supersweet	71	73	105	40		newer inbreds still being characterized
05054	supersweet	68	70	95	50		newer inbreds still being characterized
05075	supersweet	73	75	135	40		newer inbreds still being characterized
05032a2	supersweet	69	71	100	1		newer inbreds still being characterized
05032b	supersweet	71	73	110	1		newer inbreds still being characterized
05047a	supersweet	70	72	120	90		newer inbreds still being characterized

Inbred	Endosperm	Pollen	Silk	Height	% rust	MDMV/SCMV	
05047b2	supersweet	68	70	115	80		newer inbreds still being characterized
05050a	supersweet	70	72	120	30		newer inbreds still being characterized
05050b	supersweet	72	74	105	20		newer inbreds still being characterized
05066a	supersweet	70	72	105	30		newer inbreds still being characterized
05069b	supersweet	67	69	125	30		newer inbreds still being characterized
05070a	supersweet	73	75	145	30		newer inbreds still being characterized
05070b	supersweet	66	68	130	40		newer inbreds still being characterized
05081a	supersweet	72	74	130	20		newer inbreds still being characterized
05081b	supersweet	72	74	115	20		newer inbreds still being characterized
04030V	supersweet	74	76	110	1	**resistant**	
04031V	supersweet	73	75	130	1	**resistant**	
04032V	supersweet	72	74	125	20	**resistant**	
04033V	supersweet	72	74	120	20	**resistant**	
04034V	supersweet	73	75	115	20	**resistant**	
04035V	supersweet	73	75	140	20	**resistant**	
04036VW	supersweet	72	74	100	20	**resistant**	good table quality
04036VY	supersweet	72	74	100	20	**resistant**	good table quality
04037VW	supersweet	73	75	105	20	**resistant**	good table quality
04037VY	supersweet	73	75	105	20	**resistant**	good table quality
92047	supersweet	*	*	*	*	**resistant**	Late processor type, high yield potential fair quality
92054	supersweet	*	*	*	*		good flavor and texture

* Not in 2008 inbred trial

VINE CROP PEST MANAGEMENT: NEW TOOLS AND TECHNIQUES

Russell L. Groves[1], A.J. Bussan[2], Amy Charkowski[3], Tim Rehbein[4], and Bill Halfman[5]

Abstract: Wisconsin has a history in the production of fresh market and processing fruits and vegetables including cucurbit crops such as melons, cucumber, squash, and pumpkins. While acreages and crops have changed over the years, growers have adapted and remained leaders in several crops. Additionally, small-acreage fresh market production, particularly organic, continues to expand in Wisconsin. The demographics of these growers are also in transition in the state. Increasingly, a growing proportion of Amish growers are resettling in Wisconsin from Eastern states. These growers are contributing to an expanding fresh market produce industry through establishment of regional produce markets, multi-farm cooperatives and produce auctions. The geographic and social isolation of Amish communities creates a unique extension challenge in providing integrated pest management training for key pests. A key limiting factor for all cucurbit farmers includes cucumber beetles (e.g., cucumber beetles, *Acalymma vittatum*) and subsequent transmission of the bacterial wilt pathogen, *Erwinia tracheiphila*. This project focuses on the development of enhanced IPM practices for cucurbit production employing a combination of novel cultural and pest management practices. A special focus has been to emphasize practices that limit impacts on domestic and native pollinators. To date, we have documented significant reductions in both populations of cucumber beetles and the bacterial pathogen they transmit in susceptible vine crops using these tactics. Specifically, mean incidence of bacterial wilt was 2-3 X less prevalent among grower cooperators who implemented a combination of IPM-based practices when compared to both commercial and organic farm operators. The seasonal abundance and species composition of insect pollinators did vary among farms locations with *Apis* and *Bombus* spp occurring most frequently. We have demonstrated the ability to significantly reduce the reliance on broad spectrum insecticides by incorporating IPB-based, cultural practices that prevent damaging beetle feeding.

Introduction

Wisconsin Agricultural Statistics report vegetable production on over 112,000 acres in Wisconsin with a total of 2,850 reported processed and fresh market growers. Fresh market vegetables are grown and packaged for direct market sales (road-side stands & farmers markets), produce auctions throughout the state, and for large emerging produce cooperatives emphasizing locally sourced, value-added products (Organic Valley, LaFarge, WI). While acreages and crops continue to evolve in response to market demands and production limitations, growers have adapted and remained leaders in several crops. Although no "official" statistics are collected on fresh market production, the WI Fresh Market grower association estimates nearly 1,500 small-acreage producers rowing over 50 crop cultivars in the state. Recent increases in locally grown

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food has fostered the growth of local produce auctions, expansion of farmers' markets, and roadside stands in many locations in western Wisconsin. This has provided Amish and some small acreage, non-Amish farmers in the area an opportunity to diversify their farms and enhance farm income by adding vegetable enterprises. Several farms use a significant portion of their land for raising fresh market vegetables. This has presented two primary challenges; first, they have limited experience in growing vegetables commercially, creating the need for training on cultural for raising fresh market vegetables. This has presented two primary challenges; first, they have limited experience in growing vegetables commercially, creating the need for training on cultural and pest management practices on a variety of vegetable crops. Secondly, they need to make sure they have enough quality production from their field crops to meet the needs of rapidly emerging markets driven by the regional food sourcing initiatives. These farmers have been seeking information to help with these two concerns from several sources including Agribusinesses, Wisconsin Cooperative Extension, and other producers.

Among the range of production issues faced by this clientele group, cucumber beetles and the bacterial pathogen *Erwinia tracheiphila*, continue to rank high among limiting factors annually recurring in many areas. The overwintering adult insect causes feeding damage on young, emerging plants as well as blossoms and fruit. In addition to direct damage on plants, cucumber beetles are vectors of the bacterial wilt pathogen. The transmission of bacterial wilt disease is even more serious than direct damage because the disease will kill the plant. Because grower access to IPM strategies for management of this insidious pest complex has been limited, insecticides have been commonly used in conventional cucurbit production for control of cucumber beetles especially in melons and summer squash. Very often, the insecticide options used have been inappropriate formulations applied at inappropriate times leading to direct impacts on native and domestic pollinators and ultimately poor fruit set. IPM practices crucial for successfully improving our management of these beetles and the bacterial wilt pathogen they transmit are the focus of this project.

Research Objectives

To develop a comprehensive set of IPM-based tools to manage the cucumber beetle – bacterial wilt pathosystem and document reductions in total pesticide use and avoidance of risk associated with adoption of IPM.

Results and Discussion

Site Selection(s): A total of 5 experimental farms were identified on which the proposed research was conducted in 2008. Field locations 1-3 were located approximately 8.8 km southwest of Cashton, WI in both Monroe and Vernon Counties. Field Site 1 is operated by Mr. Joseph Kauffman and located at S805 Irish Ridge Road, Cashton, WI. The principal agricultural outputs of the operation include manufactured wood products, greenhouse bedding plants, and field grown fruiting vegetables and cucurbit vine crops occupying approximately 8.5 acres. Both greenhouse and field grown vegetable produce are sold locally at the Cashton, WI produce auction. Field Site 2 is operated by Mr. Christ Hershberger, S2185 County Highway D, Westby, WI. Here again, agricultural outputs of the farm operation include cucurbit vine crops, fruiting vegetables, and greenhouse bedding plants and hanging baskets produced on approximately 4.5 acres and also retail sold at the Cashton WI produce auction. Field Site 3 is operated by Mr. James Yoder, S3718 County Highway D, Westby, WI and is operated as a certified organic produce operation occupying approximately 12.5 acres. Similar to the other local farm operations, the range of vegetable offerings are similar in kind but sold as wholesale raw product to Organic Valley's, Organic Produce Pool, LaFarge, WI. Experimental Site 4 is operated by Mr.

Jerry Schneider and Ms. Lisa Riniker, 1103 Habhegger Avenue, Sparta, WI and consisted of 12 acres of retail pumpkin. Finally, Field Site 5 is operated by Mr. Brian Nelson, S1028 90 Meter Drive, Westby, WI and consisted of approximately 12 acres of cucurbit vine crops as well as a minor component of fruiting vegetables.

Briefly, Field Sites 1, 2, and 4 were included as conventional grower locations which adopted the comprehensive program of IPM-based tactics to limit insect and disease pressure, which included reduced-risk insecticides. Experimental Site 3 was included as the ‘organically-managed, comparatively standard location which included all non-chemical approaches to management of the insect pathosystem. Field Site 5 was managed by the grower/operator consistent with their past management practices. This site served as the conventional standard location as many broad spectrum insecticides were used for insect and disease control with very little adoption of IPM-based practices.

Product outcomes of the first season of research included the integration of comprehensive, biologically-based integrated pest management strategies into cucurbit production systems for direct market growers supplying regional produce auctions, and organic producers. Specifically, project participants were asked to incorporate and adopt the following sequence of culturally-based, pest management practices to reduce their reliance on what has become widespread use of both carbaryl and synthetic pyrethroids for control of cucumber beetles. First year project implementation objectives included, but were not limited to;

A.) Approximately 1,500 linear feet of the cucurbit crop was covered with floating row cover. Covered rows were sub-divided into 500 ft sections and placed in 3 separate locations over the melon, pumpkin, or squash crop at each site. Row covers were erected June 2 2008 and maintained over the crop until first flower. Generally, row covers were removed 2 July 2008 to allow for pollination services to ensue on uncovered treatments.

B.) The remainder of the cucurbit crop (1.5 to 6.0 acres/experimental site) was treated with a drench treatment of AdmirePro 2SC at Sites 1 and 2 with an in-furrow treatment of Platinum at Site 4. Treatments at Sites 1 and 2 were applied as a transplant drench at a rate of 1.4 fl oz / 1,000 plants and the in-furrow treatment at Site 4 was applied at a rate of 11.0 fl oz / acre. Product was donated by both Bayer CropSciences and Syngenta Crop Protection.

C.) A single, 300 ft row of Blue Hubbard squash was transplanted as a trap crop along one edge of each field. Trap crops were placed to intercept overwintering cucumber beetles emerging from wooded edges as they colonize the main crop. For all 4 participants with a trap crop (excluding Field Site 5), a total of approximately 1,200 plants were transplanted. Trap crop transplants were initially treated with AdmirePro immediately prior to transplant as previously described. At each site, trap crops were transplanted as a single row spaced 48” within rows over yellow plastic at the same time as the main crop.

D.) Yellow sticky panel traps were placed in 1) unmanaged areas outside the production field, 2) Hubbard squash trap crops, 3) in the main crop (AdmirePro and Platinum treated), and 4) in the covered rows (following row cover removal). A total of 4 traps were placed in each area and insect counts collected and replaced weekly. Very few differences in weekly beetle counts were obtained among the different regions within a locations suggesting that overwintering, colonizing beetles immigrated into experimental sites equally in all directions. The magnitude of colonizing populations did appear to differ among locations with the greatest populations collected at experimental Site 3, the organically-managed site (Fig. 2).

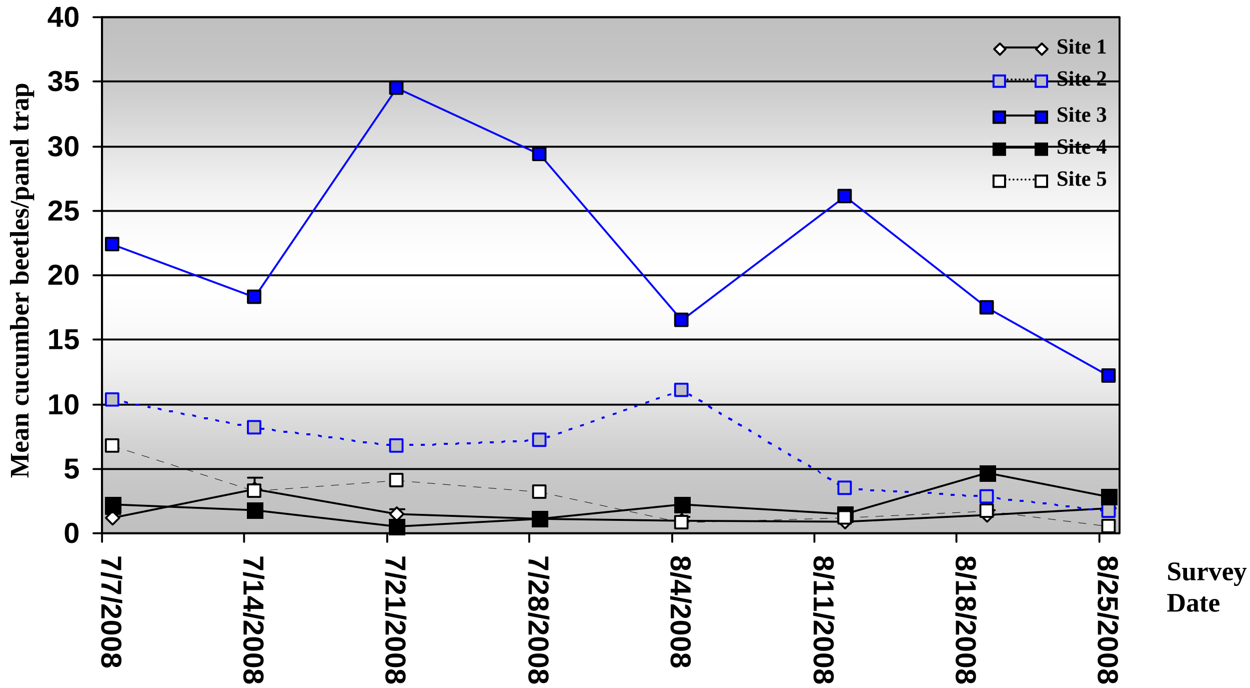

Figure 2. Seasonal capture of striped cucumber beetles among experimental field sites, southwestern Wisconsin, 2008.

E.) Following plot establishment, the total number of adult cucumber beetles were counted on five consecutive plants randomly selected from the 4 field sections described previously (e.g. unmanaged areas, trap crops, main crop, covered rows). Counts were made bi-monthly through the growing season (June – Sept). Beetle counts did vary among the different crop sections at each experimental site with the largest number often encountered on the Blue Hubbard trap crops (Table 1).

F.) Following row cover removal and during regularly scheduled beetle surveys, we continued to survey adult cucumber beetles in anticipation of the possibility of implementing foliar sprays of reduced-risk insecticides as needed / warranted based upon established thresholds for different cucurbit crops. No foliar applications of kaolin clay (Surround) were warranted on any of the infested crops that were under the row cover experiments. Foliar applications on the main crop were also not necessary throughout the remainder of the experimental interval.

G.) Beginning in early July, bacterial wilt surveys were performed monthly over a sub-selected portion of the cucurbit acreage in both insecticide-treated and row-covered areas of the experimental sections. Tissue from symptomatic plants was collected and returned to the laboratory in Madison, WI for confirmation and whole plants were counted, rouged, and composted immediately after a confirmation of symptoms. Similar to beetle counts, the mean incidence of bacterial wilt in affected vine crops varied significantly between the management units on each farm site (Table 2).

H.) A sub-sample of adult cucumber beetles (N=25 / farm / sample date) counted from the main crop have been collected in 95% EtOH and held in the laboratory for later PCR analysis of infectivity. Infectivity assessments will be performed on beetles collected in June, August, and October and these assays will be conducted this Fall, 2008 to determine at which points during the year the risk of potential infection may be greatest relative to the susceptibility of the crop / cultivars.

I.) Non-managed, weedy border areas surrounding the plot area have been maintained as weed free areas as much as possible through the second half of the growing season. This was accomplished by two mowings / cuttings of grassy vegetation in mid-August and again in mid-September.

J.) During bi-monthly field visits, a 10 minute interval of time during the early morning was spent monitoring / recording pollinator services in the main crop and the portion of the crop under row cover. Specifically, the frequency and duration of visits to flowers by domestic honeybees (*Apis mellifera*), wild bumblebees (*Bombus* spp.), and other wild pollinators such as the squash bee (*Peponapis pruinosa*) will be evaluated through visual counts.

Taken together, the proposed management program continues to enhance the close cooperation that has developed between direct market produce growers, wholesale produce buyers, county agricultural extension agents, and extension specialists at the University of Wisconsin. The collaboration team is very much on course towards the development of sustainable, culturally-based, pest management recommendations to limit the damage caused by cucumber beetles and bacterial wilt with an emphasis on reduced pesticide inputs targeted as high risk by FQPA. Field scale trials in the coming year will again be focused on confirming the effectiveness of different strategies within local production systems and verify the suitability of these multiple tactics for direct market producers.

Table 1. Mean number of adult cucumber beetles in each of the 3 management sections (main crop, row cover, trap crop) on each experimental field site in southwestern Wisconsin, 2008.

Field Site	Management Section	Sample Dates Recorded[1] 7 July	14 July	21 July	28 July	4 Aug	12 Aug	19 Aug	25 Aug
Site 1	Main crop	0.1 ± 0.1 b	0.3 ± 0.1 b	0.5 ± 0.2 b	2.8 ± 0.5 b	0.9 ± 0.2 b	1.1 ± 0.2 a	0.7 ± 0.2 a	0.7 ± 0.2 a
	Row cover	0.0 b	0.0 b	0.5 ± 0.2 b	1.9 ± 0.4 b	0.8 ± 0.1 b	0.5 ± 0.5 ab	0.7 ± 0.2 a	0.7 ± 0.3 a
	Trap Crop	1.6 ± 0.4 a	2.2 ± 0.3 a	2.2 ± 0.4 a	11.8 ± 1.5 a	5.8 ± 0.7 a	0.0 a	1.0 ± 0.3 a	1.7 ± 0.9 a
Site 2	Main crop	1.3 ± 0.3 b	6.3 ± 1.9 a	8.6 ± 1.0 a	8.4 ± 1.0	1.7 ± 0.4 b	1.8 ± 0.4 a	0.9 ± 0.2	6.2 ± 1.8 a
	Row cover	1.3 ± 0.4 b	6.0 ± 1.0 a	3.3 ± 0.6 b	2.0 ± 0.4	0.7 ± 0.2 b	2.7 ± 0.3 a	0.9 ± 0.3	0.9 ± 0.4 b
	Trap Crop	2.7 ± 0.5 a	4.7 ± 1.1 a	6.7 ± 1.4 a	3.7 ± 0.7	2.8 ± 0.3 a	3.3 ± 0.7 a	0.0	0.0 b
Site 3	Main crop	0.0 a	0.1 ± 0.1 a	0.0 b	0.1 ± 0.1	0.0 a	0.1 ± 0.1 a	0.0	0.1 ± 0.1 a
	Row cover	0.0 a	0.2 ± 0.1 a	0.1 ± 0.1 b	0.0	0.0 a	0.1 ± 0.1 a	0.1 ± 0.1	0.0 a
	Trap Crop	0.6 ± 0.3 a	0.2 ± 0.1 a	1.3 ± 0.3 a	0.0	0.1 ± 0.1 a	0.1 ± 0.1 a	0.3 ± 0.1	0.2 ± 0.1 a
Site 4	Main crop	4.7 ± 1.2 b	8.4 ± 2.1 a	4.0 ± 0.6 a	3.4 ± 0.7	5.1 ± 0.6 a	3.6 ± 0.4 a	4.4 ± 0.5	2.7 ± 0.5 a
	Row cover	7.5 ± 1.5 a	8.0 ± 1.8 a	5.7 ± 0.8 a	3.9 ± 0.6	4.9 ± 0.6 a	3.4 ± 0.5 a	3.6 ± 0.8	2.5 ± 0.9 a
	Trap Crop	2.4 ± 0.7 c	6.6 ± 1.4 a	1.8 ± 0.5 b	1.5 ± 0.5	7.2 ± 1.3 a	4.9 ± 0.9 a	5.1 ± 1.4	0.0 b
Site 5	Main crop	2.9 ± 1.1	4.7 ± 1.2	7.9 ± 2.1	4.9 ± 1.3	4.9 ± 1.3	5.9 ± 1.4	3.8 ± 0.9	6.7 ± 1.7
	Row cover	--	--	--	--	--	--	--	--
	Trap Crop	--	--	--	--	--	--	--	--
(*P*<0.0001) LSD (P=0.05)	-	(0.0085) 0.3	(<0.0001) 0.8	(<0.0001) 1.3	(<0.0001) 1.6	(0.0377) 1.3	(0.0009) 0.4	(<0.0001) 1.0	(<0.0001) 1.2

[1] Means within a column, by location, followed by the same letter are not significantly different (*P*>0.05; Fisher's Protected LSD; n = 4).

Table 2. Mean incidence of bacterial wilt, *Erwinia tracheiphila*, in each of the 3 management sections (main crop, row cover, trap crop) on each experimental field site in southwestern Wisconsin, 2008.

Field	Management	Sample Dates Recorded[1]							
Site	**Section**	**7 July**	**14 July**	**21 July**	**28 July**	**4 Aug**	**12 Aug**	**19 Aug**	**25 Aug**
Site 1	Main crop	0.0	0.0	0.1 ± 0.1 a	0.4 ± 0.2	0.1 ± 0.1	0.1 ± 0.1 a	0.0 a	0.0 a
	Row cover	0.0	0.0	0.1 ± 0.1 a	0.1 ± 0.1	0.0	0.0 a	0.0 a	0.0 a
Site 2	Main crop	0.1 ± 0.1	0.1 ± 0.1	0.5 ± 0.2 a	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1 a	0.0 a	0.1 ± 0.1 a
	Row cover	0.0	0.1 ± 0.1	0.2 ± 0.1 b	0.2 ± 0.1	0.1 ± 0.1	0.0 b	0.0 a	0.0 a
Site 3	Main crop	0.0	0.0	0.0 a	0.0 a	0.0	0.0 a	0.0 a	0.0 a
	Row cover	0.0	0.0	0.0 a	0.0 a	0.0	0.0 a	0.0 a	0.0 a
Site 4	Main crop	0.2 ± 0.1	0.4 ± 0.2	0.4 ± 0.2 a	0.3 ± 0.1	0.2 ± 0.1	0.5 ± 0.2 a	0.7 ± 0.3 a	0.5 ± 0.2 a
	Row cover	0.0	0.4 ± 0.2	0.2 ± 0.1 a	0.2 ± 0.1	0.1 ± 0.1	0.2 ± 0.1 b	0.1 ± 0.1 b	0.1 ± 0.1 b
Site 5	Main crop	0.0	0.2 ± 0.1	0.9 ± 0.3	0.6 ± 0.2	0.3 ± 0.1	0.2 ± 0.1	0.8 ± 0.2	0.7 ± 0.4
	Row cover	--	--	--	--	--	--	--	--
(*P*<0.0001) LSD (P=0.05)	-	(0.3381) 0.1	(0.0903) 0.1	(0.0494) 0.1	(0.1177) 0.2	(0.2316) 0.1	(0.0348) 0.1	(<0.0001) 0.2	(<0.0001) 0.1

1 Means within a column, by location, followed by the same letter are not significantly different (*P*>0.05; Fisher's Protected LSD; n = 4).

VEGETABLE CROP HERBICIDES: REGISTRATION AND RESEARCH UPDATE

Daniel J. Heider and Jed B. Colquhoun[1]

Research was conducted in the 2008 growing season to evaluate potential herbicides in several vegetable crops. The intent of this paper is to provide an update on these research projects and new labels available for the 2009 growing season. As always, check and read the label prior to any herbicide use.

Asparagus. It is unusual for a minor acreage crop such as asparagus to receive three new herbicide registrations in a single year, two of which have resulted in use labels. Callisto (mesotrione) has recently been labeled for use on asparagus as either a spring or post-harvest application. 3.0 – 7.7 fl oz/A may be applied prior to spear emergence or post-harvest (after final harvest), or both. If applying a split application it is important to remember that a maximum of 7.7 fl oz/A may be applied in a single year. If applying post-harvest the label specifies to minimize contact with the emerged spears/ferns to improve soil and emerged weed coverage. Be sure to follow the label for surfactant requirements to improve the activity on emerged weeds. Chateau has also been labeled for use on established asparagus with a restriction of no more than 6 oz/A per single application and no more than 6 oz/A per season. Chateau must be applied to dormant asparagus no sooner than 14 days before spear emergence or some scoring will result.

Snap bean. Over 30 current and potential herbicide programs were evaluated in snap bean in Arlington, Wisconsin. In particular, Reflex (fomesafen) was evaluated alone and in combination with current herbicides in anticipation of the recent snap bean label. Weed control was excellent where Reflex was applied, and snap bean yield was comparable to the hand-weeded check. Reflex may be applied preemergence or pre-plant surface applied; however, rate is dependent upon your location. Reflex herbicide is prohibited from use in some areas of Wisconsin so be sure to consult a label to determine if it can be used in your area.

Table beets. Research continued to identify potential herbicides that would expand the weed control spectrum in table beets. Nortron (ethofumesate) was labeled for the 2008 growing season. After planting and prior to weed emergence, apply Nortron at 60 fl oz/A. Nortron may also be applied postemergence at rates of 5.25 fl oz/A for beets with two to four leaves and at rates of 10.5 fl oz/A for beets with six to eight leaves. Seasonal use maximum for Nortron is 96 fl oz/A. Also labeled for the 2009 growing season is Alphanex (desmedipham) for postemergence control of early germinating broadleaf weeds. Apply Alphanex after beets have reached the two leaf stage. Do not add wetting agents or other spray adjuvants when applying Alphanex.

Transplanted cabbage. Goal (oxyfluorfen) has been labeled on transplanted cole crops for many years. In 2009, GoalTender is also labeled. Although both Goal and GoalTender must be applied prior to transplanting, GoalTender is a water based formulation, which may be safer to the crop if the herbicide is mechanically moved from the soil to transplant leaves. GoalTender is a 4 lb ai/gallon formulation so rates are generally about ½ of the equivalent Goal rates. Research continued in 2008 to evaluate the prospective PPO-inhibitor mode of action herbicide Chateau (flumioxazin; not currently labeled) in transplanted cabbage. Chateau provides residual control or suppression of several broadleaf and grass weed species that are problematic in cabbage production. Chateau was evaluated at three experimental use rates (1, 2, and 4 oz product/A) and

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at two application timings (immediately post-transplant and 8 days post-transplant). Some injury was observed from Chateau applications in 2008, but can generally be attributed to the excessive rainfall after application. Soils remained completely saturated for several days from a rain event that occurred shortly after transplanting. Common lambsquarters, redroot pigweed, velvetleaf, and yellow foxtail control was excellent where Chateau was applied. Season-long weed control did not result from any herbicide treatments due to the excessive rainfall.

Onions. Similar to cole crops, GoalTender (oxyfluorfen) has also been labeled for early postemergence application in seeded onions. The intent again is for the water based formulation to have enhanced crop safety over the solvent formulation of Goal 2XL. Buctril (bromoxynil) has added a preemergence label for use on muck soils only. Buctril is to be applied at least 3 to 4 days prior to onion emergence and rainfall or irrigation shortly before emergence may cause some injury.

Carrots. Studies were conducted to evaluate several unregistered or recently labeled herbicides in an effort to expand the number of options available to carrot growers. Prowl H_2O (pendimethalin) was recently labeled for preemergence use on carrots. In 2 years of field research, Prowl H_2O resulted in greater than 80% suppression of the parasitic weed dodder in the central sands. Additionally, Dual Magnum (available only through an indemnified 24c Special Local Needs label) was evaluated preemergence followed by Lorox (linuron) postemergence. In 2008, no injury was observed where either Prowl H_2O or Dual Magnum were applied preemergence and followed by Lorox postemergence.

PROPOSED NATIONAL SUSTAINABILITY STANDARDS: IMPLICATIONS FOR THE AGRICHEMICAL AND FERTILIZER INDUSTRIES

Jed Colquhoun [1]

From environmentally-concerned groups to buyers, retailers and consumers, "sustainability" is certainly the current buzzword in many industries, including agriculture. Several retailers and agricultural industries are independently developing sustainability standards, indices, and certification programs for their businesses and others throughout the supply chain. Additionally, national sustainability standards, which would ultimately encompass all agricultural crops, have been proposed or are in development by multiple groups. Given the rapid pace of developments and fluidity of the situation with these sustainability standards, the intention of this abstract is to "set the table" for discussion. Updated details will be provided during the presentation.

While the concept of sustainable agriculture has been a point of discussion for several years, the desire to use it as a marketing tool or to add value to products in the marketplace is a relatively recent development. Individual retailers and suppliers, such as Wal-Mart, are developing sustainability scorecards and standards. As a result, growers may be required to fill out several surveys to sell to multiple buyers, in addition to current requirements for good agricultural practice (GAP) surveys.

In response, multiple entities are developing national standards that would be applicable to agriculture in general and could be used to certify agricultural production with a single survey, thus reducing the duplicative efforts required to satisfy multiple buyers. Two proposed national standards in particular have floated to the top: one in development by Scientific Certification Systems, and one in development by the Keystone Center.

Scientific Certification Systems developed the "Draft American National Standard for Trial Use for Sustainable Agriculture." This standard was proposed to the American National Standards Institute (ANSI) in 2007, an organization that develops and implements voluntary standards for a variety of industries. The Leonardo Academy, a Madison-based organization accredited by ANSI, will lead the standard development process. After an initial meeting of the Standards Committee in September 2008, the initial draft standard will be re-tooled. Those critical of the initial draft standard have cited two primary issues: 1) the standard set organic production as the highest level of sustainability, and may in fact be duplicative of current organic standards in many areas; and, 2) the initial standard prohibited the use of genetically modified crops. The groups involved in this standard development are in the process of developing a new draft standard.

The Keystone Center Field to Market group consists of entities with varying interests, including several food and fiber national commodity groups, environmental organizations, end-users and retailers, and academia. The goal of this group is not to develop a certification system, but to develop a grower tool that can be used to gauge production and sustainability metrics relative to neighbors, regional and national producers of a given crop. The proposed tool would allow growers to identify potential areas of improvement as well as to follow sustainability trends through time in terms of production efficiency per unit of production area. The Keystone Center participants are currently investigating methodology and feasibility of quantifying sustainability parameters, such as water quality and energy use, at the grower level.

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PHOSPHORUS AND POTASSIUM PLACEMENT METHODS FOR CORN AND SOYBEAN: AN IOWA PERSPECTIVE

Antonio P. Mallarino [1/]

Introduction

Increasing fertilizer prices and awareness of potential impacts of excessive or badly applied nutrients on water quality has renewed interest in fertilizer management strategies that reduce nutrient inputs or improve efficacy. Fertilizer recommendations for phosphorus (P) and potassium (K) in Iowa and most states of the Corn Belt are based on soil testing and maintenance of desirable soil-test values by applying amounts removed with crop harvest. The typical Iowa farmer applies before planting corn the P and K fertilizer needed for corn-soybean rotations. A few farmers, mainly in the northern regions of the state and those using no-till management, also apply starter fertilizer for corn. Iowa research during the 1960s and 1970s showed that application of P and K fertilizer at rates of 20 lb P_2O_5 or K_2O/acre or higher rates applied with planter attachment besides and below the seeds (commonly referred to as the 2x2 method) seldom was more efficient than similar amounts applied broadcast and seldom increased yield significantly in high-testing soils. Corn response to N-P-K starter was more likely for very early planting dates with wet and cold soil and/or high residue cover. Reports of corn responses to starter have been more frequent in northern regions of the Corn Belt, such as in Minnesota and Wisconsin.

New developments since the early 1990s have determined a need for further research on P and K fertilizer methods, however. Adoption of chisel-plow, no-till, and strip-till management has increased steadily in Iowa and the Corn Belt (little or no moldboard plowing is used anymore). With no-till or chisel-plow tillage, crop residues and broadcast fertilizers are not incorporated or are partially incorporated into the most shallow soil layers. These practices result in significant residue, P, and K accumulation at or near the soil surface and also in both cooler and wetter soils in early spring. These conditions may reduce early crop growth and nutrient uptake by crops, although residue cover improves water availability and root efficiency in shallow soil layers during summer. At the same time there has been a steady increase in the width of planters that has discouraged use of 2x2 fertilizer attachments. Few Iowa farmers have fertilizer attachments and a few apply in-furrow liquid starter.

Therefore, several Iowa long-term research projects began studying broadcast, 2x2 band, and deep-band placement methods for granulated P and K fertilizers for corn and soybean and also liquid P-K starter for corn using 2x2 or in-furrow application methods. This article briefly summarizes the most relevant results of these projects. Readers must understand that results and recommendations for prevailing soil and climate conditions in Iowa should not be directly extrapolated to other regions.

Placement Methods for Primary Phosphorus and Potassium Fertilization

Ten long-term Iowa studies have assessed P and K placement methods for the corn-soybean rotation under chisel-plow/disk or no-till management since 1994. Until 2001, treatments included several rates of granulated fertilizers broadcast (in the fall), deep banded (in the fall), and banded with the planter (2x2 method). The broadcast and 2x2 methods continue being evaluated today. More than 30 additional short-term trials were established on farmers' fields managed with no-tillage to further evaluate the broadcast and deep-band methods. Fields tested from very low to very high in P and K according to Iowa interpretations, soil pH varied from acid to calcareous (up to pH 8.2), and the

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texture of the surface soil layer ranged from loam to clay-loam and silty-clay-loam. The deep bands were applied at a 5-7 inch depth and at a spacing that coincided with the corn row spacing (usually 30 inches), and planter-applied bands were placed 2 inches beside and below the seeds. At most sites the coulter-knife used to place the deep bands also tilled the soil along a narrow swath.

The results of these studies were consistent with studies conducted decades ago in Iowa concerning little and inconsistent crop response to P placement methods for any tillage system or region. Results also showed no differences among K placement methods for crops managed with chisel-plow/disk tillage. Such a lack of response to P banding was observed even with significant soil-test P stratification. However, the results for no-till crops indicated that deep-band K application often was more efficient than either broadcast or planter-band methods. Additional yield increases due to deep placed K were larger and more consistent for corn than for soybean. Data in Fig. 1 summarize results for long-term experiments at five Iowa State University research farms that compared the three placement methods for the two nutrients. The advantage for deep-band K was even higher in fields managed with permanent large ridges (not shown) than for no-till. The figure shows averages for rates of 28 and 56 lb P_2O_5/acre or 35 and 70 lb K_2O/acre because results were similar for the two rates. It is important to note that banding of P or K did not reduce the amount of fertilizer needed to achieve a certain level of yield.

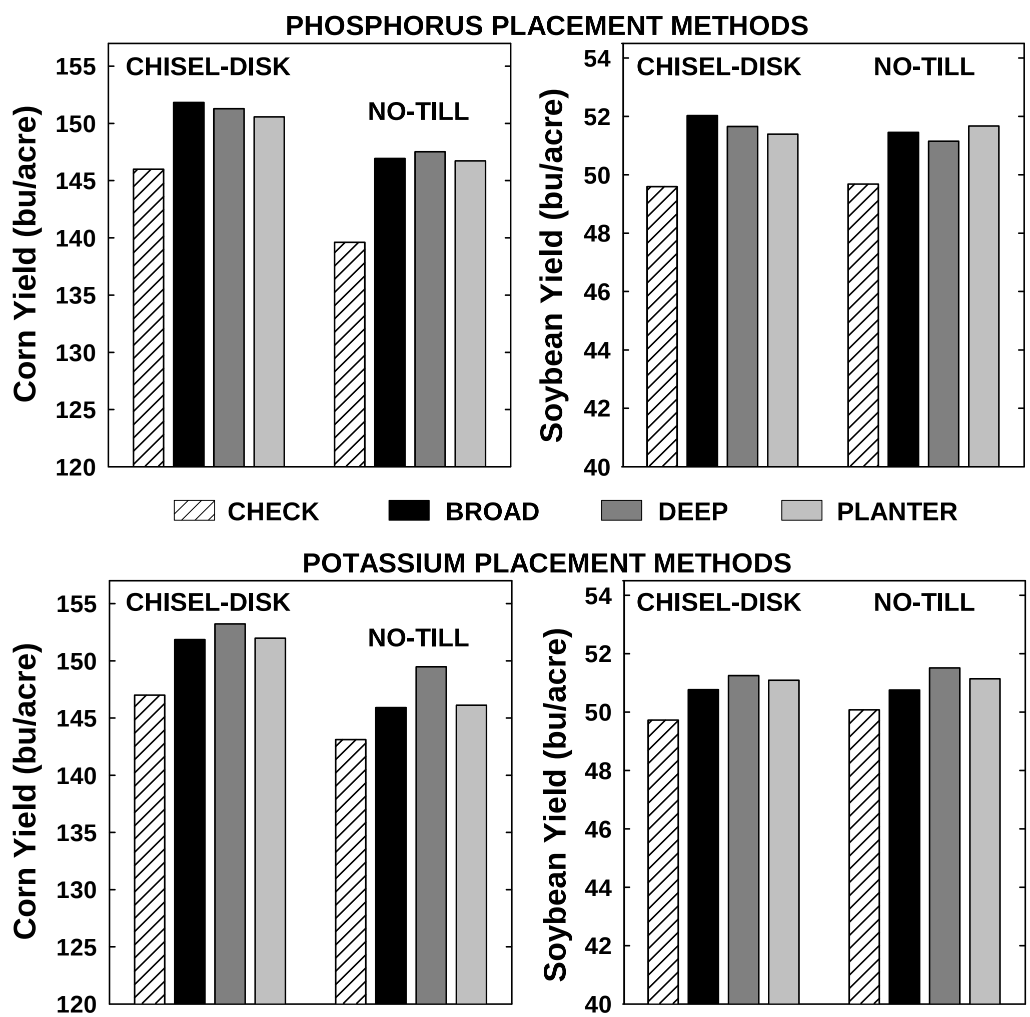

Fig. 1. Average corn and soybean yield response to P and K fertilizer placement methods across five Iowa long-term field trials and rates of 28 to 56 lb P_2O_5/acre and 35 to 70 lb K_2O/acre.

Results of evaluations of plant early growth and nutrient uptake showed very contrasting results, however. Data summarized in Fig. 2 show that banded P greatly increased early plant growth more than broadcast P, but this was not observed for K fertilizer.

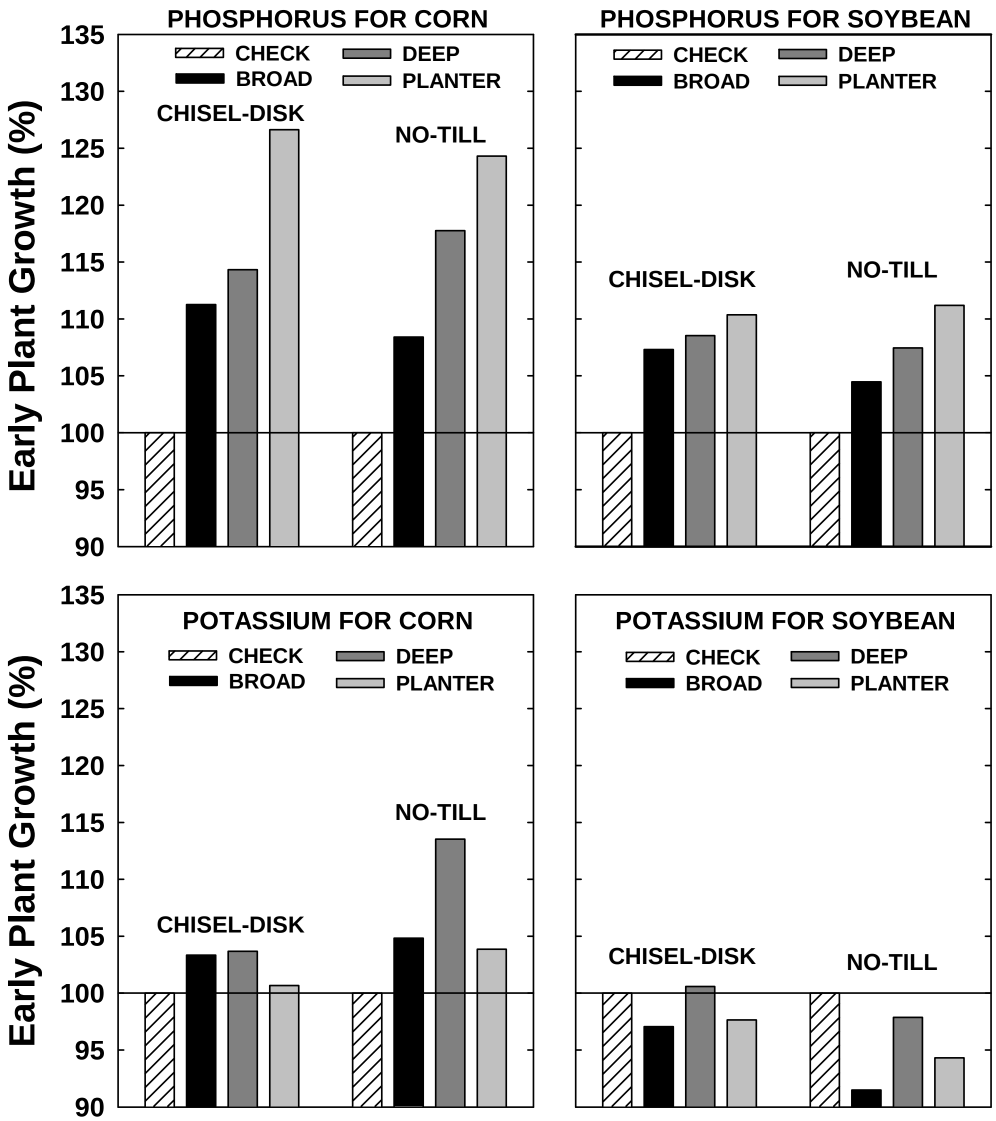

Fig. 2. Average corn and soybean early plant growth response to P and K fertilizer placement methods across five Iowa long-term field trials and rates of 28 to 56 lb P_2O_5/acre and 35 to 70 lb K_2O/acre.

Based on these results, current Iowa fertilizer recommendations do not include guidelines for P fertilizer placement methods, except for suggesting starter fertilizer under specific conditions, but recommend deep-band K for no-till and ridge-till systems. This research evaluated application rates of 28 lb P_2O_5/acre or 35 lb K_2O/acre and higher rates. Therefore, results do not exclude the possibility of placement methods differences for P or even larger for K when lower fertilizer rates are applied to soils testing very low in P or K, where the planter-band placement method may be more effective. However, in practice few farmers would broadcast very low P and K fertilizer rates. Because the average magnitude of the yield increase for deep-band K in no-till fields was variable and it does not determine a significantly lower application rate than with the broadcast method, deep K banding often may not offset increased application costs. Large variation in the no-till corn response to deep-band K was more related to deficient soil moisture in late spring and early summer than to soil-test K stratification. Therefore, conditions for large yield responses that offset costs are difficult to predict.

Liquid Starter Fertilization for Corn

Application of commercial liquid N, N-P, or N-P-K starter was tested at more than 50 trials conducted in Iowa producers' fields. All fields were managed with corn-soybean rotations and with no-till, ridge-till, or chisel-plow/disk tillage. The research was developed with different objectives using two different sets of field trials. In one set of trials, the objective was to assess corn response to P and K starter with and without the broadcast P-K rates recommended to supply the need of 2-year corn-soybean rotations applied once before corn (which ranged from 100 to 160 lb P_2O_5/acre and 100 to 180 K_2O/acre). A maintenance rate based on crop removal was also applied to high-testing soils, although this is not recommended in Iowa. In this set of trials, N fertilizer was applied across all treatments by injecting 120 to 160 lb N/acre before planting corn plus 50 to 60 lb N/acre broadcast immediately after planting. The liquid starter was applied to the seed furrow or with 2x2 planter attachments, but the two methods of application were not compared. The starter products used varied across fields and included 3-18-18 (low salt), 6-18-6, 7-21-7, or 9-18-9, and applied rates of 5 to 25 lb P_2O_5 and K_2O/acre.

This set of trials resulted in very significant outcomes. One result was that P-K starter fertilization in low-testing soils resulted in large corn yield increases but the higher broadcast rates recommended for these soils increased yield further. Other important yield results were that P-K starter never increased corn yield further when it was applied after applying the recommended broadcast P-K rates for 2-year corn-soybean rotations, and that in soils testing optimum or higher in P or K the responses were similar for starter fertilizer and the much higher broadcast rates designed to maintain soil-test values over time. Furthermore, results showed that similarly to findings with granulated fertilizers, starter P increased early corn growth in fields testing very low to very high and that this effect was greater with no-till management.

Data in Fig. 3 summarize corn early growth and grain yield responses for starter P-K, broadcast P-K, and both starter and broadcast fertilization according to the initial soil-test P level of 31 field trials that used approximately similar methods. As expected, the yield response decreased as the soil-test P level increased. Results also show that broadcast fertilizer increased grain yield more than the starter in low-testing soils, the starter in addition to broadcast fertilizer did not increase yield further, and the response to both sources was approximately similar in soils testing more than about 20 ppm Bray-1 P. The data must be interpreted with care because P and K were applied together and soil-test K varied mostly from low to very high across most soil-test P ranges, although it was also high or very high when soil-test P was high. Analysis of the data for each site (not shown) indicated little or no response to starter or broadcast fertilization when both soil P and K were high. In contrast to results for grain yield, starter P-K fertilizer almost always increased early corn growth more than the broadcast fertilizer and often increased early growth after having applied broadcast fertilizer, even in high-testing soils. Results of plant analyses (not shown) suggested that this plant growth response usually was due to starter P and sometimes due to starter N. The plant analyses suggested that in some fields the high N fertilizer rate applied uniformly across all treatment did not completely eliminate a starter N effect in some fields.

The observed similar responses to starter or broadcast P-K in soils testing medium or high should not be confused with a placement method difference. Iowa research has shown that the probability of a crop yield response is about 25% in soils testing 16 to 20 ppm P (Bray-1 method) or 130 to 170 ppm K (ammonium acetate method) to a 6-inch soil depth. Fertilization based on P and K removed with harvest is recommended for these soil-test ranges with the objective of catching any possible crop response and to maintain soil-test values over time for long-term profitability and reduced risk of yield loss. Therefore, lower fertilizer rates, even as low as starter rates, could result in maximum yield of a first crop. However, such small fertilizer rates will not maintain soil-test values over time and higher rates may have to be applied for future crops. No fertilizer is recommended for soils testing higher in P and K, except for conditions of limited soil drainage, early planting dates with cold and wet soil, or very high residue cover.

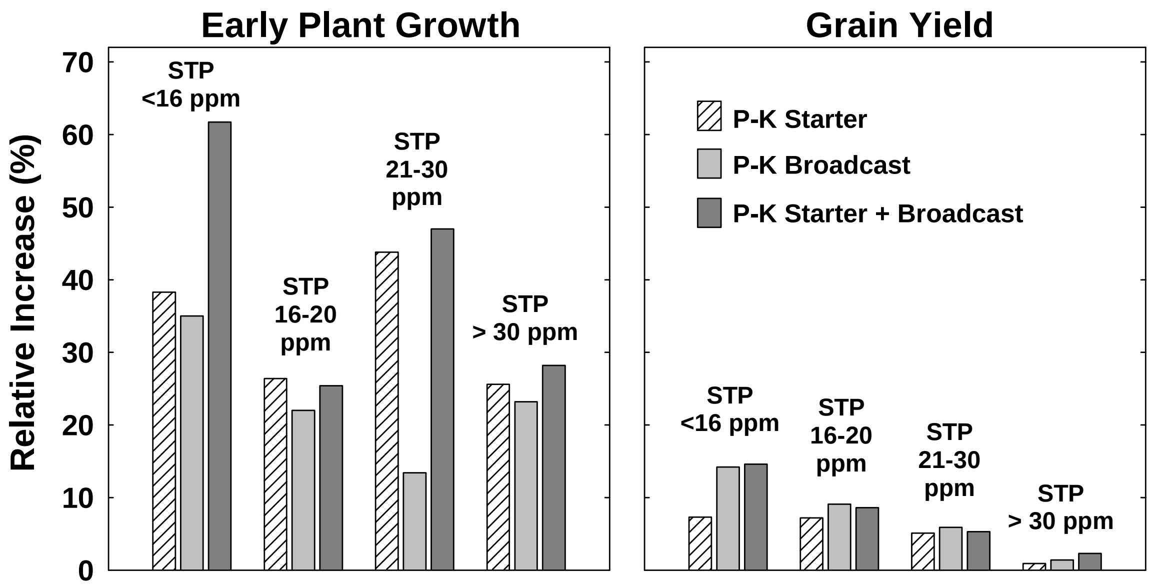

Fig. 3. Average corn early growth and yield responses to starter P and K fertilizer (5 to 25 lbP_2O_5 and K_2O/acre) and broadcast fertilizer (100 to 160 lb P_2O_5/acre and 100 to 180 K_2O/acre) across 31 Iowa trials in fields managed with no-till or chisel-plow/disk tillage.

Research involving a second set of eight replicated strip trials trials focused on determining if the occasional corn response to starter observed in Iowa high-testing soils managed with no-tillage is due to N, P, or P-K in the starter. Four replicated treatments in this set of trials were a check; commercial liquid starter N-P or N-P-K to supply 5-10, 15-25, and 0-7 lb N, P_2O_5, and K_2O, respectively (depending on the product and field); the commercial starter rate plus 28% or 32% urea-ammonium nitrate solution (UAN) to a total of 23 to 30 lb N/acre; and starter N (UAN) to supply 23 to 30 lb N/acre. All fertilizers were applied beside and below the seeds with 2x2 planter attachments. No broadcast P or K was applied because the fields tested high to very high in P and K. However, UAN or anhydrous ammonia N fertilizer was injected across the entire experimental areas at rates ranging from 110 to 160 lb N/acre in spring before planting corn in one field and sidedressed at the V4 to V6 corn growth stage in the other fields.

Figure 4 summarizes the results of these trials for both corn grain yield and early plant growth. In these eight high-testing fields, the response to starter was always due to starter N. The average grain yield increase across all fields was about 5 bu/acre, although increases at each field ranged from 0 to 9 bu/acre. There was no response to starter N (or to any starter treatment) in the field where the uniform primary N fertilization was applied in spring before planting corn. Therefore, the results from this set of trials confirmed indications from results of the other trials in that that starter N usually explains the corn yield response to starter in Iowa high-testing soils managed with no-tillage, at least when the primary N fertilization is done after planting corn.

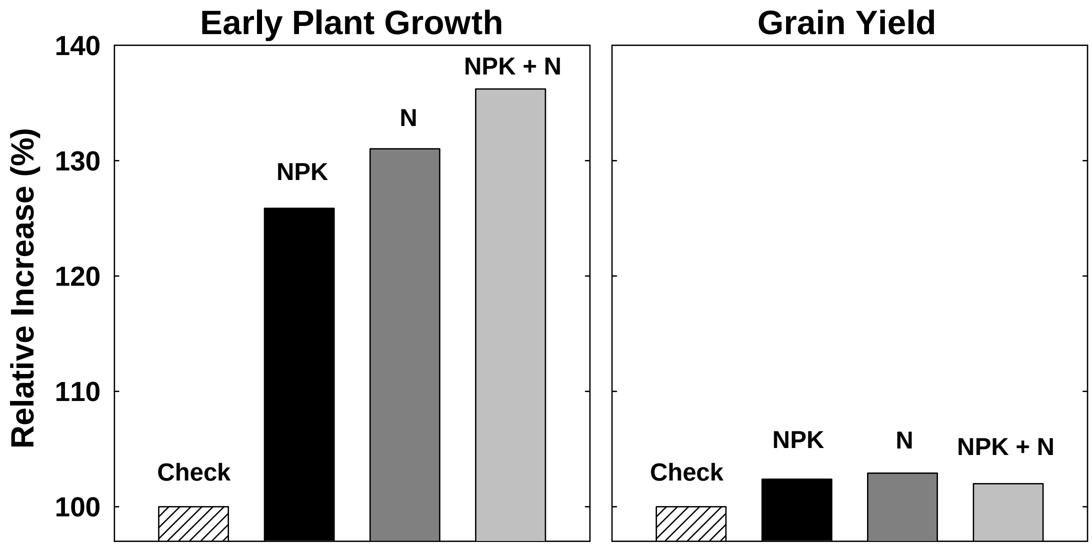

Fig. 4. Average corn early growth and yield responses to liquid starter N-P or N-P-K (5-10, 15-25, and 0-7 lb N, P_2O_5, and K_2O/acre), starter mixed with UAN (to supply a total of 23 to 30 lb N/acre), and starter N (UAN to supply 23 to 30 lb N/acre) across eight trials in Iowa high-testing fields managed with no-tillage.

Summary and Conclusions

Theoretical considerations and results of research in other regions suggest that banding the primary P and K fertilization needs of crops may be better than broadcast fertilization in some soils. Also, other considerations suggest that starter fertilization of corn can effectively supplement the primary broadcast fertilization program with certain soil and climate conditions. The Iowa experience provided useful results for Iowa crop producers, and combined with local research also may be useful for regions of neighboring states with similar soils, climate, and crop production systems.

A humid climate and medium-textured soils with properties that result in good water holding capacity and root growth determine little or no advantage of band P placement for corn and soybean in Iowa. Although shallow or deep banding of P almost always increases early crop growth, especially with no-till management, it seldom results in higher grain yield than with broadcast fertilization and does not reduce the amount of P needed for maximum yield. Research did indicate, however, that deep placement of K fertilizer often, but not always, is better than broadcast fertilization with no-till and ridge-till management. The benefit of deep K banding is poorly related to soil-test K stratification and is better related to below-normal late-spring or early summer rainfall. The research also showed that in soils having near optimum P and K levels starter fertilization and larger broadcast rates designed to maintain soil-test values over time often result in a similar yield response. This result confirms a known fact, which is that P and K rates smaller than rates designed to maintain soil-test P and K values often maximize the yield of one crop and in the short term are more profitable. The results indicated that occasional responses to starter fertilizer in Iowa high-testing no-till soils usually are explained by starter N mainly when the primary N fertilization is applied in the fall or sidedressed after planting corn, and seldom to starter P as many believe. Research results do not support using starter or broadcast fertilization across all conditions in high-testing soils. The research did indicate, however, that small starter fertilizer rates provide an economical and environmentally sound way of applying additional N, P, and K cast when producers are concerned about reduced early corn growth and yield in high-testing soils.

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ECONOMIC ANALYSIS OF ALTERNATIVE TILLAGE YIELDS: A MONTE CARLO ANALYSIS OF ARLINGTON FIELD TRIALS

Tom Cox, Jim Leverich, and Richard Wolkowski[1]

Introduction

Recent increases crop acres managed by individual producers, rising fuel and equipment costs, the desire to plant crops in a timely manner, and catastrophic erosion events have renewed interest in conservation tillage systems. Historically, no-till management has been a challenge for corn production in Wisconsin because residue has slowed the warming of the soil in the spring. Residue can also physically impair planting by plugging within the planting unit and "hair-pinning" in the seed slot. Therefore most no-till corn planters have been modified to include some type of in-row residue management attachment, either as finger coulters or disks that are designed to move some residue from the row, without substantial contact with the soil. Many producers are now considering more aggressive attachments or separate tillage operations that not only address residue concerns, but till the soil to some degree with the goal of capturing the production advantages of full-width tillage, while offering the soil conservation benefits of no-till. This practice has come to be known as strip-tillage.

1997-2007 field trials from the Arlington Research Station comparing yield differences under a traditional conservation tillage (fall chisel (CH), strip till (ST) and no-till (NT)) for 3 cropping systems (continuous corn (CC), corn following soybeans (SBC), and soybeans following corn (CSB)) are summarized by Wolkowski, et al[2]. Wolkowski et al. discuss the environmental, management, yield and economic dimensions of these alternative tillage field trial results. The current manuscript focuses more narrowly on the economic analysis of these results using Monte Carlo simulation techniques to better measure the impacts of relative yield variability across the 12 years of these alternative tillage field trails.

Clearly, some years are better/worse for these tillages and/or rotations than others, a crucial dimension of the yield/production risk essential to the economic evaluation of alternative farming systems. Wolkowski et al. evaluated the cost or production (COP) of the alternative tillages on a per acre and per bushel basis, using average yields across the 12 years of trials. Generally, less tillage incurs lower costs/acre due to lower labor, machinery, and fuel expenses using the same or fewer trips across the fields with equipment requiring less horsepower. However, these lower costs/acre can be offset by lower yields/acre due to reduced tillage systems as found in the Arlington field trials (see Table 1). Comparison of COP/bu corrects for the trade-off in lower COP/acre versus lower yields/acre. If cost reductions are sufficient to offset lower yields, then potential economic gains (lower COP/bu) due to reduced tillage systems will further complement their environmental benefits (reduced soil and nutrient loss; improved soil quality, structure and tilth, organic matter, carbon sequestration, etc).

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[2] Wolkowski, Richard, Tom Cox, and Jim Leverich. "Using Strip-tillage as an Option for Row Crop Production in Wisconsin". ***New Horizons in Soil Science***, (2)2008, November, 9 pages.

Relative Yield Variability

Table 1 provides an annual yield summary of these Arlington tillage trials for each cropping system. The "% of CH (Relative Yield)" data highlight the annual variability in both ST and NT yields relative to CH (the BASE tillage for comparison purposes). Since these are location specific (Arlington) field trials, annual tillage yields across the three crop rotations essentially hold annual weather related variability relatively constant across the tillage/cropping systems at the annual level (i.e., they experience the same weather annually). Annual relative yield variability measures the yield difference in ST and NT compared to CH (the BASE tillage system) holding weather (and, field trial management) constant across these tillage and cropping systems. Values greater (less) than 100% indicate those years when the alternative tillage yields were higher (lower) than CH.

On average over 1997-2007, ST and NT yields were 96% and 91% of CH, respectively for the CC rotation. Similarly, ST and NT yields were 99% and 95% of CH, respectively for the SBC rotation (99% and 95% for the CSB rotation). Hence, as discussed in Wolkowski et al, the reduced tillage systems, on average over the 1997-2007 Arlington field trials, produced less yield than CH. These reduced yield impacts were strongest for CC (where ST had higher yields than CH in only 2 of 10 years (1998, 2005) as did NT (2 years: 1998, 1999)). The reduced tillage systems were more yield competitive under both SBC (ST had higher yields than CH in 5 of 10 years; NT in 3 years) and CSB (ST out yielded CH in 4 of 9 years; NT in 3 of 9).

TABLE 1. Dick Wolkowski's 1997-2007 Arlington Tillage/Rotation/Fertility Study: Plot Summary.

CC	1997	1998	1999	2001	2002	2003	2004	2005	2006	2007	AVG
CH	190	160	147	189	181	161	187	182	211	212	182.0
ST	178	160	135	182	175	157	178	187	188	204	174.4
NT	176	164	147	151	174	149	159	176	166	205	166.7
% of CH (Relative Yield)											
ST	93.7%	100.0%	91.8%	96.3%	96.7%	97.5%	95.2%	102.7%	89.1%	96.2%	95.7%
NT	92.6%	102.5%	100.0%	79.9%	96.1%	92.5%	85.0%	96.7%	78.7%	96.7%	90.9%
SBC	1997	1998	1999	2001	2002	2003	2004	2005	2006	2007	AVG
CH	172	181	172	192	209	186	206	187	205	231	194.1
ST	181	175	174	204	206	184	194	191	205	228	194.2
NT	180	160	158	194	199	181	180	189	193	220	185.4
% of CH (Relative Yield)											
ST	105.2%	96.7%	101.2%	106.3%	98.6%	98.9%	94.2%	102.1%	100.0%	98.7%	99.4%
NT	104.7%	88.4%	91.9%	101.0%	95.2%	97.3%	87.4%	101.1%	94.1%	95.2%	94.7%
CSB	1997	1998	1999	2002	2001	2003	2004	2006	2005	2007	AVG
CH	--	46	51	51	56	32	57	57	57	61	52.0
ST	--	49	49	51	59	31	53	55	55	63	51.7
NT	--	44	47	49	53	32	52	54	57	62	50.0
% of CH (Relative Yield)											
ST	--	106.5%	96.1%	100.0%	105.4%	96.9%	93.0%	96.5%	96.5%	103.3%	98.9%
NT	--	95.7%	92.2%	96.1%	94.6%	100.0%	91.2%	94.7%	100.0%	101.6%	95.1%

1997 - 2007 (Yield not collected in 2000 because of combine malfunction)
Split-split plot, four replications
Main plot = rotation: Continuous corn (CC), corn/soybean (CSB), soybean/corn (SBC).
Subplot = tillage: Fall chisel/spring field cultivator, fall strip-tillage (aggressive residue mgr. 97-99; mole-knife type unit 01-08, no-till (w/o residue managers)
Sub-subplot = fertility: Nothing, fall broadcast or spring row starter 18+46+60 (treatment started in 2001)
Yields are bu/a @ 15.5 % and 13.0 % moisture for corn and soybean, respectively.

Table 2 provides additional summary statistics highlighting the year to year relative yield variability across the tillage and cropping systems. While on average ST (NT) yields are 96% (91%) of CH in the CC field trials, NT yields show more than twice the variability (standard deviation (STD) = 8.7, coefficient of variation (CV) = 9.5%) of relative to ST yields (STD = 3.8%, CV = 4%). While observed maximum (MAX) relative yields are quite similar for ST and NT (~103%), NT shows sharply lower minimum (MIN) relative yields (~79%) than ST (89%). The associated range of relative yields (Range = Max – Min) are 13.6% (ST) and 23.8% (NT). Lastly, note that the yield correlations indicate that ST yields are much more strongly correlated with CH (0.93) than are NT yields (0.60), while ST and NT yields correlate 0.72. These summary statistics indicate that NT yields demonstrate higher relative yield variability (hence, relative production risk[3]) compared to ST over the 1997-2007 Arlington CC field trials.

TABLE 2. 1997-2007 Arlington Tillage Field Trials Summary Statistics.											
									Correlations		
AVG	Std Dev	Coeff Var	Min	Max	Range	Lower 99%	Upper 99%	CC	CH	ST	NT
182.0	21.2	11.6%	147	212	65	118.5	245.5	CH	1.000	0.931	0.601
174.4	19.3	11.1%	135	204	69	116.4	232.4	ST	0.931	1.000	0.715
166.7	17.3	10.4%	147	205	58	114.7	218.7	NT	0.601	0.715	1.000
% of CH (Relative Yield)											
95.7%	3.8%	4.0%	89.1%	102.7%	13.6%	84.3%	107.0%				
90.9%	8.7%	9.5%	78.7%	102.5%	23.8%	64.9%	117.0%				
									Correlations		
AVG	Std Dev	Coeff Var	Min	Max	Range	Lower 99%	Upper 99%	SBC	CH	ST	NT
194.1	18.6	9.6%	172	231	59	138.3	249.9	CH	1.000	0.886	0.776
194.2	16.9	8.7%	174	228	54	143.6	244.8	ST	0.886	1.000	0.952
185.4	18.3	9.8%	158	220	62	130.6	240.2	NT	0.776	0.952	1.000
% of CH (Relative Yield)											
99.4%	4.3%	4.3%	91.9%	106.3%	14.4%	86.5%	112.3%				
94.7%	6.1%	6.4%	85.6%	104.7%	19.0%	76.5%	113.0%				
									Correlations		
AVG	Std Dev	Coeff Var	Min	Max	Range	Lower 99%	Upper 99%	CSB	CH	ST	NT
52.0	8.7	16.8%	32	61	29	25.8	78.2	CH	1.000	0.957	0.940
51.7	9.0	17.4%	31	63	32	24.7	78.7	ST	0.957	1.000	0.947
50.0	8.6	17.2%	32	62	30	24.2	75.8	NT	0.940	0.947	1.000
% of CH (Relative Yield)											
98.9%	4.7%	4.7%	93.0%	106.5%	13.5%	84.9%	112.9%				
95.1%	5.0%	5.2%	84.7%	101.6%	16.9%	80.1%	110.0%				

Similar, but generally smaller, impacts are found in the SBC and CSB rotations. In contrast to the CC results (NT more than twice ST), SBC relative yield variability in NT versus ST is roughly 50% higher (STD: 6.1% versus 4.3%; CV: 6.4% versus 4.3%). SBC correlations of ST and CH yields fall compared to CC (0.89 versus 0.93) while NT and CH yield correlations improve (0.78 versus 0.60). ST and NT yield correlations for SBC improve slightly over the CC results (0.78 versus 0.72). CSB results show the least relative yield variability across tillages: NT is roughly 10% higher than ST (STD: 5.0% versus 4.7%; CV: 5.2% versus 4.7%). SBC correlations of ST and CH yields increase compared to CC (0.96 versus 0.93) and SBC (0.89) while NT and CH yield correlations improve (0.94 versus 0.60 (CH) and 0.78(SBC)).

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[3] Note that there are multiple sources of variability that influence the economic and environmental efficiency of cropping systems: those related to production (weather, soils/slopes, timing of operations) and those related to markets (input and output prices). Management is the crucial farmer controlled dimension of this inherent cropping systems variability. Here we focus on yield variability due to tillage and cropping system under field trial conditions (holding management and annual weather impacts constant), under fixed (2007 WI custom hire) COP, and ignore output price variability.

Across the 3 cropping systems in these field trials, ST showed less relative yield variability compared to CH than NT. These impacts were most pronounced in the CC rotation (~ NT twice as much relative yield variability as ST), and less so under SBC (50% more) and CSB (10% more). Similarly, ST and NT correlations increase under CSB (0.95) compared to CC (0.72) and are roughly equal under SBC (0.95).

Cost of Production @ 1997-2007 Average Yields

In addition to yield and environmental performance differences across tillage systems, economic costs of production (COPs) must be considered. Reduced tillage systems commonly generate fewer trips across the fields using the same or less horsepower to accomplish more tasks (e.g., tillage and fertilization in one pass). Hence, reduced tillage systems should lower costs of production as well as increase environmental performance (via decreased soil and nutrient losses, improved organic matter and water holding capacity, etc). Measuring these potential reduced costs on a $/bushel (versus $/acre) basis provides an adjustment for the possibility of lower yields under the reduced tillage.

Appendix Tables 1 and 2 provide corn and soybean COP/acre estimates using 2007 WI custom hire rates for the alternative tillage systems in these field trials: CH: fall chisel/spring cultivator, assumed as the BASE or reference tillage; ST: fall strip-tillage; NT: no-till without residue managers). Two N fertilizer options were also evaluated: applied with an applicator or applied with the planter. While the assumed custom hire rates are likely higher than those faced by individual farmers owning older machinery and/or who do not fully account for labor and capital costs, custom hire rates do provide a consistent, market-based estimate of the full economic costs of the alternative tillage systems. These full economic costs include competitive labor rates as well as the depreciation, repairs and the opportunity costs of machinery that are often not included in "back of the envelope" cost calculations. Therefore, these estimates provide somewhat conservative, "upper bounds" to the actual cost of production faced by farmers.

Table 3 indicates that under the 2007 COP/acre assumptions, reduced tillage systems were less costly compared to CH across all cropping systems, with NT generating more cost savings than ST, as expected. For the CC portion of these field trial 1997-2007 average yields, ST and NT respectively averaged 7.6 and 15.3 bushels/acre less than CH (182 bu/acre). However, the estimated cost/acre are also lower than CH for both reduced tillage system: ST, -$23.20/acre to -$11.20/acre; NT -$25.90/acre. Comparison of these tillage systems on a per bushel basis adjusts for the yield as well as cost differences. For continuous corn, this comparison is not favorable to the reduced tillage systems as their reduced costs/bushel are overshadowed by the associated reduced yields. Hence, only ST with applicator (versus planter) N has marginally lower cost/bu compared to CH.

The situation changes in the SBC and CSB rotations. In contrast to the CC results, the first-year corn following soybean (SBC) under ST yields are virtually identical to CH (+0.1 bu/acre) while yield under NT is reduced -8.7 bu/acre compared to CH. Given that COP are identical to the CC results above (i.e., planting corn under the alternative tillage systems), these more competitive yield differences generate more competitive cost/bu returns to reduced tillage. Under ST costs/bu range from -$0.06 to -$0.12/bu lower than CH while NT ranges -$0.02 to -$0.03/bu, depending on the N delivery system. This suggests than both cost savings and improved environmental performance are possible with these reduced tillage SBC systems compared to CH, with ST providing stronger economic gains compared to NT.

Table 3: Comparison of 1997-2007 Average Yields and 2007 Costs of Production by Crop and Tillage System: Arlington Field Trials					
Crop/ System	Average	2007 COP/acre		COP/bushel	
CC	YIELD	N w/ App	N w/ Planter	N w/ App	N w/ Planter
CH	182.0	$463.85	$492.35	$2.55	$2.71
ST	174.4	$440.65	$481.15	$2.53	$2.76
NT	166.7	$437.95	$466.45	$2.63	$2.80
Change from Chisel Plow Average 1997-2008					
ST	-7.6	-$23.20	-$11.20	-$0.02	$0.05
NT	-15.3	-$25.90	-$25.90	$0.08	$0.09
Probabilty < Chisel Plow Average 1997-2008					
ST	66.7%	--	--	54.7%	42.6%
NT	97.0%	--	--	22.7%	21.9%
SBC	YIELD	N w/ App	N w/ Planter	N w/ App	N w/ Planter
CH	194.1	$463.85	$492.35	$2.39	$2.54
ST	194.2	$440.65	$481.15	$2.27	$2.48
NT	185.4	$437.95	$466.45	$2.36	$2.52
Change from Chisel Plow Average 1997-2008					
ST	0.1	-$23.20	-$11.20	-$0.12	-$0.06
NT	-8.7	-$25.90	-$25.90	-$0.03	-$0.02
Probabilty < Chisel Plow Average 1997-2008					
ST	49.6%	--	--	87.6%	69.6%
NT	76.3%	--	--	56.8%	56.1%
CSB	YIELD	N w/ App	N w/ Planter	N w/ App	N w/ Planter
CH	52.0	$333.30	--	$6.41	--
ST	51.7	$322.10	--	$6.23	--
NT	50.0	$307.40	--	$6.15	--
Change from Chisel Plow Average 1997-2008					
ST	-0.3	-$11.20	--	-$0.18	--
NT	-2.0	-$25.90	--	-$0.26	--
Probabilty < Chisel Plow Average 1997-2008					
ST	55.3%	--	--	71.3%	--
NT	75.4%	--	--	76.4%	--
CC = continuous corn; SBC = corn following soybeans; CSB = soybeans following corn. The year 2000 is not included due to a combine malfunction.					
CH: Fall chisel/spring field cultivator. ST: fall strip-tillage: aggressive residue mgr. 97-99; mole-knife type unit 01-08. NT: no-till (w/o residue managers).					

The situation changes in the SBC and CSB rotations. In contrast to the CC results, the first-year corn following soybean (SBC) under ST yields are virtually identical to CH (+0.1 bu/acre) while yield under NT is reduced -8.7 bu/acre compared to CH. Given that COP are identical to the CC results above (i.e., planting corn under the alternative tillage systems), these more competitive yield differences generate more competitive cost/bu returns to reduced tillage. Under ST costs/bu range from -$0.06 to -$0.12/bu lower than CH while NT ranges -$0.02 to -$0.03/bu, depending on the N delivery system. This suggests than both cost savings and improved environmental performance are possible with these reduced tillage SBC systems compared to CH, with ST providing stronger economic gains compared to NT.

The soybean (CSB) results are similar to the corn (SBC) results, except that reduced tillage yield differences compared to CH narrow further: ST, -0.3 bu/acre and NT, -2.0 bu/acre. In addition, the estimated COP for NT is almost 2.5 times less than ST, generating substantive COP reductions compared to CH: ST, -$11.20/acre and NT, -$25.90/acre. On a per bushel basis, these yield and COP differences translate to -$0.18/bu (ST) and -$0.26/bu (NT) cost savings over CH.

Economic analysis of this field trial suggests that, on average, the economic benefits (defined as reduced COP/bu) to reduced tillage are likely to be stronger under SBC and CSB rotations than CC. For SBC and CSB rotations, reduced (1997-2007) average trial yields compared to CH under the alternative reduced tillage systems evaluated, are likely to be offset by the reduced costs associated with reduced tillage systems. This suggests that both increase economic ($/bu) as well as environmental performance are likely to be attainable under these rotations with reduced tillage systems.

Annual Cost of Production Comparison

Following up on the discussion of Tables 1 and 2, economic analysis at average relative yields (Table 3) can be deepened by evaluating the variability of annual COP/bu (Table 4, annual results; Table 5, summary statistics) across tillage and cropping systems. This comparison provides additional insight into the expected variability of relative yields and COP/bu under the alternative tillage and cropping systems, an important aspect of their production uncertainty

TABLE 4. 1997-2007 Arlington Tillage Field Trials: Annual COP/bu Comparison (N w/ APP).

CC	1997	1998	1999	2001	2002	2003	2004	2005	2006	2007	AVG
CH	$2.44	$2.90	$3.16	$2.45	$2.56	$2.88	$2.48	$2.55	$2.20	$2.19	$2.58
ST	$2.48	$2.75	$3.26	$2.42	$2.52	$2.81	$2.48	$2.36	$2.34	$2.16	$2.56
NT	$2.49	$2.67	$2.98	$2.90	$2.52	$2.94	$2.75	$2.49	$2.64	$2.14	$2.65
						% of CH (Relative COP/bu)					
ST	101.4%	95.0%	103.4%	98.7%	98.3%	97.4%	99.8%	92.5%	106.6%	98.7%	98.6%
NT	101.9%	92.1%	94.4%	118.2%	98.2%	102.0%	111.0%	97.6%	120.0%	97.6%	101.2%
SBC	**1997**	**1998**	**1999**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**AVG**
CH	$2.70	$2.56	$2.70	$2.42	$2.22	$2.49	$2.25	$2.48	$2.26	$2.01	$2.41
ST	$2.43	$2.52	$2.53	$2.16	$2.14	$2.39	$2.27	$2.31	$2.15	$1.93	$2.28
NT	$2.43	$2.74	$2.77	$2.26	$2.20	$2.42	$2.43	$2.32	$2.27	$1.99	$2.38
						% of CH (Relative COP/bu)					
ST	90.3%	98.3%	93.9%	89.4%	96.4%	96.0%	100.9%	93.0%	95.0%	96.2%	94.7%
NT	90.2%	106.8%	102.8%	93.4%	99.2%	97.0%	108.1%	93.4%	100.3%	99.1%	97.8%
CSB	**1997**	**1998**	**1999**	**2002**	**2001**	**2003**	**2004**	**2006**	**2005**	**2007**	**AVG**
CH	--	$7.25	$6.54	$6.54	$5.95	$10.42	$5.85	$5.85	$5.85	$5.46	$6.63
ST	--	$6.57	$6.57	$6.32	$5.46	$10.39	$6.08	$5.86	$5.86	$5.11	$6.47
NT	--	$6.99	$6.54	$6.27	$5.80	$9.61	$5.91	$5.69	$5.39	$4.96	$6.35
						% of CH (Relative COP/bu)					
ST	--	90.7%	100.6%	96.6%	91.7%	99.8%	103.9%	100.2%	100.2%	93.6%	97.2%
NT	--	96.4%	100.1%	96.0%	97.4%	92.2%	101.1%	97.4%	92.2%	90.7%	94.8%

Similar to the results from Tables 1 and 2, Tables 4 and 5 indicate that there is substantive annual variability in COP/bu across tillage and cropping systems. Adding COP/acre differences to the relative yield variability from Tables 1 and 2 increase relative variability in the COP/bu results. Under CC, ST and NT have lower COP/bu in 8 and 5 out of 10 years, respectively (Table 4) and ST COP/bu averages 98.6% (-$0.02) of CH (NT: 101.2%, +$0.08). NT variability compared to ST is roughly 2.5 times higher (Std Dev 11.7 versus 4.3, CV 11.6% versus 4.3% and range 40.6% versus 14.2%). This indicates that adding COP/bu differences and aggregating over annual results (versus evaluating at average results) increased the relative variability in NT versus ST. ST and NT average 94.7% (-$0.12) and 97.8% (-$0.03) lower COP/bu than CH under SBC (CSB: 97.2% or -$0.18 for ST and 94.8% or -$0.26 for NT).

SBC and CSB results are similar, with ST and NT having lower COP/bu than CH in 9 and 6 years out of 10, respectively, for SBC (and, 5 and 7 years out of 9 for CSB). NT relative COP/bu variability is roughly twice that of ST for the SBC rotation (~15% higher for CSB).

TABLE 5. 1997-2007 Arlington Tillage Field Trials: Annual COP/bu Comparison (N w/ APP) Summary Statistics.

CC	AVG	Std Dev	Coeff Var	MIN	MAX	Range	Lower 99%	Upper 99%
CH	$2.58	$0.31	12.0%	$2.19	$3.16	$0.97	$1.65	$3.51
ST	$2.56	$0.31	12.2%	$2.16	$3.26	$1.10	$1.62	$3.49
NT	$2.65	$0.26	9.7%	$2.14	$2.98	$0.84	$1.88	$3.43
% of CH (Relative COP/bu)								
ST	98.6%	4.3%	4.3%	92.5%	106.6%	14.2%	85.9%	111.4%
NT	101.2%	11.7%	11.6%	79.5%	120.0%	40.6%	66.0%	136.3%
SBC	**AVG**	**Std Dev**	**Coeff Var**	**MIN**	**MAX**	**Range**	**Lower 99%**	**Upper 99%**
CH	$2.41	0.2	9.2%	$2.01	$2.70	$0.69	$1.74	$3.08
ST	$2.28	0.2	8.4%	$1.93	$2.53	$0.60	$1.71	$2.86
NT	$2.38	0.2	9.9%	$1.99	$2.77	$0.78	$1.67	$3.09
% of CH (Relative COP/bu)								
ST	94.7%	3.4%	3.6%	89.4%	100.9%	11.5%	84.4%	104.9%
NT	97.8%	6.8%	7.0%	85.6%	108.1%	22.4%	77.4%	118.3%
CSB	**AVG**	**Std Dev**	**Coeff Var**	**MIN**	**MAX**	**Range**	**Lower 99%**	**Upper 99%**
CH	$6.63	1.5	22.9%	$5.46	$10.42	$4.95	$2.08	$11.18
ST	$6.47	1.5	23.9%	$5.11	$10.39	$5.28	$1.82	$11.11
NT	$6.35	1.4	21.4%	$4.96	$9.61	$4.65	$2.27	$10.44
% of CH (Relative COP/bu)								
ST	97.2%	4.4%	4.5%	90.7%	103.9%	13.2%	84.1%	110.3%
NT	94.8%	4.9%	5.2%	84.7%	101.1%	16.4%	80.1%	109.5%

Annual Cost of Production: Monte Carlo Analysis

To further develop and analyze the observed relative yield and COP/bu variability from these Arlington field trials, Monte Carlo simulation was used to more fully characterize these results. Monte Carlo techniques basically use estimated probability distributions (in this case based on annual tillage yields for each cropping systems) to draw a large sample (10,000 replications here) of representative observations that more fully characterize the distribution of relative yields and COP/bu across the tillage and cropping systems. While the number of annual observations from the field trials (10 and 9 years for the CC/SBC and CSB, respectively) are a bit "light" (15 to 30 base observations are preferable), the field trial (experimental control) nature of these data provide a reasonable basis for characterizing their underlying distributions (especially means and standard deviations). A "best fit" distribution estimation routine was used to fit 30+ statistical distributions to the yields from the 3 tillages for each cropping system. The "best fit" distributions (those with the highest predictive power) revealed that all yield distributions except for CSB NT (which was a uniform distribution: all values between the high and low are equally likely to occur) were approximately normally distributed (very little skewness: i.e., means approximately equal to the median and mode). The virtue of the normal distribution for Monte Carlo analysis is that it always generates values close to the observed mean and standard deviation, hence will replicate the observed data quite closely (if there is not much skewness). For these reasons, normal distributions evaluated at observed yield means and standard deviations were used to characterize the randomness of tillage. Simulated tillage yields for each cropping system were assumed to be correlated at the observed yield correlations from Table 1. This multivariate simulation procedure forces the simulated yields to correspond to observed yield correlations and limits the individual tillage yields for each cropping system from being too extreme relative to observed interrelationships. Lastly, to approximate large sample properties for the simulation, 10,000 replications were generated and summarized (take a random draw for each tillage yield, compute the results in Table 3, store and repeat 10,000 times, then generate the summary statistics similar to Table 4). Table 6 summarizes the results of this Monte Carlo analysis.

If the base data provide a good basis for characterizing the underlying variability in tillage yields, the key source of variability in COP/bu, then Monte Carlo procedures provide a means to more fully sample from the range of feasible, interrelated (by cropping system) yields, hence the COP/bu of the alternative tillages. In addition, the estimated "empirical distributions" provide estimated probabilities that yields (or COP/bu) are at or below particular threshold values (in this case, those for the BASE tillage CH). These probabilities provide a useful characterization for how likely the alternative tillages are to perform relative to CH. In addition, the "best fit" distributions to these simulation forecasts are estimated. These provide a powerful prediction tool for summarizing the field trials that can be used in further economic and/or environmental simulations.

Table 6. Summary Statistics for Monte Carlo Simulations (10,000 replications).

Statistics	Mean	Standard Deviation	Coeff. of Variability	Minimum	Maximum	Range Width	Median	Variance	Skewness	Kurtosis
CC CH: YIELD	182.0	21.1	0.1162	108.6	258.2	149.6	166.7	447.2	0.00	2.97
CC ST: YIELD	174.4	19.3	0.1109	93.4	248.6	155.2	174.4	374.0	0.00	2.99
CC NT: YIELD	166.7	17.3	0.1040	99.9	230.5	130.6	166.7	300.7	0.0011	2.99
CC CH - ST: Yield Difference	-7.6	18.1	-2.38	-75.4	67.8	143.3	-7.5	325.8	0.00	3.10
CC CH - NT: Yield Difference	-15.3	8.2	-0.5364	-56.2	27.2	83.4	-15.4	67.4	0.0304	3.56
CC CH - ST: COP/bu (N w/ APP) Difference	-$0.03	$0.27	-10.69	-$1.53	$1.70	$3.23	-$0.02	$0.07	-0.0869	4.02
CC CH - ST: COP/bu (N w/ Planter) Difference	$0.05	$0.29	5.79	-$1.55	$1.95	$3.49	$0.05	$0.09	-0.0422	4.02
CC CH - NT: COP/bu (N w/ APP) Difference	$0.07	$0.12	1.67	-$0.82	$0.93	$1.75	$0.08	$0.01	-0.5151	5.97
CC CH - NT: COP/bu (N w/ Planter) Difference	$0.09	$0.13	1.48	-$0.86	$1.00	$1.86	$0.09	$0.02	-0.5015	5.95
SBC CH: YIELD	194.1	18.6	0.0959	121.7	267.7	146.0	194.1	346.3	0.0086	3.02
SBC ST: YIELD	194.2	16.9	0.0868	131.2	257.2	126.0	194.2	284.2	0.0047	2.99
SBC NT: YIELD	185.4	18.3	0.0985	115.1	255.0	139.9	185.4	333.2	0.0012	2.99
SBC CH - ST: YIELD Difference	0.1	8.8	88.79	-39.0	43.1	82.1	0.1	77.3	0.0298	3.35
SBC CH - NT: YIELD Difference	-8.7	12.3	-1.42	-56.6	36.6	93.2	-8.6	152.4	-0.0013	3.11
SBC CH - ST: COP/bu (N w/ APP) Difference	-$0.13	$0.11	-0.9017	-$0.80	$0.41	$1.21	-$0.12	$0.01	-0.4187	4.10
SBC CH - ST: COP/bu (N w/ Planter) Difference	-$0.06	$0.12	-1.88	-$0.78	$0.54	$1.32	-$0.06	$0.01	-0.3630	4.07
SBC CH - NT: COP/bu (N w/ APP) Difference	-$0.03	$0.16	-6.12	-$0.72	$0.77	$1.49	-$0.03	$0.03	0.0499	3.65
SBC CH - NT: COP/bu (N w/ Planter) Difference	-$0.02	$0.17	-8.86	-$0.75	$0.83	$1.58	-$0.02	$0.03	0.0561	3.66
CSB CH: YIELD	52.0	8.7	0.1680	20.0	87.2	67.2	52.0	76.3	0.00	3.00
CSB ST: YIELD	51.7	9.0	0.1743	17.2	87.3	70.1	51.7	81.1	-0.0011	3.01
CSB NT: YIELD	50.0	8.6	0.1720	18.9	82.4	63.5	50.0	74.0	0.0058	2.99
CSB CH - ST: YIELD Difference	-0.3	2.7	-8.12	-18.4	15.6	34.0	-0.4	7.3	0.0224	4.00
CSB CH - NT: YIELD Difference	-2.0	3.0	-1.52	-16.6	12.1	28.7	-2.0	9.2	0.0471	3.54
CSB CH - ST: COP/bu (N w/ APP) Difference	-$0.16	$0.41	-2.50	-$4.19	$9.34	$13.53	-$0.17	$0.17	1.37	38.15
CSB CH - NT: COP/bu (N w/ APP) Difference	-$0.26	$0.45	-1.74	-$4.46	$4.23	$8.70	-$0.26	$0.21	-0.0396	10.55

Lastly, the probabilities that the relative ST and NT yields and COP/bu relative to CH from this Monte Carlo exercise are summarized in Table 7 (as well as at the bottom of Table 3).

This table summarizes the probability that the corresponding ST or NT value (relative yield or COP/bu) is less than CH (i.e., that the change from CH is less than zero). These are computed from the empirical (frequency) distribution function generated by the Monte Carlo simulation. Probabilities near 50% indicated that the 2 values (ST or NT in comparison to CH) are equally likely. For CC, these probabilities indicate that NT yields are very likely to be less than CH based these data (97% chance). Similarly, the NT COP/bu are very unlikely to be greater than those for

CH (~22%-23% chance). ST yields are predicted to be less than CH in 2 out of 3 cases (67%) with COP/bu (N w/ APP) less than CH 55% of the time (N w/ Planter, 43%).

Under the SBC cropping results, ST yields are predicted to be greater than CHabout ½ the time (50%), with COP/bu less than CH 88% (N w/ APP) and 70% (N w/ Planter) of the time. Clearly these "stronger" probabilities are "better bets" than probabilities less than ½ (50%) of the time. NT is a bit less strong probabilistically than ST, with yields consistently less than CH (76% of the time) offset by COP/bu less than CH about 56%-57% of the time (both fertilizations). NT really shines under CSB, where highly likely lower yields (75%) are offset by equally likely lower COP/bu (76%). ST is expected to yield similar to CH (55%) and generated COP/bu savings over CH 71% of the time.

Table 7. Comparison of Probability ST or NT < CH.

		COP/bushel	
Crop/ System	YIELD	N w/ App	N w/ Planter
CC			
ST	66.7%	54.7%	42.6%
NT	97.0%	22.7%	21.9%
SBC			
ST	49.6%	87.6%	69.6%
NT	76.3%	56.8%	56.1%
CSB			
ST	55.3%	71.3%	
NT	75.4%	76.4%	

Summary/Conclusions

Clearly, the environmental, COP/acre and COP/bu benefits of reduced tillage systems are compelling but likely require adjustments to management as well as current machinery complements. Increased adoption of these reduced tillage systems requires a more thorough understanding of their relative environmental and economic dimensions, as well as opportunities (and willingness) to acquire different management skills. More research/outreach of alternative tillages along these dimensions is clearly warranted. For example, characterization of key weather related factors (wet/dry spring or pollination period, degree days, good/bad year, etc) across the years of these trials may provide for more general conclusions as to the likelihood that one tillage will outperform another. Similarly, observation across more soils, locations, and under different management (e.g., NT with row cleaners) would add more robustness to the current estimates. These provide rich opportunities for additional on-farm research.

Evaluating the economics of tillage systems is very complex. Consideration must be given to the initial and maintenance costs of equipment, the size of tractor needed to pull the tool, equipment depreciation, labor and opportunity costs, conservation program incentives, and increased management costs related to fertilizer and pest management. Producers will have to determine if it is cost effective to strip-till all row crops, as opposed only strip-tilling first-year corn into soybean stubble or fall-killed alfalfa, no-till planting soybean into corn or small grain stubble, and using chisel plowing or similar full-width systems for growing continuous corn. Growers are encouraged to set up simple side-by-side comparisons of different tillage systems to evaluate response on their own soils. Evaluation of economic COP/acre and COP/bu are also encouraged, as these Arlington field trials indicated that potentially lower yields under reduced tillage can be offset by gains in lower COP. Use of WI custom hire rates for field operations likely provide upper bounds on these COP, as they reflect market rates of return for the labor, machinery and capital involved in these alternative tillage systems. In many instances, both economic and environmental performance may be enhanced by wider adoption of reduced tillage systems.

Experienced no-tillers will likely take exception to the relative NT yields and COP estimates found in these field trials. NT systems often require increased management (planting, spraying and fertilization) and several years to achieve their full yield potential. In particular, the "soil equilibrium" (improved organic matter, soil structure, water absorption capacity, soil biotics, etc) under NT takes several years to develop and mature. These more "mature" NT systems are likely to generate yields quite competitive with the CH yields observed in these field trials. In this context, the relatively poor performance of NT relative to ST and CH may indicate the expected short run yields for a NT cropping system that is early in the adoption/adaptation stage. The ST results suggest a hybrid/transition cropping system that reaps much of the best of both NT and CH tillage systems while providing an opportunity to acquire the management skills and machinery complement to move towards even less tillage, improved yields, lower costs and improved environmental performance found by seasoned no-tillers.

Appendix Table 1. Corn Costs Per Acre @ 2007 WI Custom Hire Rates.

	Nitrogen Applied With Applicator				Nitrogen Applied With Planter			
Implement	No-Till	Planter Strip Till	Pre-Strip Till	Chisel	No-Till	Planter Strip Till	Pre-Strip Till	Chisel
Chisel Plow				$14.70				$14.70
Field Cultivator				$11.50				$11.50
Strip Till Tool			$15.00				$15.00	
Dry Fertilizer Application	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00
Nitrogen Applicator	$12.00	$12.00		$12.00				
Planter	$16.10	$16.10	$15.80	$15.80	$16.10	$16.10	$15.80	$15.80
Sprayer Pass I	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50
Sprayer Pass II	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50
Combining	$26.40	$26.40	$26.40	$26.40	$26.40	$26.40	$26.40	$26.40
Machinery Costs Subtotal	$74.50	$74.50	$77.20	$100.40	$62.50	$62.50	$77.20	$88.40
Nitrogen Fertilizer	$87.75	$87.75	$87.75	$87.75	$128.25	$128.25	$128.25	$128.25
P and K Fertilier	$65.70	$65.70	$65.70	$65.70	$65.70	$65.70	$65.70	$65.70
Herbicide	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00
Seed	$75.00	$75.00	$75.00	$75.00	$75.00	$75.00	$75.00	$75.00
Variable Costs Subtotal	$263.45	$263.45	$263.45	$263.45	$303.95	$303.95	$303.95	$303.95
Land/Rental Costs	$100.00	$100.00	$100.00	$100.00	$100.00	$100.00	$100.00	$100.00
Total Costs: CORN	$437.95	$437.95	$440.65	$463.85	$466.45	$466.45	$481.15	$492.35
Change from Chisel	-$25.90	-$25.90	-$23.20	--	-$25.90	-$25.90	-$11.20	--
Breakeven Cost/Yield Difference	-8.4	-8.4	-7.5	--	-7.9	-7.9	-3.4	--
Cost/Bushel (= Breakeven Price)	$2.92	$2.92	$2.94	$3.09	$3.11	$3.11	$3.21	$3.28

Appendix Table 2. Soybean Costs Per Acre @ 2007 WI Custom Hire Rates.

	Nitrogen Applied With Applicator				Nitrogen Applied With Planter			
Implement	No-Till	Planter Strip Till	Pre-Strip Till	Chisel	No-Till	Planter Strip Till	Pre-Strip Till	Chisel
Chisel Plow				$14.70				$14.70
Field Cultivator				$11.50				$11.50
Strip Till Tool			$15.00				$15.00	
Dry Fertilizer Application	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00
Planter	$16.10	$16.10	$15.80	$15.80	$16.10	$16.10	$15.80	$15.80
Sprayer Pass I	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50
Sprayer Pass II	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50	$7.50
Combining	$26.10	$26.10	$26.10	$26.10	$26.10	$26.10	$26.10	$26.10
Machinery Cost Subtotal	$62.20	$62.20	$76.90	$88.10	$62.20	$62.20	$76.90	$88.10
P and K Fertilier	$70.20	$70.20	$70.20	$70.20	$70.20	$70.20	$70.20	$70.20
Herbicide	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00
Seed	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00
Variable Cost Subtotal	$145.20	$145.20	$145.20	$145.20	$145.20	$145.20	$145.20	$145.20
Land/Rental Cost	$100.00	$100.00	$100.00	$100.00	$100.00	$100.00	$100.00	$100.00
Total Costs: BEANS	$307.40	$307.40	$322.10	$333.30	$307.40	$307.40	$322.10	$333.30
Change from Chisel	-$25.90	-$25.90	-$11.20	--	-$25.90	-$25.90	-$11.20	--
Breakeven Cost/Yield Difference	-3.5	-3.5	-1.5	--	-3.5	-3.5	-1.5	--
Cost/Bushel (= Breakeven Price)	$6.83	$6.83	$7.16	$7.41	$6.83	$6.83	$7.16	$7.41

FERTILIZER MANAGEMENT: NEW ECONOMICS, NEW PRACTICES?

Carrie Laboski [1/]

Fertilizer prices are at or near record highs. In addition, prices, particularly for nitrogen (N), will likely be volatile through spring. In the current high cost environment, how can, or should, fertilizer management be changed to maximize economic returns? The objective of this paper is to briefly outline how to assess fertilizer management practices to ensure profitability.

The first step is to start with a current (less than 4 years old) soil test. The soil test will allow you to prioritize lime, phosphorus (P), and potassium (K) applications. Remember liming is the cornerstone of a good soil fertility program. If the soil pH is below the target pH of the most sensitive crop in the rotation, then fertilizer dollars should be allocated first to lime. The reason for this is that if the pH is less than ideal, additions of other nutrients will not be used efficiently.

Once pH is taken care of the P and K needs can be assessed. Current (mid-December 2009) potash prices average about \$880/ton, which translates to \$0.73/lb K_2O. For soils testing very high or very high in K, consider eliminating or reducing potash applications. Remember that corn silage and alfalfa remove large quantities of K and soil test K levels may move into the optimum range before the next scheduled soil sampling. Current phosphate prices are more than \$900/ton of MAP or DAP which translates into very expensive phosphate fertilizer (if \$0.50/lb N, then more than \$0.75/lb P_2O_5). Thus, on soils testing over optimum for P it would be prudent to eliminate P fertilizer applications because the probability of a response is quite small and the fertilizer is very expensive. When soils test optimum for P or K, apply near recommended rates. For soils testing below optimum in P or K, reduce application rates to the rate recommended for optimum testing soils. Manure is an excellent nutrient source and where nutrient management plans allow, use manure to meet all or part of the P and K nutrient needs.

For corn grown on soils testing over optimum for P, a small response to starter fertilizer can often be obtained. Many starter fertilizers are extremely expensive today; thus the practice of using starter fertilizer on corn regardless of soil test P levels needs to be assessed. The response of corn grain yield to starter fertilizer on high P testing soils was evaluated on 100 sites throughout Wisconsin from 1995-1997 (Bundy and Andraski, 1999). These data can be used to determine the probability of an economic return on starter fertilizer. First the cost of starter fertilizer must be divided by a price of corn to determine the minimum yield increase per acre needed to pay for the starter fertilizer. The probability of obtaining the necessary minimum yield increase is shown in Table 1. As an example, if starter fertilizer costs \$50/acre and corn is \$4.15/bu, then a yield increase of at least 12 bu/acre is needed to pay for the starter fertilizer. Based on the 100 site-years of data, there is only a 6% chance of obtaining at least a 12 bu/acre yield increase. Thus, in this situation using starter fertilizer on high P testing soils may not be in the best economic interest of the grower. Please note, for soils testing optimum or lower, starter fertilizer remains an excellent way to supply needed nutrients.

Table 1. Probability of a minimum increase in corn grain yield when starter fertilizer is applied to high P testing soils (Bundy and Andraski, 1999).

Yield increase of at least	Probability of minimum yield increase
bu/acre	%
4	49
6	34
8	18
10	10
12	6
16	5
20	3

Nitrogen application rates for corn can be reduced by using the MRTN approach to selecting a N rate (Laboski et al., 2006). For all crops remember to subtract all manure and legume credits from your targeted N rate to obtain the amount of fertilizer needed. If you are in doubt about the amount of N to credit for corn, use a pre-sidedress nitrate test to confirm manure and forage legume credits.

In addition to selecting an economical N rate, it is important to make sure that N is used efficiently by the crop and is not lost. A quick reminder of a few best management practices for N is:

1) Use sidedress applications on sandy soils
2) Sidedress applications on silt loam soils that tend to be wet may reduce the potential for denitrification.
3) Nitrification inhibitors may be beneficial for preplant N applications particularly on soils that tend to be wet.
4) Urea should be incorporated into the soil within about 24 hr either mechanically or by 0.1-0.2" of rainfall/irrigation. If incorporation is not possible and rain is not imminent, consider using a urease inhibitor
5) Control weeds no later than weed height of 4" to increase N use efficiency in corn.

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FOLIAR FERTILIZATION OF SOYBEAN WITH NITROGEN, PHOSPHPORUS, AND POTASSIUM: WHERE, WHEN, AND WHY?

Antonio P. Mallarino [1/]

Renewed Interest in Foliar Fertilization of Soybean

Many producers are reducing or skipping preplant fertilization for soybean due to high fertilizer prices, and in 2008 many fields were planted late or replanted due to excess rainfall with colder than normal temperatures. Therefore, producers and crop consultants wonder if foliar-applied fluid fertilizer could improve soybean growth and grain yield. Prior to the 1990s, research in Iowa and the Midwest had focused mainly on foliar fertilization at late soybean reproductive stages (R4 to R7). Hundreds of trials from the 1970s to the middle 1980s included nitrogen (N), phosphorus (P), potassium (K), sulfur (S), and micronutrients treatments. The soybean plant has a sharp decline in root activity during late seed development stages with large nutrient translocation from leaves and pods into the developing seed. Researchers theorized that nutrients applied to the foliage at this time could increase yield by delaying leaf senescence and seed starvation. A few early experiments in Iowa suggested that spraying nutrients in the ratio 10-2.3-3.6-0.5 (N-P_2O_5-K_2O-S) between the R5 and R6 growth stages could increase yield by 7 to 8 bu/acre even after preplant fertilization. However, more than 200 subsequent trials in the region showed inconsistent results, with mostly no yield increases and frequent yield decreases. Work mainly during the late 1990s and early 2000s in rain-fed conditions of the Midwest has shown mostly yield decreases when N sources were sprayed at late growth stages. The more positive results were observed under very high yield conditions and irrigation in some starts of the Great Plains region. These results have discouraged further research and adoption of foliar fertilization of soybean at late reproductive stages. Because of concerns about Asian Soybean Rust spreading north and evidence of soybean grain yield response to midseason application of fungicides, however, some producers are considering mixing fluid fertilizers and fungicides for midseason foliar application to soybean.

Therefore, research in Iowa during the last few years has focused on the study of foliar fertilization of soybean at early vegetative stages and on the possibility of mixing fluid fertilizers and fungicides for application at early reproductive stages. This summary article reviews issues involved, provides a brief summary of many studies conducted in Iowa during the last few years, and provides some recommendations. Readers must understand that research results and recommendations for prevailing soil and climate conditions in Iowa should not be directly extrapolated to other regions.

Foliar Fertilization of Soybean at Vegetative Stages

Small amounts of nutrients sprayed onto soybean foliage at early stages could supplement inadequate pre-plant fertilization and increase nutrient supply at a time when roots and N fixing root nodules are not well developed. Furthermore, foliar fertilization could enhance growth if soil conditions limit root growth and nutrient uptake even when soil nutrient levels are adequate. Small amounts of N, P, and (or) K applied to the foliage at early critical periods could be effective if foliar fertilization is viewed as a complement for soil P and K fertilization and symbiotic atmospheric N fixation. About 100 replicated field trials were conducted from 1994 until 2006 to evaluate these possibilities by spraying foliar fertilizers with or without mixing it with glyphosate herbicide or a fungicide at the V5 to R3 growth stages. All experiments were conducted at farmers' fields, and the treatments were replicated three to four times at each site using conventional small plots or strip trials.

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The products tested (not all products were included in all trials) included the low-salt fluid fertilizer 3-18-18 (N-P_2O_5-K_2O), 8-0-8, and 10-10-10 both with or without S and sometimes with or without the micronutrients boron (B), iron (Fe), and zinc (Zn). The product application rates ranged from 2 to 6 gallons/acre applied once or twice spaced 8 to 10 days. The fields were managed with no-till, ridge-till, or chisel-plow tillage. The majority of fields tested Optimum or higher for P and K according to Iowa State University interpretation class but there were some low-testing soils.

Figure 1 summarizes results from 66 trials that compared three sets of six treatments. Each graph shows averages across all fields and averages for fields where at least one treatment was statistically different from the control. Foliar fertilization increased yield in 15 to 30 percent of the fields depending on the trial set and year. Differences between treatments were inconsistent across fields but responses tended to be higher for a rate of 3 gallons/acre of 3-18-18. Adding S or micronutrients did not produce higher yield. The highest rate of 10-10-10 (with or without S) and 8-0-8 fertilizers reduced yield in a few fields (some leaf burn was observed). Double applications were statistically similar to single applications. Responses were observed in low-testing fields and also in fields testing Optimum or higher. The average response to the best treatment (3 gallons/acre of 3-18-18), which was common to the three sets of trials, across all trials was 0.7 bu/acre but the average response across the responsive trials was 4.1 bu/acre. Twenty-three additional trials consisted of simpler comparisons of 3 gallons/acre of 3-18-18 fertilizer applied once at the V5-V6 growth stage and an untreated control because this was the fertilizer and rate most effective in the previous trials. These trials used a conventional small-plot methodology or were replicated strip trials, and the fertilizer often was mixed with glyphosate herbicide. The results of these trials showed a response in about 15 percent of the trials, and the average yield increase across all trials was about 0.5 bu/acre .

Reasons for yield increases from foliar fertilization in low-testing soils are obvious. However, yield increases in fields testing Optimum or higher in P and K were difficult to explain. Complex multivariate statistical analyses were used to understand the relationship between yield response and soil-test values, soil type, tillage system, nutrient uptake at early or late growth stages, rainfall, temperature, planting date, etc. These analyses did not support strong conclusions but suggested conditions in which a response to foliar fertilization was more likely. In some years, responses were higher and more frequent in ridge-till and no-till fields compared with chisel-plow tillage. In general, the responsive fields with Optimum or high soil-test levels had slower early plant growth and P or K uptake than non-responsive fields due to cool early temperatures or excessive rainfall. Therefore, conditions that inhibit root growth and/or nutrient uptake early during the growing season (except drought) increase the likelihood of a yield response. Unfortunately there is no simple “absolute yardstick” that can be used to identify these conditions that increase chance of response to foliar fertilization in producers’ fields. For example, this project and many others have not been able to identify a reliable critical or optimal nutrient concentration in young soybean tissue.

Foliar Fertilization and Fungicide Application to Soybean

Five field trials were conducted in 2005 and 2006 to study foliar fertilization and fungicide application alone or in a spray mixture for soybean. Adapted glyphosate-resistant varieties were used at all trials. Soybean was planted using narrow rows (7.5 inches) at the three sites and spaced 30 inches at two sites. Eight treatments were replicated three times at each site using conventional small plots. Foliar fertilization treatments consisted of a control, a single application of 3 gallons/acre of 3-18-18 fluid fertilizer at the V5-V6 and R2-R3 growth stages, 3-18-18 applied at both V5-V6 and R2-R3 stages, and 3.3 gallons/acre of 28% urea-ammonium nitrate (UAN) solution (10 lb N/acre) applied at the R2-R3 stage. The fungicide *Pyraclostrobin* [Headline® (BASF)] was sprayed at 12 oz/acre at the R2-R3 growth stage alone and in combination with 3-18-18 and UAN fertilizers. All solutions sprayed at the R2-R3 stage were mixed with a 90% non-ionic surfactant at a rate of 0.1 quart/10 gallons. Solutions turned a slight milky-white color when fertilizers and fungicide were mixed but no precipitation or material settling was observed. Treatments were sprayed with a CO_2 powered sprayer calibrated to apply 30 gallons of liquid/acre at 25 psi based on product recommendations. Spraying was done in early morning or evening to lessen the risk of leaf burning, and there was no rainfall 24 hours before and after treatment application.

The UAN fertilizer caused moderate leaf burning at most sites while application of 3-18-18 fertilizer caused minor or no burning (not shown). Fungicide application consistently and significantly delayed leaf senescence and increased green leaf area late in the season (not shown). Foliar fertilization affected soybean maturity only at one site, where 3-18-18 and UAN sprayed at the R2-R3 growth stage advanced maturity. Brown Spot and Bacterial Blight were the most prevalent diseases. The fungicide reduced incidence and/or severity of Brown Spot at three sites and, unexpectedly, the fungicide also reduced incidence or severity of Bacterial Blight at four sites, which is a result we cannot fully explain. Foliar fertilization seldom affected disease incidence and never affected the fungicide effect on disease control. All treatments reduced incidence of Cercospora at one site, and at another site both incidence and severity of Brown Spot were lowest when either 3-18-18 or UAN were sprayed in mixture with the fungicide.

The fungicide applied alone increased soybean grain yield significantly at four sites of the five sites, although the yield response was clearly explained by disease control only at two sites. Therefore, the fungicide effect at delaying leaf senescence may partly explain the yield responses. Foliar fertilization with 3-18-18 or UAN had inconsistent effects on yield. The 3-18-18 fertilizer increased yield slightly at two sites when it was sprayed at the V5-V6 growth stage but not when sprayed at the R2-R3 stage. Fertilization with UAN did not affect yield at two sites, increased it slightly at one site, and decreased it significantly at two other sites. Mixing fluid fertilizers with the fungicide did not influence the effect of each product applied separately. Figure 2 shows average treatment effects on grain yield across the five sites. The 3-18-18 fertilizer applied alone did not affect yield, UAN fertilizer applied alone decreased yield by 2.1 bu/acre, and the fungicide applied alone or in mixture with 3-18-18 increased yield by 3.5 bu/acre.

General Recommendations

Foliar fertilization of soybean will not be cost-effective when applied across all fields because the expected average response is less than 1 bu/acre. The probability of a larger yield increase is 15 to 20 percent. Except for too high application rates of products with high salt content, N, or S which often burned leaves sometimes decreased yield, the research showed inconsistent differences between nutrient ratios or frequencies of application. However, a single application of the low-salt 3-18-18 fertilizer at 3 gallons/acre resulted in the more consistent yield increases. Mixing this fertilizer with glyphosate for early application or with Headline® fungicide for mid-season application caused no problems but did not increase the efficacy of either product. The probability of a yield response that offsets costs will be increased by targeting fields for spraying. These include fields with low soil nutrient levels due to insufficient pre-plant fertilization and conditions where soil or climate factors limit nutrient uptake in late spring and early summer. Unfortunately these conditions often cannot be easily identified in the field.

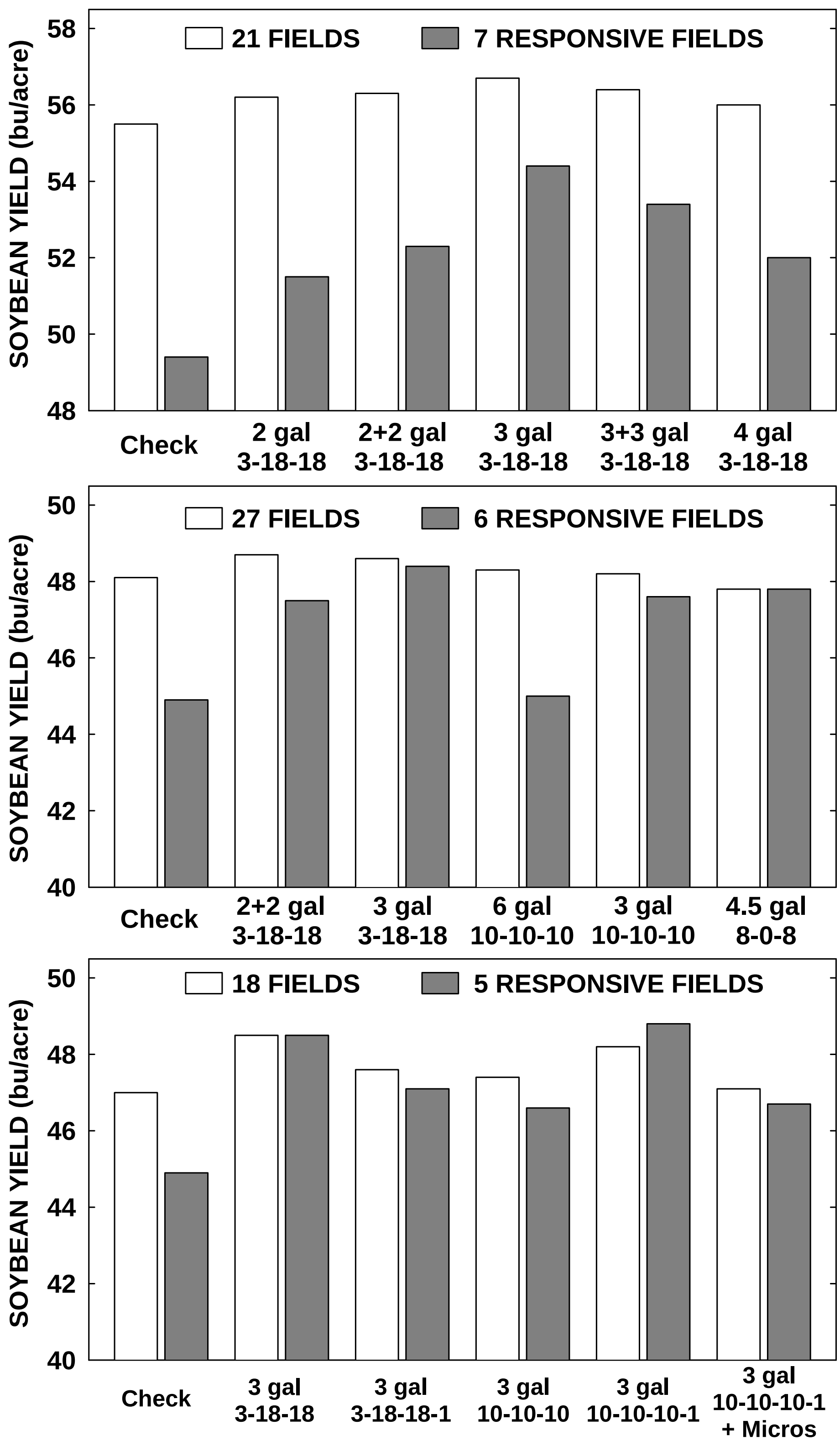

Figure 1. Soybean grain yield response to foliar fertilization across sites of three sets of trials conducted in Iowa with different treatments. The bars represent average yield responses across all sites and only the responsive sites for each trial set.

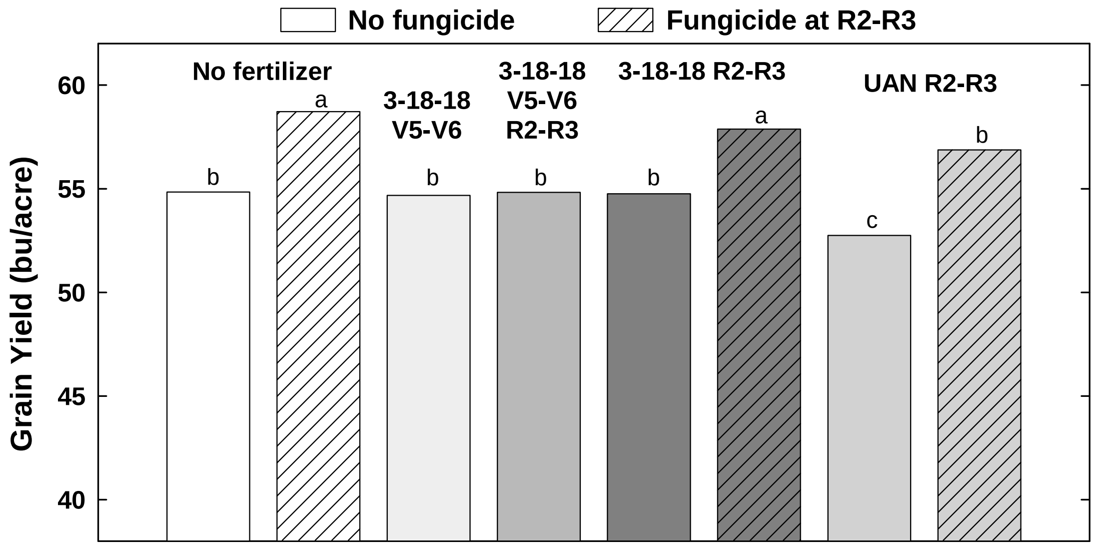

Figure 2. Effects of foliar fertilization and fungicide application on grain yield of soybean (averages across five trials conducted in Iowa).

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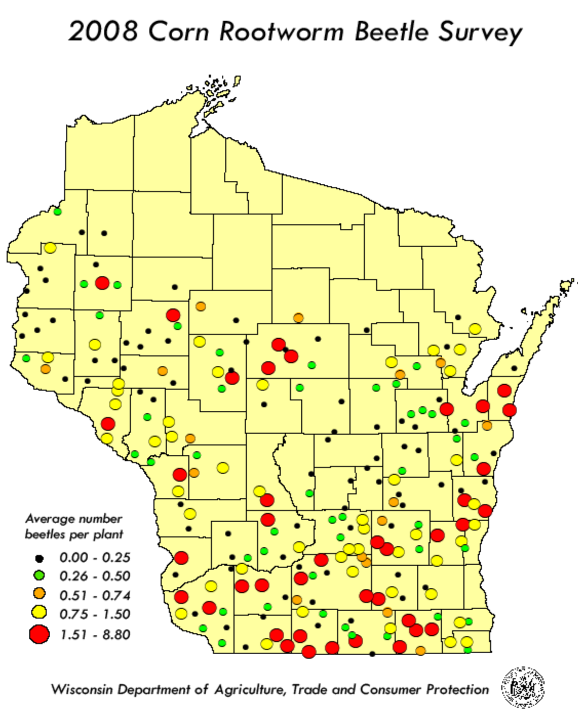
WISCONSIN INSECT SURVEY RESULTS 2008 AND OUTLOOK FOR 2009

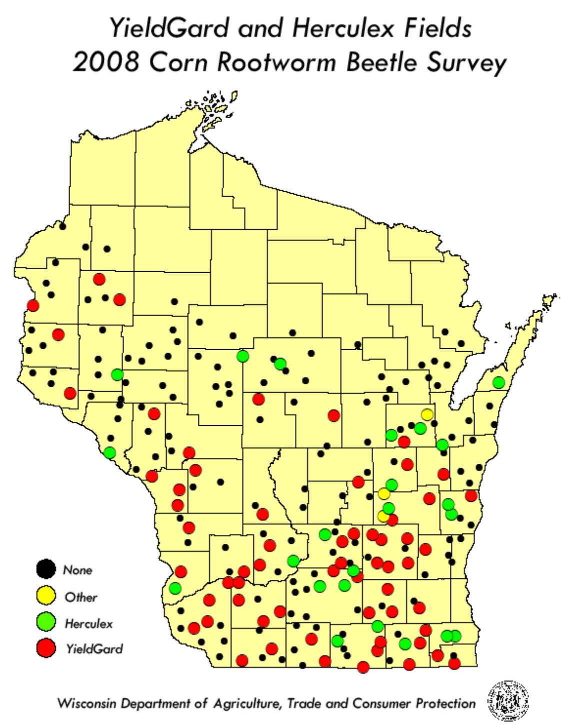
Krista L. Hamilton[1/]

Corn Rootworm

Field data from the annual survey of adult corn rootworms in August revealed an increase from 2007 populations in 6 of the 9 agricultural reporting districts, including the southwest, southeast, west central, northwest, north central and northeast, and a decrease in populations in the remaining districts. The state average was 1.0 beetle per plant, the same average as in 2007. Average populations by district were as follows: northwest 1.1; north central 1.5; northeast 1.6; west central 1.0; central 0.5; east central 0.6; southwest 0.5; south central 0.9; southeast 0.6 (see table on Page 152). The western species constituted 52% of the state average population, while the northern species made up about 48%. Research entomologists consider an average of 0.75 beetle per plant to indicate an elevated risk for root injury in continuous corn the following year if some form of control is not used, and 38% of 229 fields in the major corn growing counties had such a count or higher. The obvious conclusion from these results is that there is a high potential for rootworm damage to continuous corn next season.

The use of transgenic Bt corn rootworm hybrids was also measured for the third season. The percentage of survey sites that were Bt corn rootworm fields increased to 40% in 2008 from 27% in 2007. For the third year, Monsanto's YieldGard was the most prevalent of the technologies. The YieldGard Bt-Cry3Bb1 protein was detected in 28% of the fields, the Herculex Bt-Cry34/35Ab1 protein was detected in 11% of the fields, and the mBt-Cry3A protein from Agrisure was found in 1% of the fields. More Bt-rootworm corn was planted in the southwest and south central districts from 2006-2008 relative to the other districts. The maps below summarize the results of the annual corn rootworm beetle survey.





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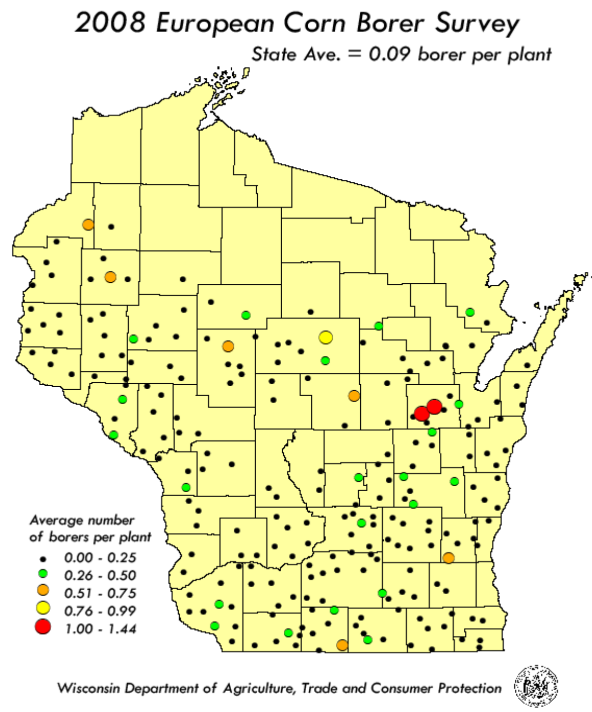
European Corn Borer

Flights of spring moths developing from overwintered larvae in May and June were distinctly lower than in the previous year, as egg and larval survival was apparently influenced by wet conditions in the southern half of the state. The magnitude of the second flight of moths was nearly four times lighter than in 2007.

Results of the fall survey of second generation larvae showed a sizeable decrease in population densities from 2007 to 2008. Populations were well below normal, averaging 0.09 borer per plant (9 borers per 100 plants), the lowest average since 1998. The state average is about one-third that of last season and the 10-year average of 0.31 per plant, and far below the 50-year average of 0.46 per plant. Counts in individual districts were also extremely low. The most drastic reductions were noted in the west central, central and south central districts.



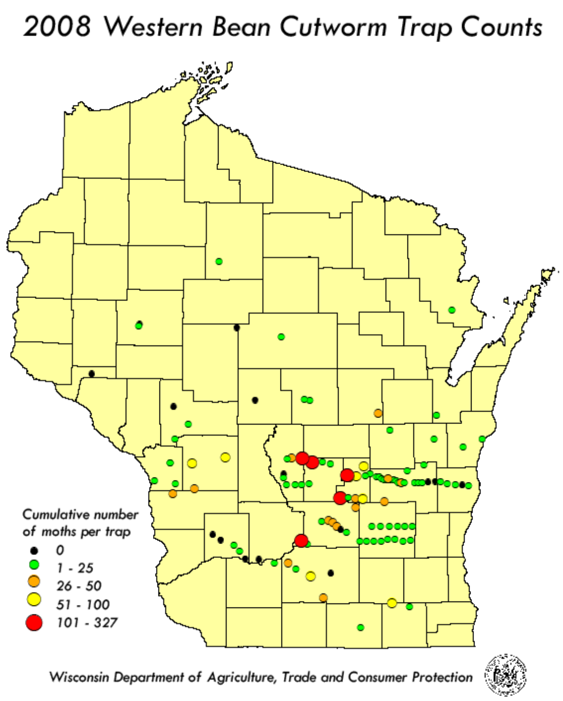
Injury to corn from larval feeding was not detected in 64% of the grain corn fields examined, most of which were presumed to be Bt hybrids. Roughly 2.5% of the fields had populations exceeding 0.50 borer per plant and only 1% had populations above the economic threshold of 1.0 borer per plant. The fall abundance survey in 230 fields registered the third lowest population since 1942.

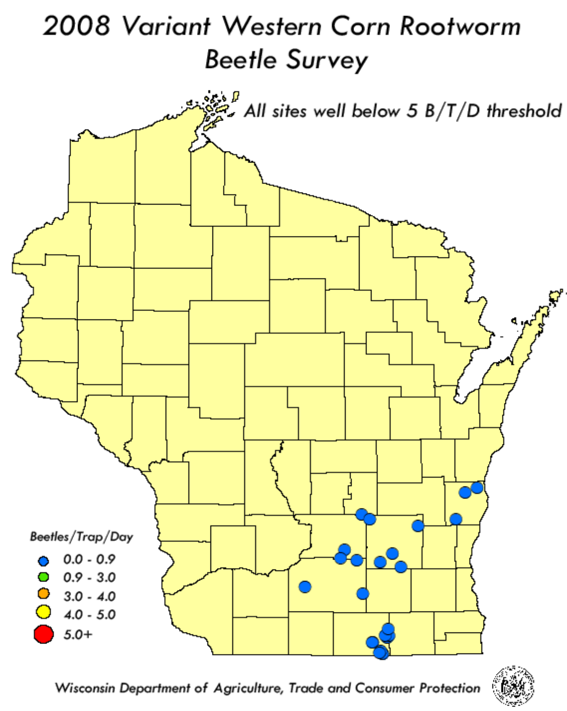
Table 1. European corn borer fall abundance survey summary 1999-2008 (Average no. borers per plant).

District	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	10-Yr Ave
NW	0.15	0.24	0.33	0.44	0.20	0.13	0.01	0.27	0.24	0.12	0.21
NC	0.03	0.04	0.05	0.26	0.14	0.20	0.36	0.16	0.35	0.18	0.18
NE	0.18	0.03	0.07	0.75	0.23	0.22	0.33	0.23	0.07	0.12	0.22
WC	0.30	0.31	0.67	0.71	0.16	0.05	0.24	0.42	0.52	0.04	0.34
C	0.30	0.41	0.48	1.21	0.44	0.06	0.44	0.51	0.42	0.11	0.44
EC	0.25	0.19	0.33	0.44	0.20	0.22	0.25	0.11	0.21	0.20	0.24
SW	0.57	0.39	0.87	0.65	0.34	0.10	0.49	0.20	0.28	0.05	0.39
SC	0.61	0.33	0.48	0.86	0.51	0.05	0.67	0.38	0.33	0.07	0.43
SE	0.31	0.16	0.36	0.61	0.21	0.02	0.35	0.16	0.12	0.04	0.23
State Ave	**0.30**	**0.24**	**0.40**	**0.66**	**0.30**	**0.10**	**0.40**	**0.29**	**0.31**	**0.09**	**0.31**

Western Bean Cutworm

The first moths were captured in a pheromone trap on July 2 in Fond du Lac County, with the peak of the moth flight occurring from July 25-August 6. Egg masses were noted near Westfield in Marquette County on July 29. Severe larval injury to corn from this flight was reported or observed in Adams, Columbia, Door, Green Lake, Juneau, Lafayette, Marquette and Sauk counties, where exceptional fields had 50-72% of the ears infested in late August. Moth activity declined to low levels by August 21. A cumulative high count of 327 moths for the July-August monitoring period was registered near Princeton in Green Lake County. The 112 Wisconsin pheromone traps captured a total of 2,433 moths in 2008, a minor increase from the 2,178 moths captured in 110 traps in 2007. Although the annual flight was comparable to last year, late season infestations were more prevalent and larvae were far more abundant.





Variant Western Corn Rootworm

The Wisconsin Variant Western Corn Rootworm Trapping Network monitored 26 soybean fields in August of 2008 and found none with populations above the economic threshold of 5 Beetles/Trap/Day (B/T/D) for the four-week sampling period. Of the 26 soybean fields in Columbia, Dane, Dodge, Rock, and Sheboygan counties, the highest average of only 0.88 B/T/D was found in Rock County. Pressure from the variant was also light in 2007, when averages in all 53 fields sampled were well below the economic threshold. The variant has been detected above the 5 B/T/D threshold in five counties since 2004, including Jefferson (2005), Kenosha (2005), Racine (2005), Rock (2004-2006), and Walworth (2004-2005).

Results of the 2008 survey indicate that first-year corn planted after soybeans in the fields monitored is at a low risk for economic damage from larval rootworm feeding in 2009. It should be noted that the averages obtained during the August sampling period are specific to those fields sampled. Despite apparently low pressure from this insect in the last two years, individual fields in southern Wisconsin may be subject to damage.

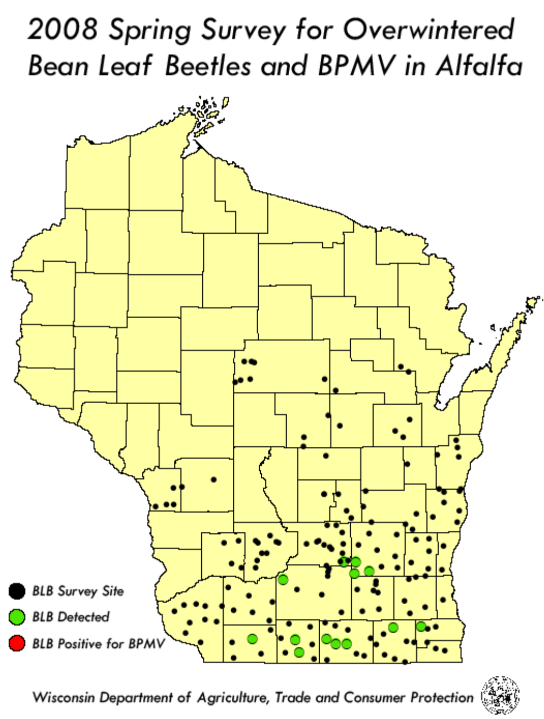
Corn Earworm

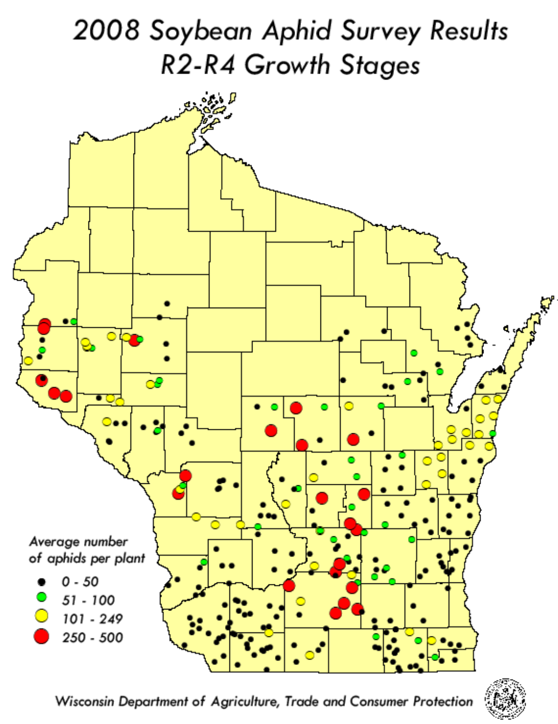
An early flight of migrant corn earworm moths beginning June 3 and continuing through June 26 produced heavy infestations of larvae by mid-July and prompted the treatment of many sweet corn fields in the southern and central counties. Four successive weeks of large flights of moths in August led to a second round of serious infestations in the state. In terms of magnitude, this later flight was 23% lighter than the flight documented in 2007, although late larval infestations were much heavier this season. The cumulative seasonal capture was 5,624 moths in 2008, compared to 8,055 moths in 2007. Areas of heaviest infestation occurred in Adams, Columbia, Dane, Dodge, Jefferson and Marquette counties, and a few scattered locations in Rock County. Moths continued to be registered near Chippewa Falls and Marshfield as late as October 3.

Bean Leaf Beetle

The first overwintered beetles were swept from a Walworth County alfalfa field on May 14, about two weeks later than last year. Winter mortality due to extreme cold temperatures was estimated to be high, ranging from 52-69%. The annual survey of 167 first crop alfalfa fields from May 14-June 4 substantiated this prediction, yielding just 21 bean leaf beetles, the fewest obtained since surveys began in 2003.

The accompanying map provides an indication of the distribution of overwintered beetles last spring. Each black circle signifies a first crop alfalfa field, and each green circle signifies a field at which beetles were collected. Only 8% (13 of 167) of the first crop alfalfa fields surveyed contained beetles. Laboratory testing of the 21 beetles subsequent to the field portion of the survey showed all were negative for bean pod mottle virus (BPMV), suggesting a negligible risk for early season BPMV transmission to soybeans. This insect cannot be credited with causing any economic damage to soybeans in 2008.





Soybean Aphid

Flooding in June caused a large proportion of soybeans to be planted late or replanted, and this historic event, in combination with cool temperatures in August, significantly impacted soybean aphid dynamics in 2008. Populations increased noticeably later than in other years and remained above economic levels into September. This development is not reflected in the low averages found during the annual survey, which appraised aphid levels at R2-R4, before peak densities were reached.

The annual soybean aphid survey conducted from July 21-August 21 showed 92% of the 299 soybean fields examined contained non-economic populations of aphids. Economic or high densities of 250 or more aphids per plant were found at 8% of the sites, distributed principally in the central and northwest districts. Low to moderate populations were observed throughout the southern, east central and northeast districts; numbers were particularly low in the southwest and northeast areas. Averages by agricultural reporting district were as follows: northwest 90 per plant; northeast 34 per plant; west central 121 per plant; central 142 per plant; east central 66 per plant; southwest 14 per plant; south central 98 per plant; southeast 23 per plant. The 2008 state average density of 70 aphids per plant is well below both the 2007 average of 164 per plant and the 6-year average of 198 per plant. The highest survey average of 758 aphids per plant was recorded in 2003.

Table 2. Soybean aphid survey summary 2003-2008 (R2-R4 stages of growth).

District	Ave no.soybean aphids per plant **2008**	Ave no.soybean aphids per plant **2007**	Ave no.soybean aphids per plant **2006**	Ave no.soybean aphids per plant **2005**	Ave no.soybean aphids per plant **2004**	Ave no.soybean aphids per plant **2003**
NW	90	13	56	306	1	566
NC	—	109	22	113	7	93
NE	34	13	58	42	25	170
WC	121	356	101	198	9	632
C	142	170	44	175	43	680
EC	66	10	159	124	5	968
SW	14	302	55	44	2	149
SC	98	188	30	75	11	993
SE	23	54	23	91	6	1268
State Ave	**70**	**164**	**69**	**118**	**11**	**758**

STATUS OF EMERALD ASH BORER IN WISCONSIN

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DO INSECT THRESHOLDS CHANGE WITH HIGH CROP PRICES?

Eileen Cullen [1/]

After attending this workshop, participants will gain knowledge necessary to:

- Define the IPM terms *economic injury level*, *economic threshold*, *damage boundary*, and *gain threshold*.
- Answer the question, "do insect economic thresholds change with higher crop prices?"
- Identify the components that make up an insect *economic injury level*
- Understand why the soybean aphid economic threshold of 250 aphids/plant does not change when soybean prices increase from $5.50/bushel to $15.00/bushel.
- Understand how potato leafhopper economic thresholds in alfalfa may help preserve long-standing biological control success for alfalfa weevil.

Background

The National Research Council (1989) equated integrated pest management (IPM) adoption in field and forage crops with pest scouting and use of economic thresholds before a decision is made to apply insecticide. Three IPM terms and definitions are important for discussion purposes and data review during this workshop presentation.

Economic Injury Level (EIL): The EIL is defined as the lowest number of insects that will cause economic damage (i.e., amount of pest injury justifies cost of insecticide application given control costs and value of the crop (Pedigo, 1989).

Economic Threshold (ET): The ET is set below the EIL to allow lead time to arrange insecticide treatment and suppress an insect population before it reaches the EIL (Stern et al., 1959). The ET is based on an understanding of population dynamics and growth rates for the particular insect pest. By setting the ET at a lower value than the EIL, we are predicting that once the population reaches the ET, chances are good that it will grow to exceed the EIL. Economic thresholds are also referred to as "action thresholds" or simply "thresholds". That is, the point at which treatment is recommended to prevent pest populations from reaching the EIL.

Damage Boundary: The number of a pest insect that must be present before its injury can be measured as yield loss (Pedigo, 1989). Regardless of crop price, there is no reason to spend money, effort, or environmental impact to control insects that are present in numbers fewer than the damage boundary because there will not be any observable return in protected yield and there can be detrimental effects on natural enemy insects (Tollefson et al., 2008).

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Do insect economic thresholds change with higher crop prices?

Keeping in mind that the economic threshold (i.e., the insect population density at which control action is taken) is already set below the economic injury level, the question we really need to be asking is *do insect Economic Injury Levels (EILs) change with higher crop prices?* Yes, the calculation of an EIL for an insect is a continuing process because new values are required with changes in the input variables. Consequently, when crop market value, management costs, and/or plant susceptibility change, recalculation of the EIL is necessary (Pedigo, 1989).

How do entomologists determine the economic injury level (EIL)?

In order for entomologists to calculate the EIL, we need to know the straightforward values such as cost of treatment per acre, and value of crop per acre (grain crops) or per ton (alfalfa hay). Looking strictly at the economics of an insect pest management decision, entomologists and IPM practitioners first consider the *gain threshold*. The gain threshold is expressed in amount of harvestable yield; when cost of suppressing insect injury equals money to be gained from avoiding the damage. The gain threshold is expressed as:

$$\textit{Gain threshold} = \frac{\text{Management costs (\$/acre)}}{\text{Market value (\$/bushel)}} = \text{bushels/acre}$$

For example, if management costs for application of an insecticide are $18 per acre and harvested corn is marketed for $5.00 per bushel, the gain threshold would be 3.6 bushels per acre. The gain threshold is an important measure because it represents a basic margin for determining benefits of management and establishing treatment decision parameters (Pedigo, 1989). The gain threshold is a basic break-even analysis and can be calculated as a first step when determining the EIL (Pedigo et al., 1986).

However, in order to determine the Economic Injury Level, we need more than the gain threshold, we also need to know how much yield loss the insect pest population causes at various population densities. Farmers and consultants need reliable information on the statistical relationship between insect pest population levels and crop yield loss, an estimate of yield loss per insect.

To estimate the damage per insect, research plots are set up with various-sized insect populations on a crop at specific growth stages. Depending on the crop and insect pest combination, and on how the study is designed, various-sized insect population treatments may be established by infesting plots or caged plants with specific numbers of the pest insect, or by manipulating insect population levels using different rates and timing of insecticide application. Subsequently, yields are measured at the end of the season for grain crops, or at cutting for alfalfa harvest, and statistical procedures are used to determine the loss per insect. Entomologists use linear regression analysis, a statistical procedure, to analyze field research data and determine the relationship between number of insects per plant and yield loss.

We need this information over a wide range of insect pest densities, even very low levels of insect pest populations. It's actually very useful for farmers and IPM consultants to know with a high level of certainty that insect pest densities below a certain level will not cause measurable yield loss in experiments. In other words, at a certain point insect numbers are low enough that there is no yield difference between treated and untreated plots. Regardless of how high crop prices go, there is no benefit or need to treat below the *damage boundary*. Conversely, as long as the insect population is above the damage boundary, increasing crop prices may lead to a decrease in the EIL. Under these conditions, a lower insect pest population causes injury that justifies insecticide application given the higher value of the crop.

The full EIL equation incorporates cost of treatment per acre (C), value of the crop (V), yield potential of the crop (Yp), statistical coefficients from the linear regression relationship between insects per plant and yield loss (*a* and *b*), and the proportion of control that can be achieved by treatment (K). However, the basic formula for calculating the EIL can be condensed as written below (Pedigo 1989). The take-home message is that the EIL includes more than just the cost of treatment per acre and market value of the crop.

$$\text{EIL} = \frac{\text{gain threshold}}{\text{loss per insect}}$$

For insect pest/crop combinations when the relationship between insects per plant and yield loss cannot be approximated by a straight line (i.e., it is curvilinear), a more complex form of the EIL equation must be used.

Revisiting IPM decision support for field and forage crop insect pests

North Central region field and forage crops are intimately linked as alfalfa is the primary perennial legume crop in rotation with annual commodity crops. This agricultural system is undergoing rapid change in terms of increasing crop prices, and the proportion of acreage planted to each of these crops. In Wisconsin, for example, a significant shift occurred in 2007 when farmers planted 4.1 million acres of corn – 11% more than in 2006. Many of these corn acres came from soybean acres. In 2008, soybeans returned to average state level (1.7 million acres), while winter wheat increased to 350,000 acres (a 40% increase from 2006). By contrast, Wisconsin alfalfa remained constant at 2.4 million acres from 2003 to 2008 and new seedings decreased by 26% from 500,000 acres in 2007 to 370,000 acres in 2008 (data: USDA NASS, 2008). Corn and soybean crop prices have increased significantly and remained favorable over the last two to three years, due in part to surging investment in biofuels. In 2007, alfalfa prices increased sharply, partly due to tight hay supplies and partly in response to rapid increase in corn costs exerting upward pressure on forage value (Mintert, 2008).

Farmers and consultants are questioning whether to lower economic thresholds (ET) and apply insecticide at lower insect pest densities in field and forage crop systems. The EIL and ET levels for soybean aphid, *Aphis glycines* Matsumura, were developed quite recently and published in 2007 (Ragsdale et al., 2007). By comparison, EIL and ET levels for potato leafhopper, *Empoasca fabae* (Harris), in alfalfa were first developed over 20 years ago (Cuperus et al., 1983). Although potato leafhopper (PLH) economic thresholds have been revisited for PLH-resistant glandular haired alfalfa varieties (Lefko et al., 2000), hay and forage producers ask frequently if they should treat below established economic thresholds on PLH-susceptible (normal) alfalfa varieties, given increasing alfalfa hay prices (Holin, 2008).

This workshop will explore two case studies. First, we review the recent North Central region university research data (Ragsdale et al., 2007) for soybean aphid yield-loss measurements across six states over 3 years, and a wide range of soybean prices, including recent high prices in the 'teens'. Second, we review existing yield-loss relationship data for potato leafhopper in alfalfa and the link between leafhopper insecticide application timing and parasitoids responsible for alfalfa weevil biological control.

Case study 1: Soybean aphid economic threshold

A common question during the 2008 growing season was … "The price of beans needs to be factored into the threshold in some way. Do $15 soybeans mean we lower the economic threshold below 250 aphids/plant?" The economic threshold of 250 aphids/plant has not changed.

The soybean aphid economic threshold is valid through the R5 stage. Replicated field plot research was conducted over 3 years, in 19 yield-loss experiments, across six states (Iowa, Michigan, Minnesota, Nebraska, North Dakota, and Wisconsin). This data set was used to determine the relationship between number of aphids/plant and yield loss across a range of aphid densities and soybean varieties.

The economic threshold (ET) of 250 aphids/plant is set below the economic injury level (EIL). When the research was conducted 2004, 2005, 2006, soybean prices were $5.50-$6.50/bushel. At that time the EIL, or number of aphids that need to be present for the value of the lost yield to equal the costs of control, was approximately 674 aphids/plant.

Now that market value for soybeans has increased, a lower EIL can be calculated (based on the linear regression analysis of the relationship between soybean aphid/plant and soybean yield over a wide range of densities, over 3 years across six states). David Ragsdale, the lead author of the Economic Threshold study (Journal of Economic Entomology 100: 1258-1267) re-calculated the EIL. For example, for soybeans selling at $15/bushel, with $8/acre control costs, and anticipated yield of 50 bu/acre. The EIL is lowered from 674 aphids/plant to 450 aphids/plant.

The economic threshold (i.e., insect population density at which control action is taken) of 250 aphids/plant is still below this revised EIL of 450 aphids per plant. When soybean prices were $5.50-$6.50/bushel, the ET of 250 aphids/plant allowed 7 days lead time to treat before reaching the EIL of 674 aphid/plant. A lower EIL (450 aphids/plant) given higher soybean prices, simply reduces the lead time to 3-4 days to treat before reaching the EIL. Thus, the economic threshold of 250 aphids/plant has not changed.

For an excellent, detailed explanation of the Upper Midwest research data behind the soybean aphid economic threshold of 250 aphids/plant and Economic Injury Level, please see the Plant Management Network web seminar with voice narration. It takes about 26 minutes to view the slide set. Access the presentation by Dr. Dave Ragsdale, University of Minnesota, at:
http://www.plantmanagementnetwork.org/edcenter/seminars/SoybeanAphid/

From the link above, click on "Part II: Soybean Aphid: Economic Threshold and Economic Injury Level".

In our research across the Upper Midwest, using the common experimental protocol detailed in the web seminar above, treating below 250 aphids/plant resulted in NO detectable yield increase. 250 aphids/plant is not where injury begins, it is below the *damage boundary*. The economic threshold of 250 aphids/plant provides lead time to treat the field within a few days to prevent it from reaching the revised EIL of 450 aphids/plant.

Case study 2: Potato leafhopper economic thresholds

Initial research that established an economic injury level and economic thresholds for potato leafhopper on alfalfa was conducted between 1979-1981 in Minnesota (Cuperus et al., 1983). This research was performed on established alfalfa stands in 0.25-acre plots. Rather than infesting plots, or caging plants within plots, natural infestation potato leafhopper population densities were manipulated across treatments by cutting practices (maintaining uncut alfalfa refuges from which potato leafhoppers could infest treatment plots) and application of insecticides. Potato leafhoppers were sampled weekly during 2nd and 3rd crops, at various crop heights ranging from 2 to 21 inches. Similar to soybean aphid EIL studies (Ragsdale et al., 2007), potato leafhopper abundance was expressed as potato leafhopper/sweep/week. Cumulative numbers are used because damage potential depends on duration of infestation, population density, and alfalfa height when infestation occurs.

In this original work (Cuperus et al., 1983), the potato leafhopper EIL was defined as the number of cumulative potato leafhopper/sweep/week that caused a yield loss reduction equivalent in value to the cost of control. The study used a control cost of $6.50 per acre application cost of dimethoate, and 1983 alfalfa crop values calculated based on cost of replacement feeds (soybean meal; corn) at the time. In summary, this original work established an economic injury level of approximately 0.74 potato leafhoppers (PLH) per sweep; and economic thresholds for a range of alfalfa heights: 0.32 PLH/sweep at 2 inches, 0.40 PLH/sweep at 5 inches, and 0.5 PLH/sweep at 7 inches.

Compared to the research data set for soybean aphid economic injury levels and economic threshold where the damage boundary is known (Ragsdale et al., 2007), potato leafhopper studies have not yet identified the damage boundary on alfalfa. Cuperas et al. (1983) did show that alfalfa dry-matter yield loss per potato leafhopper is a curvilinear relationship, with more yield loss at low leafhopper numbers than at high leafhopper numbers. However, their economic injury level and economic thresholds summarized above took this relationship into account. Moreover, the potato leafhopper economic thresholds in use today for non-glandular haired varieties (DeGooyer et al., 1998; Lefko et al., 2000) are more conservative than those originally calculated by Cuperas et al. (1983).

Current potato leafhopper economic thresholds on alfalfa are 0.1 potato leafhopper (nymphs and/or adults) per 15 inch diameter sweep net sample for each 1 inch of plant height, if the alfalfa is < 10 inches tall, and $\geq$ 2 potato leafhoppers per sweep if the alfalfa is taller than 10 inches (Rice, 1996; DeGooyer et al., 1998; Boerboom et al., 2008). For example, the economic threshold for 6 inch alfalfa is reached at 5 potato leafhoppers/10 sweeps, or 0.5/sweep. Taller plants are able to tolerate more leafhoppers (Wilson et al., 1989). If the economic threshold is reached on tall alfalfa within 7 days of planned harvest, the cultural control of early harvest is advised, rather than insecticide treatment (Undersander et al., 2004).

Finally, alfalfa supports a diverse population of insect species. In addition to potato leafhopper, key insect pests in Wisconsin and the North Central region include alfalfa weevil, *Hypera postica* (Gyllenhal), and a complex of aphid species dominated by pea aphid, *Acyrthosiphon pisum* (Harris). The rest are local, sporadic or incidental herbivores, and many are beneficial insect predators and parasitoids, or pollinators (Flanders and Radcliffe, 2000). A highly successful importation biological control project for alfalfa weevil in the Midwest established multiple parasitoid species that have nearly eliminated the need for insecticide application against alfalfa weevil (Radcliffe and Flanders, 1998). Moreover, alfalfa provides an ecosystem service (Koshel and Mcallister, 2008) as habitat for beneficial insects important to annual crop/pest combinations such as soybean/soybean aphid (Schmidt et al., 2007).

Potato leafhopper represents the pivotal insecticide use decision for Wisconsin farmers each year in alfalfa, a crop with several attributes, as described above, which make it an excellent candidate for the application of IPM approaches.

Current potato leafhopper economic thresholds appear conservative enough to protect against dry-matter yield loss in the current high value hay market. At this time, university research does not support lowering potato leafhopper economic thresholds below the current 0.1 PLH/sweep for each 1 inch of plant height. Additional field research quantifying "no effect" (i.e., damage boundary) when alfalfa is treated below current economic thresholds would be useful and preliminary studies in Wisconsin aim to obtain these data.

This workshop will conclude with a discussion of how current economic threshold treatment decision support for potato leafhopper in alfalfa will continue to provide IPM decision support allowing growers and advisors to benefit from highly effective potato leafhopper insecticide management tactics, while re-focusing on the importance of scouting-based economic threshold treatment decisions to preserve long-standing biological control success for alfalfa weevil.

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FUTURE OF BIOCONTROL FOR SOYBEAN APHID

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Introduction

The soybean aphid, *Aphis glycines*, is a serious pest of soybean in Wisconsin and the upper Midwest. An import from China, the initial detection in 2000 of the soybean aphid in North America was in Wisconsin (Wedberg et al., 2001). Midwestern entomologists responded to the challenge of soybean aphid management by working together to determine a treatment threshold (Ragsdale et al., 2007) to use in conjunction with insecticidal control. In addition, research on soybean plant resistance is underway and is showing great potential as a tool for soybean aphid management (Hill et al., 2006a,b, Diaz-Martin et al., 2007). A third important management tactic, and the topic of this report, is biological control (or biocontrol) of the soybean aphid. We use the term biological control in its broadest context to include the actions of all types of aphid natural enemies – predators, parasitoids and pathogens - and species that are naturally occurring as well as those under human manipulation. We will focus our comments on predators and parasitoids. Soybean aphid is attacked by a number of pathogenic fungi (Nielsen and Hajek, 2005), but we have not observed pathogens to be a significant source of aphid mortality in Wisconsin.

Predators

A complex of insect predators attacks the soybean aphid in Wisconsin (Table 1). The most commonly encountered predator of the nine listed is the Asian lady beetle. Ironically, this predator is also an exotic species from China that was intentionally introduced into the southeastern U.S. and arrived in Wisconsin in the late 1990s. The Asian lady beetle is an aggressive and voracious predator of soybean aphids, but unfortunately it has significant negative attributes as well. The seven spotted lady beetle is an exotic species as well, having arrived in Wisconsin in the early 1980s.

Table 1. Soybean aphid predators commonly found in Wisconsin.

Species	Order: Family	Predatory stage(s)
Lady beetles	Coleoptera: Coccinellidae	Larva & Adult
Asian lady beetle (*Harmonia axyridis*)		
Seven spotted lady beetle (*Coccinella septempunctata*)		
Pink lady beetle (*Coleomegilla maculata*)		
Minute pirate bug (*Orius insidiosis*)	Hemiptera: Anthocoridae	Nymph & Adult
Damsel bugs (*Nabis* species)	Hemiptera: Nabidae	Nymph & Adult
Lacewings		
Green lacewings (*Chrysoperla* species)	Neuroptera: Chrysopidae	Larva
Brown lacewings (*Hemerobius* species)	Neuroptera: Hemerobiidae	Larva
Predatory flies		
Syrphid flies (many species)	Diptera: Syrphidae	Larva
Aphid midge (*Aphidoletes* sp.)	Diptera: Cecidomyiidae	Larva

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Parasitoids

Predators have responded to the soybean aphid invasion, and collectively they help suppress aphid numbers and lessen the impact of the pest on soybean productivity. However, a major component of the suite of natural enemies that typically attack pest aphids – parasitoids – is largely missing for the soybean aphid. These parasitoids are tiny, non-stinging wasps. The female uses her "stinger" to lay an egg inside an aphid, where the wasp larva feeds, develops, and eventually kills the host aphid. Parasitoids fill an important niche – they have much shorter generation times than do predators and can thus "keep up" better with growing aphid populations, plus parasitoids often provide better control than do predators at low aphid densities early in the season.

To address this absence of soybean aphid parasitoids, a collaborative project involving university and federal (USDA) entomologists has sponsored exploration in China and other Asian countries to find and collect parasitoids of the soybean aphid. Promising species are shipped to quarantine facilities in the U.S. to be evaluated for potential establishment against soybean aphid here. While in quarantine, each of the parasitoid species is studied to assess its potential effectiveness to control soybean aphids as well as to ensure insignificant risks for safety and non-target effects. This approach, which is known as "importation" or "classical" biological control, has been successfully employed for a number of other exotic insect pests.

More than a dozen parasitoid species are now in quarantine in the U.S., and one species, known only by its scientific name *Binodoxys communis*, has been fully vetted (e.g. Wyckhuys et al., 2008) and obtained USDA and selected state permits for release in soybean fields. *B. communis* was released in six states (IA, IN, MN, MI, and SD, as well as WI) during 2008, at 32 separate sites across the region, and the parasitoid was subsequently recovered at most of the release sites. We made seven releases in Wisconsin, which are detailed in Table 2. We monitored each of these sites weekly, and we recovered parasitoids at all but the Muscoda site. However, *B. communis* must survive the winter and be recovered in 2009 before truly successful establishment can be determined.

Table 2. 2008 Wisconsin releases of *Binodoxys communis* for soybean aphid biological control.

Date	Location	Numbers released	Initial/Final Aphid Numbers (per plant)
2 July	West Madison Ag Research Station #1	1,000	0.9/616
	West Madison Ag Research Station #2	1,000	2.2/540
14 July	Dodge County (Columbus)	500	7.1/981
	Winnebago County (Ripon)	500	10.1/852
5 August	Grant County (Muscoda)	1,000	125/345
	Dane County (Lodi)	1,000	92/260
18 August	Dane County (Deerfield)	3,000	152/239

During the past two summers (2007 and 2008), we have also encountered a native parasitoid, *Lysiphlebus testaceipes*, attacking soybean aphids in significant numbers in Wisconsin. We had observed *L. testaceipes* in previous years, but only sporadically and in very low numbers. This parasitoid is known to have an extremely broad host range of aphids it will attack. It is possible that *L. testaceipes* is adapting to the presence of the soybean aphid, in essence expanding its host range to include soybean aphid, and if so it may be a significant natural enemy in future years.

Conclusions

Soybean aphid biological control is an important consideration in managing this pest. Future efforts should be directed at establishing additional parasitoid species to enhance the overall effectiveness of biological control. In addition, there is need to determine how best to integrate the three major control tactics (biological control, plant resistance, and chemical control), to ensure they are compatible plus take advantage of potential synergies. For example, soybean plants with resistance to the aphid will likely reduce reliance on insecticides for aphid control, thus minimizing the harmful effects of insecticides on natural enemies. Also, it is conceivable that plant resistance may enhance biological control by slowing the soybean aphid's population growth rate, thus giving natural enemies an edge in the struggle between predators and prey, and again reducing the need for insecticidal inputs.

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NITROGEN AVAILABILITY OF TREATED AND RAW DAIRY MANURE

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Abstract

There is minimal information on the nitrogen (N) availability and composition of treated manures. Knowing how N availability differs with manure treatment will result in better N crediting guidelines. Raw dairy manure and anaerobically digested manure were incubated with five typical Wisconsin soils for 112 d. Net N mineralized from the different N sources were compared. Nitrogen mineralization differed by manure type and also by soil. Overall, the digested slurry and the digested separated liquid mineralized more N than the raw slurry. The digested separated solid mineralized significantly less N than the other manures. Net N mineralization as a percent of total N applied was 39, 58, 49, and 17% for raw, digested slurry, digested separated liquid, and digested separated solids, respectively, when averaged over all soils. C:N ratio of manure was found to be the most useful predictor of manure N mineralization.

Introduction

On farm manure treatment systems are increasing in popularity among producers nationwide for various reasons, including more efficient transportation and storage along with reduced odor and lower pathogen levels in treated manure. Such treatment systems (anaerobic digestion, composting, and solid separation) alter the chemical and physical properties of manure, which have the potential to affect plant available nutrients. Little research has been conducted assessing the impacts of manure treatment on availability of N in the treated manures.

In Wisconsin, first year N application rates for dairy manure are based on 30% availability of total N if surface applied and 40% total N if incorporated within 72 hours of application (Laboski et al., 2006). No adjustments are currently made for N availability regarding the treatment type or manure composition. A few past studies have shown manures with different handling systems or at different stages of treatment mineralize N differently. For example, Kliese et al. (2005) and Shi et al. (1999) found composted manures mineralize N slower and less than raw manures. Several studies have also shown relationships between certain manure properties (such as C:N or neutral detergent fiber, NDF) and N mineralization rates (Griffin et al., 2005; Kyvsgaard, 2000). However, more research is needed to quantify the differences in N mineralization between treated and raw manures to determine if nutrient availability guidelines should be modified to consider manure treatment or manure characteristics.

The objectives of this study are to 1) determine how much N mineralization differs between raw and treated manures, 2) assess manure compositional effects on N mineralization, and 3) evaluate soil series effects on manure N mineralization.

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Materials and Methods

An incubation was carried out for 112 days with various dairy manures incorporated into multiple agricultural soils to study the effects of manure treatment and soil type on N mineralization. Five common Wisconsin soils were collected from throughout the state including: Plano silt loam, Kewaunee silt loam, Fayette silt loam, Withee silt loam, and Richford sand. The soils were collected from a 0 to 0.2 m depth, sieved through a 2-mm sieve, air dried, and stored in plastic containers until needed. Soil characteristics are provided in Table 1.

Four dairy manures were collected from one farm at various treatment stages (Fig. 1) and include: raw slurry, digested slurry, and digested and separated liquid and solid manures. All manures were analyzed and stored frozen until needed. Manure characteristic data can be found in Table 2.

For each soil/manure combination, manure was mixed with soil at a rate of 150 mg total N kg^{-1} soil with four replications. Deionized water was then added to each container to reach 60% water filled pore space. After thoroughly mixing the manures and soil, each 350-g container was aliquoted into seven 40 g subsamples and placed in smaller containers and packed to a bulk density of 1100 kg m^{-3}. Lids with four small ventilation holes were placed on each subsample container and incubated at 25°C for 0, 3, 7, 14, 28, 56, and 112 days. Water was periodically added to the samples to maintain 40 to 60% water filled pore space. On each sampling date, the entire subsample was removed, air dried, ground, and stored until analyzed.

Soil samples were extracted with 2 M KCl. Ammonium and nitrate were analyzed on a PowerWave^{TM} XS microplate spectrophotometer (BioTek Instruments; Winooski, VT) using the sodium salicylate-nitroprusside method (Keeney and Nelson, 1982) and the single reagent method with vanadium (Doane and Horwáth, 2003), respectively.

Net N mineralized was calculated as the N mineralized in a treatment minus the N mineralized from the control. A generalized linear model for a completely randomized design was used to assess the affect of manure treatment and soil type on net N mineralized at 112 d ($Nmin_{net112}$) using Fisher's protected LSD for means separation at α=0.05. Relationships between $Nmin_{net112}$ and manure characteristics (including total N, neutral detergent fiber, acid detergent fiber, lignin, total C and C:N ratio) were assessed.

Results and Discussion

For all silt loam soils (Fayette, Kewaunee, Plano, and Withee) the digested slurry had greatest N mineralization over the course of the incubation, followed by digested separated liquid, raw slurry, then the digested separated solid (Fig. 2). On the sand soil (Richford), the digested separated liquid had the greatest N mineralization, followed by the digested slurry, raw slurry, then the digested separated solid. The digested separated solid mineralized N rapidly in the first 7 to 14 days of the incubation, after which some of the mineralized N immobilized.

For all soils, the digested separated solid had significantly lower net N mineralization at day 112 ($Nmin_{net112}$) than the other manures (Table 3). The digested slurry had significantly greater $Nmin_{net112}$ than digested separated liquid and the raw slurry for three of the silt loams (Fayette, Plano, and Withee). On one silt loam soil (Kewaunee) there was no significant difference in $Nmin_{net112}$ between the raw slurry, digested slurry and digested separated liquid. The digested separated liquid had greater $Nmin_{net112}$ than the digested slurry and raw slurry in the sand (Richford). However, differences in $Nmin_{net112}$ were not always significant. For the raw slurry, there was no significant effect of soil type on $Nmin_{net112}$. For all other manure treatments there were some differences in $Nmin_{net112}$ (sometimes significant) with soil type. However, there was no consistent effect of one soil type on $Nmin_{net112}$.

$Nmin_{net112}$ as a percent of total N applied was 39% for raw slurry when averaged over all soils. This is in agreement with the current first year N availability estimates for dairy manure from Wisconsin (Laboski et al., 2006). $Nmin_{net112}$ as a percent of total N applied was 58%, 49% and 17% for digested slurry, digested separated liquid, and digested separated solid, respectively, when averaged over all soils.

$Nmin_{net112}$ was best correlated with the C:N ratio of manure (r=-0.99 p<0.01). Similar results were found by Barbarika et al. (1985). $Nmin_{net112}$ was to be significantly correlated to $C:NH_4$ (r=-0.96 p<0.04), which is consistent with findings by Griffin et al. (2005). However, $Nmin_{net112}$ was not found to be significantly correlated with $NDF:NH_4$, which contrasts with findings by Griffin et al. (2005). Ratios of NDF:N (r=-0.97 *p*<0.03) and ADF:N (r=-0.95 *p*<0.05) were also found to be significantly correlated with $Nmin_{net112}$.

Conclusion

Averaged over all the soils, N mineralization is greater in digested slurry and digested separated liquid manure and less in digested separated solid manure compared to raw manure. N availability recommendations to producers should be modified to consider these differences in N mineralization. The C:N ratio was found to be the most useful predictor of N mineralization in soil. More manure treatments are currently being evaluated to assess their N availability in comparison to raw manure.

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Table 1. Soil characterization.

Soil series†	Taxonomic name	pH	OM
			g kg^{-1}
Plano sil	Fine-silty, mixed, superactive, mesic Typic Agriudoll	5.7	42
Kewaunee sil	Fine, mixed, active, mesic Typic Hapludalf	7.7	32
Fayette sil	Fine, silty, mixed, superactive, mesic Typic Hapludalf	7.1	27
Withee sil	Fine-loamy, mixed, superactive, frigid Aquic Glossudalf	6.7	27
Richford s	Loamy, mixed, superactive, mesic Arenic Hapludalf	6.7	19

† sil, silt loam; s, sand.

Table 2. Selected manure characteristics.

Characteristic	Units	Raw slurry	Digested slurry	Digested separated liquid	Digested separated solid
Dry Matter	g kg^{-1}	49.2	75.0	26.0	254
Total N	g kg^{-1}	39.6 ±0.1†	38.5 ±3.0	79.3 ±2.3	22.9 ±1.4
NH4-N	g kg^{-1}	20.6 ±1.4	20.4 ±1.1	52.5 ±2.7	5.92 ±0.06
NDF	g kg^{-1}	457 ±7	475 ±5	201 ±16	728 ±10
ADF	g kg^{-1}	320 ±13	370 ±17	214 ±11	592 ±4
Lignin	g kg^{-1}	113 ±4	167 ±11	118 ±7	261 ±3
Total C	g kg^{-1}	387 ±36	318 ±16	366 ±10	433 ±13
C:N		9.8 ±3.5	4.6 ±4.2	8.3 ±0.7	19 ±9

† mean ± standard deviation.

Table 3. Mean net N mineralization on day 112.

Manure	Soil				
	Fayette	Kewaunee	Plano	Withee	Richford
	mg N kg-1 soil				
Raw Slurry	45.9 C†	67.0 A	64.0 C	53.2 C	62.1 B
Digested Slurry	87.6 A,bc	78.4 A,cd	103.7 A,a	90.1 A,b	72.5 AB,d
Digested Separated Liquid	67.8 B,b	64.1 A,b	76.9 B,a	78.7 B,a	77.0 A,a
Digested Separated Solid	21.1 D,bc	28.5 B,ab	33.6 D,a	27.7 D,ab	16.3 C,c

† Means within a row for a given manure followed by the same lowercase letter or means with a column for a given soil followed by the same uppercase letter are not significantly different ($p<0.05$) from each other.

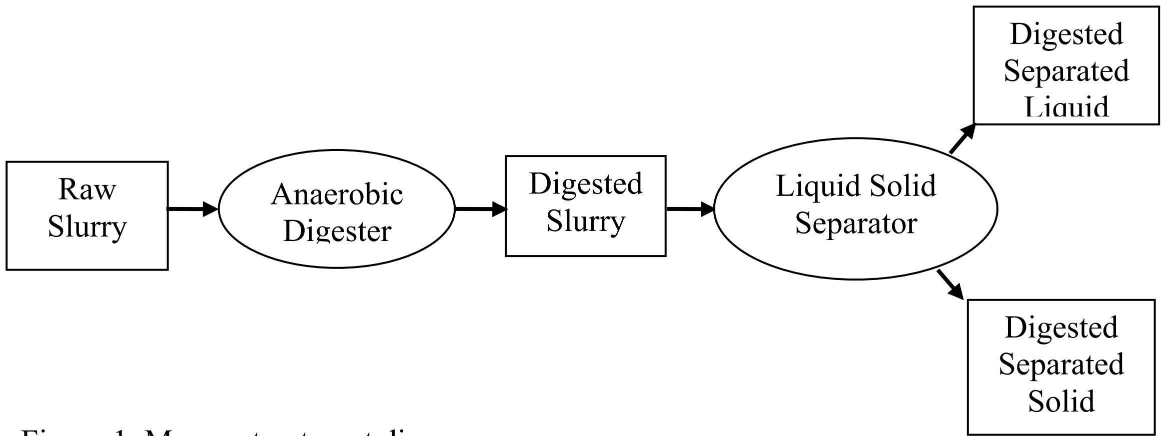

Figure 1. Manure treatment diagram.

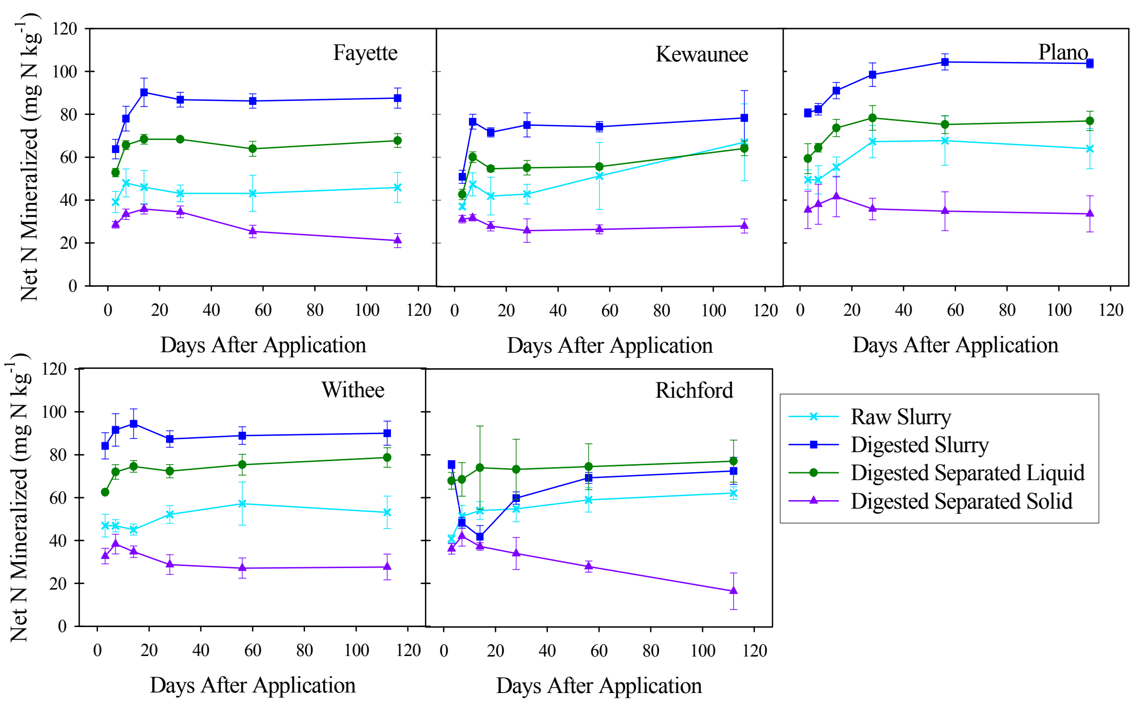

Figure 2. Net N mineralized throughout the incubation for each soil.

DAIRY MANURE NUTRIENTS: VARIABLE BUT VALUABLE

Bill Jokela[1] and John Peters[2]

Nutrient management planning for a dairy farm is important to maximize utilization of manure nutrients for crop production, as well as to avoid excessive application rates and adverse water quality impacts. The nutrients in manure have become even more valuable recently with dramatic increases in fertilizer prices. But just what is the content of various nutrients in dairy manure? How much is it worth as fertilizer replacement? How variable is the nutrient content from different farms? And have there been changes over time with shifts in feeding or other management practices? Recent summaries of manure analyses run by laboratories in Wisconsin and Vermont can help to answer these questions.

Manure Nutrient Content: Laboratory vs. Book Values

Most state extension programs publish "book values" of manure N, P, and K content for use in nutrient management planning when nutrient lab analysis from individual farm samples are not available. Book values for Wisconsin are published in UW Extension publication A2809 (Laboski et al., 2006). Another commonly used source for book values in the Midwest is the Livestock Waste Facilities Handbook (MWPS, 2007). Comparison of these book values to average values for laboratory analysis of dairy manure N, P, and K content from recent long-term summaries in Wisconsin and Vermont are shown in Table 1. The book values from UW-Extension A2809 agree quite well with average numbers from both WI and VT summaries, whereas the MWPS book values are somewhat higher or lower in some cases.

What is the Fertilizer Value of Manure?

Using average NPK values from the long-term Wisconsin summary, nutrient availability factors from A2809, and current fertilizer prices, we can estimate the dollar value of dairy manure (Table 2). It is important to recognize that only a portion of the total nutrient content, especially of N, is available to the crop in the first year, the remainder being either lost or tied up in the soil (and some becoming available in future years). Availability factors have been developed to estimate what percentage of the total nutrient content is available, that is, what its fertilizer equivalence is. UW Extension nutrient availability values are: N, 40% for incorporated manure (within 3 days) and 30% for non-incorporated; P_2O_5, 60%; and K_2O, 80%. Because these are estimates based on experience and limited research, values vary among states. For example, University of Minnesota Extension uses somewhat higher values, and some states break manure nitrogen into two N pools, urea or ammonium-N, and organic N.

Using UW-Extension nutrient availability estimates and current fertilizer prices, the N, P, and K in an average liquid dairy manure has a first-year fertilizer value of about $23 per 1000 gallons (Table 2). If the manure were applied to a field with high soil test P and K (and, therefore, no additional P or K need), the nitrogen alone would be about $7.50. The comparable numbers for solid manure are close to $6 per ton NPK and $3.75 for N only. Assuming an application rate of 10,000 gal per acre of liquid manure or 20 tons per acre solid manure (typical for corn production), the fertilizer value would be $75 per acre for N and over $200 for NPK.

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Table 1. Dairy manure nutrient content: Lab analysis averages vs. book values.

		Lab analysis		Book values	
System	Nutrient	WI[1]	VT[2]	A2809[3]	MWPS[4]
		lbs/1000 gal			
Liquid	N	22	24.0	24	31
	P_2O_5	8	9.0	9	15
	K_2O	19	20.6	20	19
	DM %	7	7.0	6	--
		lbs/ton			
Solid	N	11	10.2	10	10
	P_2O_5	6	5.5	5	3
	K_2O	10	8.5	9	6
	DM %	33	29.1	24	--

[1] Averages of 4,691 solid/semi-solid dairy and 10,144 liquid dairy manure samples analyzed by four Wisconsin-based laboratories 1998-2008 (Peters, 2008).
[2] Averages of 1623 liquid and 743 solid/semi-solid dairy manure samples analyzed by Univ. of Vermont Agricultural and Environmental Laboratory 1992-2006 (Jokela et al., 2005).
[3] UW-Extension Publication A2809 (Laboski et al., 2006).
[4] Livestock Waste Facilities Handbook (MWPS, 2007).

Table 2. Average total and available N, P, and K content and dollar value of dairy manure based on average nutrient analysis of 14,855 samples by Wisconsin labs (Peters, 2008)

Nutrient	Total	Available		
		Liquid Manure		
	lb/1000 gal		\$/1000 gal[1]	\$/10,000 gal
N	22	8.8	7.48	75
P_2O_5	8	4.4	4.56	46
K_2O	19	15.2	11.10	111
Total			23.14	231
		Solid/Semi-solid Manure		
	lb/ton		\$/ton	\$/ton
N	11	4.4	3.74	75
P_2O_5	6	3.6	3.42	68
K_2O	10	8.0	5.84	117
Total			13.00	260

[1] N as urea \$0.85/lb, P_2O_5 as MAP or DAP is \$0.95/lb, and K_2O as potash is \$0.73/lb

Variability of Nutrients in Manure

These calculations of dairy manure nutrient content and dollar value were based on average nutrient content. The nutrient content of manure on an individual farm, however, may vary considerably from the average. Variability of N and P content of over 1600 liquid dairy manure samples analyzed by the University of Vermont Agricultural and Environmental Testing Lab over a 15-year period is shown in Figure 1. The average, or mean, N and P values for liquid manure (24 lb N/1000 gal and 9 lb P_2O_5/1000 gal; Table 1) match well with the peaks of the histograms and 30 to 40 % fall within about 20% of the mean. However, over a third of the samples are more than 8 lb N and 4 lb P_2O_5 above or below the mean, which would result in large errors in N or P application rates if average values were used. The large variability could be the result of a number of factors such as differences in diets and bedding, amount of water entering the storage facility, degree of agitation, and sampling technique.

For example, the application rate to meet a 100 lb/acre crop N need based on the average value of 24 lb/1000 gal (9.6 lb available) would be 10,400 gal per acre. However, if the actual N analysis were 16 lb/1000 gal (8 lb less), that rate of manure would only supply an estimated fertilizer equivalent of 67 lb/acre, and would likely result in a nitrogen-deficient crop. The same manure application rate would closely match the P requirement (50 lb P_2O_5/acre) for a 150-bu/acre corn crop on a soil testing optimum in P. But if the actual analysis were off by 4 lb/1000 gal, the available P would be in excess or short 17 lb/acre. If the nutrient management plan required application on a P basis, a P content error of +/- 4 lb P_2O_5/acre could make a considerable difference in the allowable application rate and land area required. This emphasizes the importance of sampling and analysis of manure from individual farms rather than relying on book values in order to have reliable nutrient content values for nutrient management planning.

Trends Over Time

The long-term summaries of dairy manure nutrient analysis from Wisconsin (10-year) and Vermont (15-year) provide an opportunity to examine changes in nutrient content over time as a result of shifts in animal diets or other management practices. While there is considerable year-to-year variation and specific farms sampled are not the same each year, we can still observe some general trends over time.

Nitrogen content of dairy manure showed only small trends, with a slight decline in WI and increase in VT (Data not shown). Potassium content of liquid and/or solid increased over time in samples from both states (Data not shown?). However, phosphorus is the nutrient of primary interest because of concern about excess manure P application contributing to runoff water quality problems. Phosphorus content of liquid manure decreased by about 30% over the 10-year period in WI and for the 1992-2004 period in VT. (Figs. 2 and 3) (There were unexplained increases in the last two years in VT.) Solid/semi-solid manure showed a similar trend in the VT data but little change over time in WI (Data not shown.). The most likely cause of the decline in liquid manure P content is a shift to lower P in diets. Research results and extension education efforts in the past ten or more years have emphasized the economic and environmental importance of feeding dairy rations that meet but don’t exceed the animal P requirement, which has led to less P supplementation of feed. This phenomenon is supported by a decreasing trend in P content of total mixed rations (TMRs) in Wisconsin since 2002 (Fig. 2).

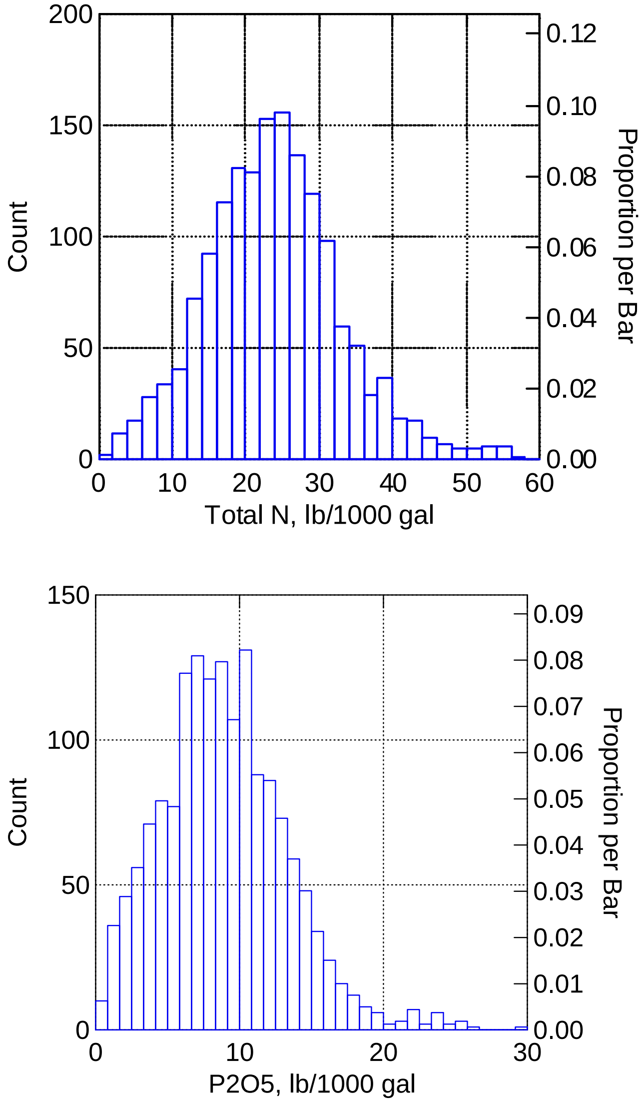

Figure 1. Variability of liquid manure N (top) and P (bottom) in Vermont samples.

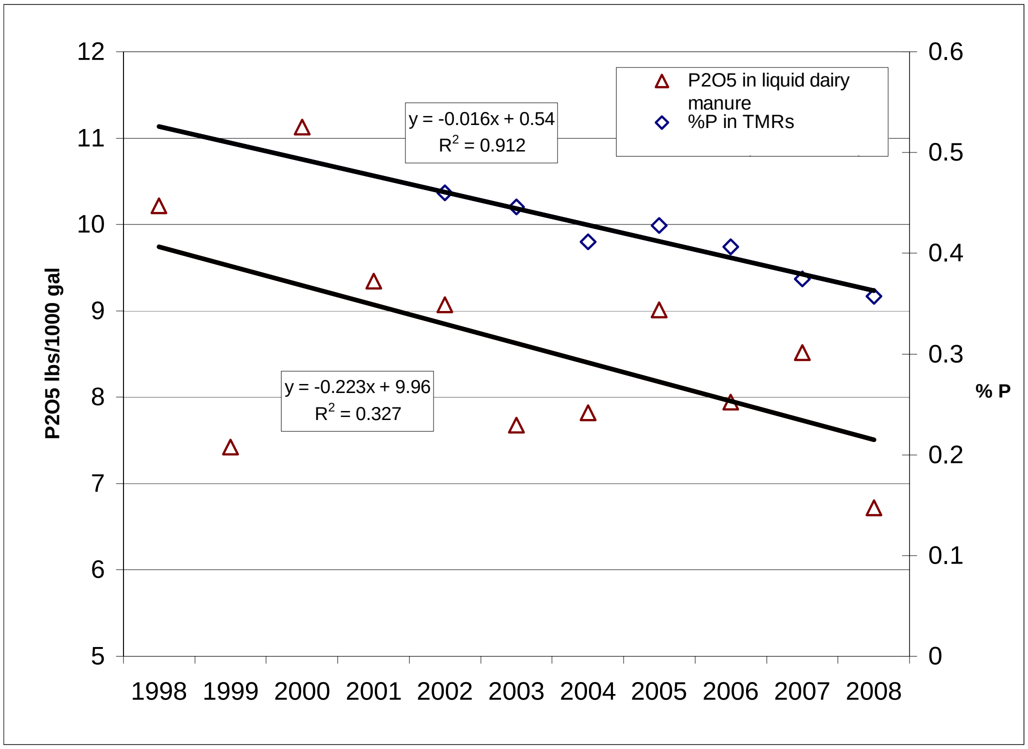

Figure 2. Long term trends in P content of liquid dairy manure and TMRs in Wisconsin.

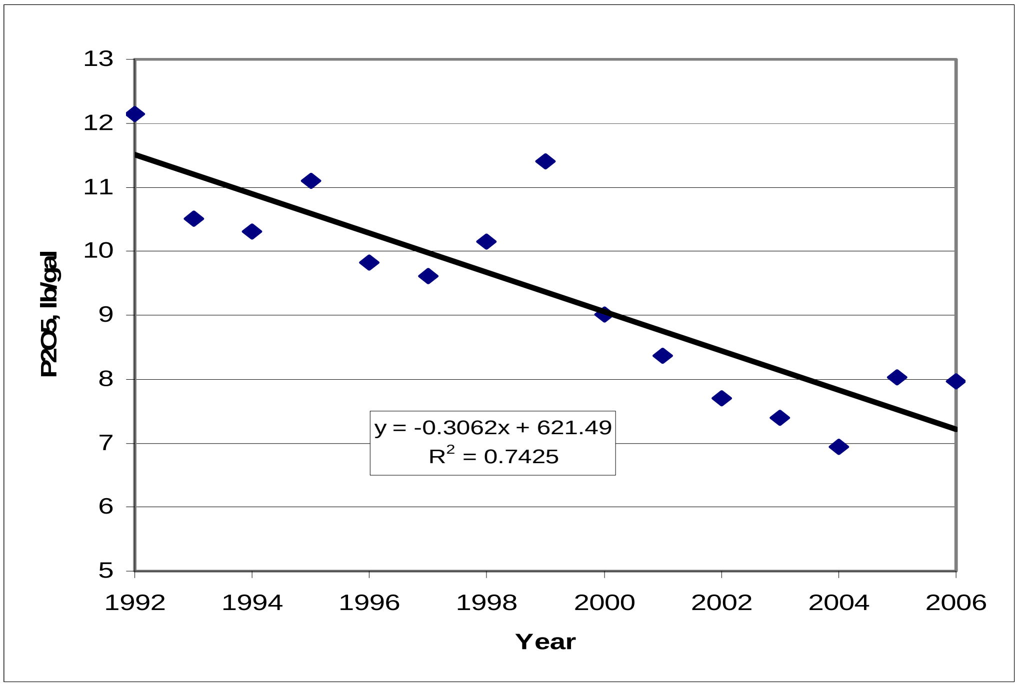

Figure 3. Long term trends in P content of liquid dairy manure in Vermont.

Manure also contains a variety of micronutrients that are of benefit to crops. The WI lab data doesn't include analysis of micronutrients, and the VT data showed only slight, if any, trends for most micronutrients. The exception was copper (Cu). The copper content of solid/semi-solid dairy manure in VT showed large year-to-year variation and also no consistent trend over time (Data not shown). But the copper content of liquid manure increased somewhat over the first seven years, and then increased dramatically in the post-1998 period, reaching values of over 500 mg/kg (dry matter basis) compared to averages under 100 at the beginning of the period. Distribution of copper values over the range showed large numbers of samples in the 100 to 1000 range and a number of samples testing several thousand mg/kg (Fig. 4). These results reflect increased use of copper sulfate in foot baths to treat hairy heel warts, and disposal of waste foot bath solution into liquid manure pits (Thomas, 2001; Stehouwer and Roth, 2004). The total loading of copper onto fields may be greater than the averages would indicate because most of the largest herds use liquid manure storage. The lack of increased copper in solid/semi-solid manure probably reflects a lower occurrence of hairy heel wart in management systems with solid manure and, possibly, alternative disposal methods. The pronounced increase in copper content of liquid manure raises concerns about possibilities of excessive loading of soils leading to toxic levels and crops and feed, although we are not aware of any documented cases at this time.

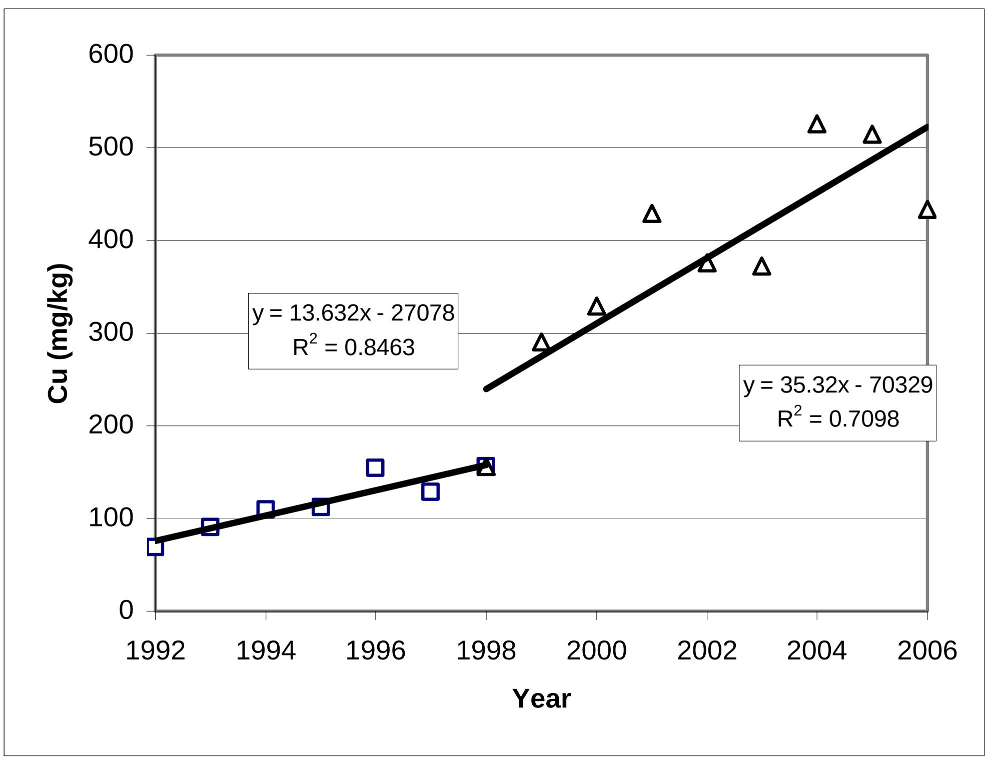

Fig. 4. Long-term trends in copper content (dry matter basis) of liquid dairy manure in Vermont.

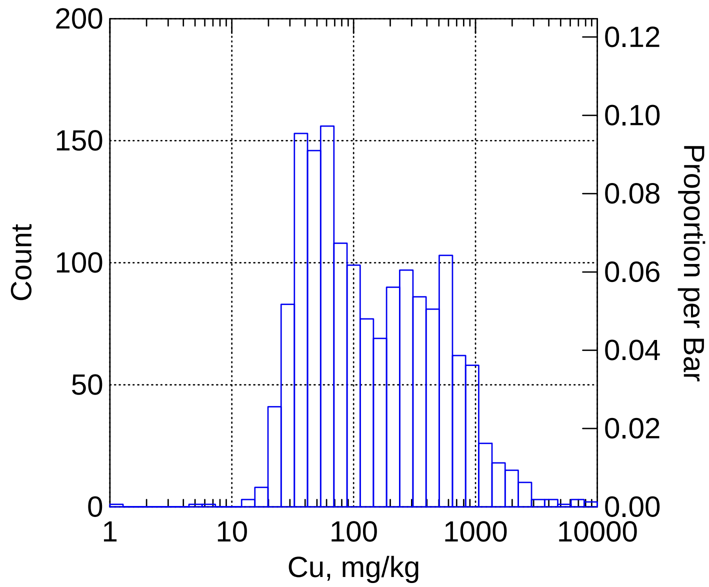

Fig. 5. Variability of copper content in liquid manure in Vermont samples (DM basis).

Summary

Summaries of over 14,000 dairy manure samples from Wisconsin and 2300 from Vermont over a 10 to15-year period showed average values that were consistent with UW-Extension book values but differed from those for some nutrients in the Livestock Waste Facilities Handbook. High variability, however, indicates that these average values are not reliable for nutrient management planning purposes, emphasizing the need for farm-specific sampling and analysis of manure to determine application rates. With high current fertilizer prices, the available nutrients in manure can be worth as much as $75 for N and over $200 for N, P, and K per acre at typical application rates for corn production. Two long-term trends were especially noteworthy. Manure content of P decreased significantly over most of the time period, presumably reflecting lowered P in dairy diets. And copper content of liquid manure in Vermont samples increased dramatically after1998, reflecting increased use of copper sulfate foot baths and raising concerns about long-term soil loading and potentially increased plant levels.

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FARMING FOR NITROGEN: INTERCROPPING CORN AND KURA CLOVER

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Introduction

Alfalfa and corn silage, grown in rotation, have long been the primary high quality forages harvested to support the dairy industry in Wisconsin. However, removal of essentially all plant residues with corn silage production results in excessive erosive soil loss (Gallagher et al., 1996), prompting the need for alternative soil conserving systems. The proposed removal of stover for biofuel feedstock after corn grain harvest will result in additional land prone to soil and nutrient runoff because of a lack of cover. Furthermore, the ever-increasing cost of nitrogen fertilizer encourages the search for cropping systems that rely on biologically fixed nitrogen for both corn grain and silage production.

Legume "living mulches" have been tested in the northern USA as a means to meet nitrogen requirements of corn (Eberlein et al., 1992; Hartwig and Ammon, 2002), but those perennial legumes evaluated reduced corn yields or failed to recover after corn harvest. Kura clover seems to be ideally suited to serve as living mulch. It is extremely persistent and produces rhizomes that allow it to fill in gaps that may otherwise be invaded by weeds (Albrecht and Kim, 1998). Our earlier research demonstrated that with adequate suppression, kura clover can be managed to provide minimal competition to corn (Zemenchik et al., 2000) and that the clover will recover to full production in the following growing season. The purpose of this paper is to review performance of herbicide resistant corn hybrids in kura clover living mulch.

Results and Discussion

The Model System

In many early attempts to intercrop corn with forage legumes as living mulches it was a challenge to provide the appropriate amount of suppression to minimize competition from weeds and the companion legume. Too much suppression removed the legume and too little suppression reduced corn yields. Herbicide-resistant corn hybrids have made this task much easier, and corn silage and grain yields in killed or suppressed kura clover are routinely similar (Table 1).

Table 1. Silage and grain yields of corn grown in kura clover living mulch near Lancaster and Arlington, Wisconsin in 1999 and 2000.

Corn/kura treatment	Silage yield	Grain yield
	tons DM/acre	bushels/acre
Roundup Ready Corn		
Kura clover killed	8.9	194
Kura clover suppressed	8.3	196
Liberty Link Corn		
Kura clover killed	8.6	188
Kura clover suppressed	8.4	184

Data from Affeldt et al. (2004).

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A successful model system that has been developed and tested includes suppression of kura clover with glyphosate in mid-April, no-till corn establishment when soil conditions allow, band-killing kura clover over the corn row with a broad-leaf herbicide at corn planting time, and a second application of glyphosate or Liberty herbicide (with appropriate resistant hybrids) 35 days after sowing corn to control both kura clover and annual weeds. This level of suppression is adequate for corn production (Table 1) and allows kura clover to recover to full production for hay or pasture by June of the following season. After identification of an appropriate clover suppression regime, attention was focused on both fertilizer nitrogen replacement value and potential environmental impact of kura clover living mulch.

Nitrogen Replacement Value

Corn grown in kura clover living mulch, as previously described, was fertilized with 0 to 80 lb N/acre (in the form of ammonium nitrate), in a side-dressed application at corn V5 stage. Whole plant corn yield, as for silage, was not increased by nitrogen fertilizer application ($P < 0.05$), although there was a tendency for an increase in silage yield with the first increment of nitrogen fertilizer (Fig. 1). Likewise, there was no significant ($P < 0.05$) increase in corn grain yield associated with nitrogen fertilizer application to corn grown in kura clover living mulch (Fig. 1). We suspect that mineralization of nitrogen from kura clover residues contributes to nitrogen pools available for corn production. These data suggest that in this intercropping system, there seems to be no advantage to applying more than 20 lb/acre of nitrogen fertilizer, an amount that could easily be included in the starter fertilizer at planting.

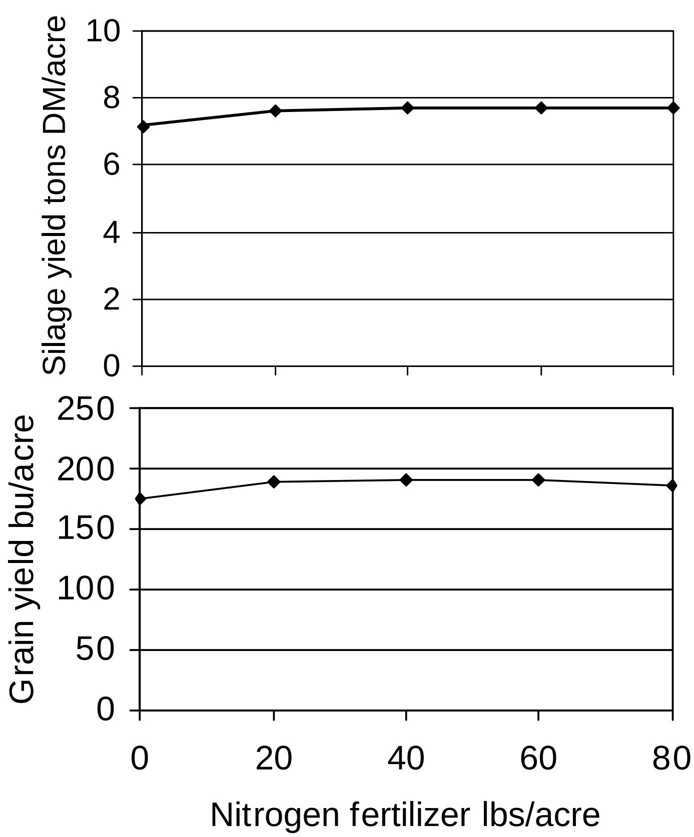

Figure 1. Corn silage and grain yield response to nitrogen fertilizer when grown in suppressed kura clover. Data are pooled over two seasons from Arlington and Lancaster, WI.

Environmental Impact

Our preliminary data from a sloping field at Lancaster suggest that there may be substantial reduction in soil erosion, but less effect on water runoff, from corn intercropped with clover compared to monoculture corn with conventional tillage (Table 2). More extensive research is planned to document the impact of corn production for silage, grain, and biofuel feedstock in living mulch on soil, nutrient, and water runoff from erosion prone landscapes.

Table 2. Sediment loss and water runoff from conventional and living mulch corn production systems at Lancaster, WI with three major rainfall events in 2006.

	Sediment loss (lb/acre)		Water runoff (gal/acre)	
Sample date	Conventional corn	Living mulch	Conventional corn	Living mulch
July 27	85	4	4,700	4,500
August 3	93	11	4,100	3,000
September 11	76	7	4,100	3,500

The concentration of nitrate-N in leachate 40 inches below the soil surface is substantially lower under corn produced in kura clover living mulch than under monoculture corn (Table 3). This is the case whether nitrogen fertilizer is applied to the living mulch or not. We speculate that the deep root system of kura clover captures nitrate that would otherwise potentially leach into the groundwater.

Table 3. Nitrate-N leachate under corn or corn-kura clover living mulch during the growing season and after corn harvest.

Season	Monoculture Corn + 80 lb/acre N	Living mulch corn + 80 lb/acre N	Living mulch corn + 0 N
		ppm nitrate-N	
Growing season	7.5	3.9	4.5
Dormant season	28.0	13.8	6.3

Growing season is April 1 through Sept. 30; Dormant season is Sept. 30 through March 31

Summary

Corn grown in suppressed kura clover requires little or no nitrogen fertilizer, an input cost that is expected to remain high in the foreseeable future. Permanent groundcover in this intercropping system would be expected to minimize soil loss from fields harvested for corn silage or stover for biofuel feedstock, and our preliminary data support this hypothesis. Nitrate concentrations in water below the root zone are substantially lower in the intercropping system than without clover, providing hope that nitrate contamination of groundwater could be reduced even as corn acreage increases to meet food and energy demands. Much work remains to be done to create profitable cropping systems that allow incorporation of legume living mulches into Wisconsin agriculture, and to more clearly document the environmental impact of these systems.

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COVER CROPS AND NITROGEN CREDITS

Matthew D. Ruark [1/] and James K. Stute [2/]

Introduction

With dramatic fluctuations in feed, fuel, and fertilizer prices, much attention is again being paid toward use of cover crops in agricultural systems. Cover crops provide benefits to agricultural systems such as reductions nitrogen (N) loss and potential reduction in N fertilizer need to maintain crop yields. Cover crops in Wisconsin's agricultural systems are most often used prior to corn following a short season crop such as winter wheat, potatoes, or vegetables. There are two main types of cover crops used in Wisconsin: (1) cool-season grasses and (2) legumes. Cool-season grasses are primarily used to provide ground cover in cropping systems that leave little residue after harvest in effort to reduce soil erosion. Leguminous cover crops are used to add N into the soil system through biological fixation of atmospheric N. When these legumes are incorporated into the soil, this "fixed" N becomes plant available as the soil tissue decomposes. Legume crops are grown for one season or less, and incorporated into the soil without harvesting, are referred to as green manures. Current UW recommendations are to take N credits when utilizing green manures such as alfalfa, sweet clover, red clover, and hairy vetch (Table 1). However, several field studies conducted in the past decade indicate that cool-season grasses and other green manures such as berseem clover, crimson clover, and medic also impact the economic optimum N fertilizer rate (i.e., the N fertilizer rate that maximizes the economic return to N based on the price ratio of N fertilizer and corn). This paper summarizes recent research related to both cover crop types in Wisconsin.

Table 1. Green manure N credits in A2809

Crop	<6" growth	>6" growth
	lb N/a credit	
Alfalfa	40	60-100†
Red clover	40	50-80†
Sweet clover	40	80-120†
Vetch	40	40-90†‡

† Use upper end of range for spring seeded legumes, lower end of range for fall seeded
‡ For vetch >12" of growth, use 110-160 lb N/a

Cool-season grasses

Cool-season grasses, such as rye, oat, and triticale, are used in Wisconsin to provide ground cover to reduce soil erosion following potato and vegetable crops on the Central Sands region of Wisconsin. Outside of the Central Sands region, these grasses are used to establish ground cover following corn silage removal. These grasses establish quickly, providing adequate ground cover in a short amount of time. They have also been referred to as "catch" crops, as they can take up N during the non-growing season, reducing N leaching losses. For example, it has been shown that cover cropping with rye is a valuable management tool in reducing nitrogen (N) losses during winter months on tile drained land in Indiana (Kladivko et al., 2004). While cover crops have

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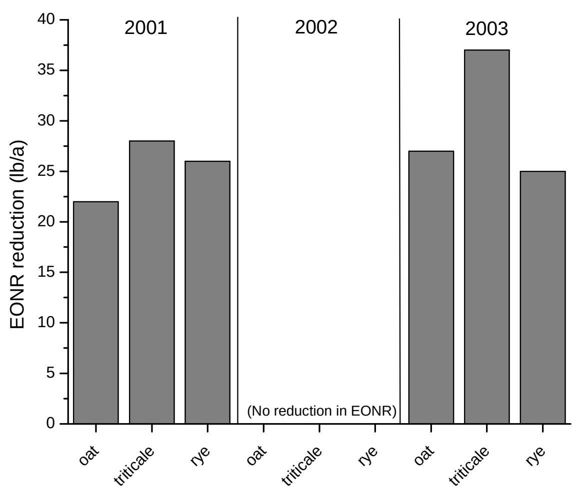
many positive soil conservation and water quality effects, consistent economic gains relative to corn yield or reduced N rates have not been discovered. However, recent research by Andraski and Bundy (2005) provide evidence that the use of rye, oat, and triticale in the Central Sands have a positive economic return relative to a reduction in N rates, an increase in corn yields, or both (Table 1). In this 3-year study (2001–2003), cover crops were planted in late August following harvest of sweet corn, and incorporated in May prior to planting of field corn. In 2 of 3 years, the economic optimum N rate (EONR) was between 22 and 35 lb/a and in 2 of 3 years, cover crops led to a corn yield increase between 20 and 32 bu/a (EONR determined at a N-fertilizer to corn price ratio of 0.10). The authors concluded that the potential yield increase from cool-season grasses as cover crops on the Central Sands is the most practical benefit, as a reduction in N fertilizer rates is risky on these soils with high leaching potential. Therefore, no N credits should be taken when using rye, oat, or triticale as cover crops, even when incorporated.



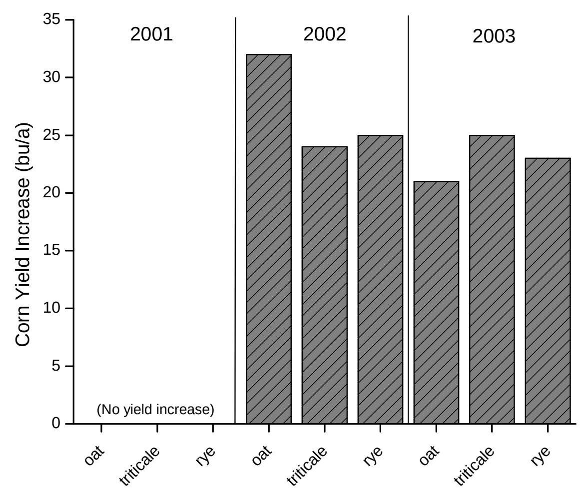


Figure 1. Reduction in the economic optimum nitrogen rate (EONR) (a) and increase in corn yield (b) attributed to use of cool-season grasses as winter cover crop. (Data adapted from Andraski and Bundy, 2005).

Legumes (Green Manures)

The value of green manuring in Wisconsin is most beneficial when legumes are planted after short-season crops such as vegetables and winter wheat and before high N demand crops such as corn. There are five main establishment practices associated with these crops: (1) frost seeded into winter wheat, (2) companion seeded with small grains, (3) spring-seeded (on fallow soil), (4) seeded after pea harvest (June-July), and (5) seeded after small grains (July-August). It is often most beneficial to allow as much above ground production as possible before chemically killing the crop in late fall (prior to freezing conditions). After the cover crop has been incorporated into the soil and corn has been planted, N mineralizes from green manure in synchrony with corn N uptake (Fig. 2).

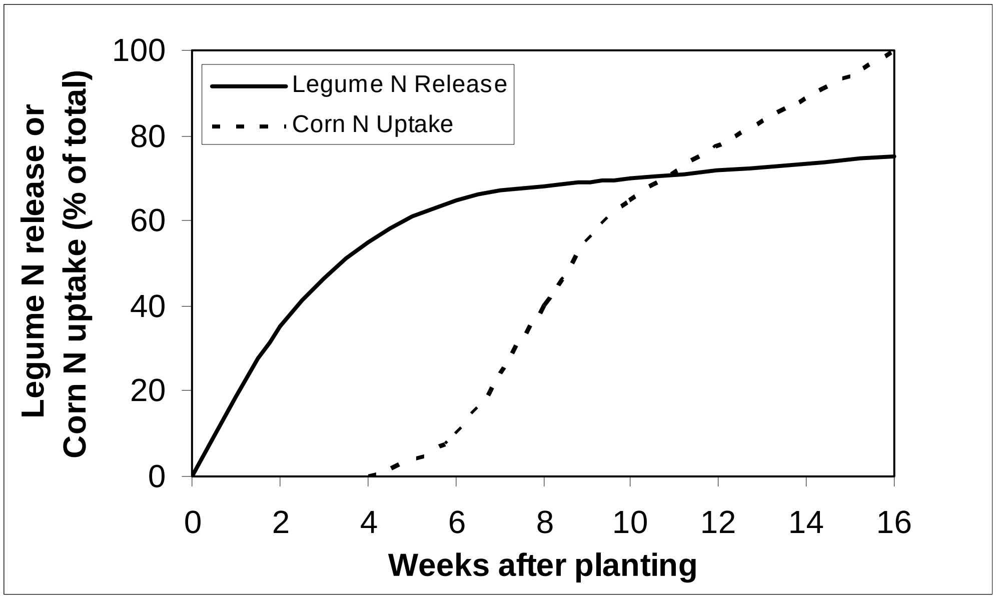


Figure 2. Synchrony between legume N supply and corn N uptake.

Table 2. Effect of cover crop type on economic optimum nitrogen rate (EONR) and corn yield at EONR at Lancaster, WI (N fertilizer to corn price ratio = 0.10) (Source: Stute et al., unpublished).

	1999		2001	
Cover	EONR	Yield at EONR	EONR	Yield at EONR
	lb/a	bu/a	lb/a	bu/a
None	105	204	96	140
Hairy vetch	86	209	27	145
Alfalfa	+150†	209‡	83	144
Red Clover	+150†	205‡	51	138
Medic	+150†	216‡	69	150
Berseem clover	84	207	84	149
Crimson clover	67	204	56	149

†The EONR is greater than the highest N rate in this study
‡The yield at the highest N rate in this study (i.e., 150 lb/a)

In Wisconsin, recent research has focused on the use of legumes following winter wheat. In 1999 and 2001, field studies were conducted at Lancaster, WI to reevaluate presently used cover crops (alfalfa, red clover, hairy vetch) and to evaluate new cover crops (berseem clover, crimson clover, medic) for EONR and corn yield. The experi-mental design was a randomized complete block, split plot with four replications. The main plot treatments were the six legume cover crops plus one treatment with no cover crop. The split plot treatments were six N rates (e.g. 1999: 0, 30, 60, 90, 120, and 150 lb/a; 2001: 0, 25, 55, 80, 100, and 135 lb N/a). In 1999, hairy vetch, berseem clover, and crimson clover reduced the EONR for corn compared to non-cover cropped systems (19, 21, and 38 lb/a, respectively) (Table 2). The EONR for three of the legume cover crops (alfalfa, red clover, and medic) were not maximized within the confines of the experi-mental set up (i.e., yield increase was linear up to 150 lb/a). In 2001, a comparatively low yielding year, all legume cover crops reduced the EONR compared to the no cover crop system (range: 12 to 69 lb N/a) (Table 2). In contrast to results by Andraski and Bundy (2005), where cool-season grasses increased yields at the EONR, these green manure systems did not consistently or dramatically increase corn yields at the EONR. Therefore, the largest benefit of using legume cover crops for green manure is related to reduction in N inputs. While this is only two years of data, it does support the current UW recommendations for green manure N credits for corn.

Summary

Use of cover crops provides many agronomic and environmental benefits to agricultural systems in Wisconsin. Field research conducted over the past decades confirms the economic benefit of using cover crops in both the Central Sands and the Driftless regions of the state. Additionally, this research has discovered that berseem clover, crimson clover, and medic are equally effective of reducing EONR as more established green manures such as alfalfa, red clover, and hairy vetch.

For a complete listing of leguminous cover crops available for use in Wisconsin, see "Legume Cover Crops in Wisconsin: A Guide to Farmers" (Stute, 1996). It is important to remember that there are many factors that determine the effectiveness of cover crops. A given legume may or may not perform satisfactory under you soil conditions and management. Be aware that it may take a couple of years to find which legume works best on your soil.

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PROFILING ROOT LESION NEMATODE PESTS OF CORN

Ann MacGuidwin[1]

There is a renewed interest in nematode pests of corn. Even as producers fine-tune fertility and cultural practices such as planting date and plant density, yields fail to reach the genetic potential of new cultivars in some fields. In many cases, nematodes are a major contributor to stagnant or declining yields. There is an industry push to bring new nematicides to market, so producers who are knowledgeable about nematodes will be positioned to take advantage of new technology and products.

Root lesion is the most common nematode pest of corn in Wisconsin. Surveys conducted in 1999 and 2007 showed more than 95% of corn fields positive for root lesion nematodes, *Pratylenchus* spp. The severity of the infestations, as measured by population densities of nematodes, increased in the eleven years between surveys. In 2007, more than 25% of the fields were above the damage threshold for root lesion nematodes. This observation has been made across the North Central region of the U.S. Some have speculated reasons for this increase, including the loss of broad-spectrum insecticides with nematicidal activity, a shift in rotations, and the adoption of reduced tillage regimens.

In 2008, we demonstrated the damage potential for one root lesion nematode species, *P. penetrans*, by studying 25 locations in a corn field. Soil samples were collected soon after planting and right before harvest. Root samples were collected six times during the growing season. Population densities of nematodes 17 days after planting (corn growth stage V-1) were significantly correlated with grain yield and seed test weight. Yields were reduced more than 20% at locations in the field with population densities greater than 200 root lesion nematodes per 100 cc soil.

Root lesion, like other nematode pests, rarely disappear from an infested field and should be considered a site characteristic. Nematodes are distributed throughout the soil profile and occur where ever corn roots grow so some can escape the lethal effects of tillage or pesticides. Root lesion nematodes have an extremely wide host range that includes soybeans, grains, vegetables, and weeds so there is always food available to the population.

Fields are at risk when nematode population densities are high. Factors that encourage the build-up of root lesion nematode population densities include susceptible hosts and favorable climates. The most important factor is adequate, but not excessive soil moisture. As animals, nematodes can escape zones of unfavorable conditions, but population densities rise rapidly when soil factors become conducive. All infested fields are at risk for nematode damage.

Estimating population densities of root lesion nematodes is based on census data collected by soil sampling. A bulk sample composed of many soil cores is used to profile populations at the field scale. The protocol for sampling is similar to that used for soil fertility tests. Samples can be collected at any

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time of the year. For the purposes of managing root lesion nematodes, the goal is to estimate the size of the nematode population at the start of the corn crop. Most often, this is accomplished by projections that account for the time of year the sample was collected.

The most important factors for obtaining an accurate estimate of nematode populations are where in the field to collect soil cores and how many cores to collect. Our lab has studied the spatial distribution of root lesion nematodes in commercial fields, including one field sampled in 2008 at an intensity of 105 separate soil samples, each comprised of multiple soil cores. Our data are consistent with other studies in that root lesion nematodes occur in patches. Collecting too few cores or sampling too small an area of a field can miss a root lesion nematode problem. Due to the lack of distinctive above-ground symptoms, the best sampling scheme is to systematically collect cores in a pattern than covers the field.

Root lesion nematodes are able to feed on corn roots from the outside or they can crawl into roots to live and feed from the inside. Estimates of densities for root lesion must include roots to account for the proportion of the population living as endoparasites. Our data show overwhelming evidence that the best estimates are made using the root fragments collected with the soil sample. Digging a few plants for root assays can lead to a very biased and inaccurate estimate of the nematode population in the field and is no longer recommended.

Estimates of nematode population densities are the starting point for integrated nematode management. Not every field needs to be sampled every year, but every field should be sampled periodically to check the status of the nematode population. Ideally, the path traversed by the sample collector should be noted to insure that changes in assay results are real and not an artifact of the patchiness of nematode population densities. The introduction of new nematicides should help boost yields, but is not likely to decrease the damage potential of root lesion nematodes. Enhanced root growth contributes to better crop growth and yields, but it also means that the few nematodes remaining will have ample food to grow, reproduce, and build to high population densities for the next corn crop.

INSECT RESISTANCE MANAGEMENT AND REFUGE REQUIREMENTS FOR Bt CORN

Eileen Cullen [1/]

ABSTRACT

Widespread farmer adoption of Bt corn hybrids and new Bt traits for caterpillar pests in addition to corn rootworm have increased the number of acres where target insect pests are exposed to Bt active ingredients each growing season. The purpose of Insect Resistance Management (IRM) is to maintain the effectiveness of Bt crops as an insect pest management tool by preventing or delaying development of insect resistance to Bt traits. The IRM plan is implemented by planting refuge corn acres on each farm where a Bt corn hybrid is planted. Refuge corn acres do not contain the Bt insect trait used in the Bt planting. A refuge provides a corn crop habitat that allows target pest insects to feed, mate and reproduce without being exposed to the Bt trait. Mating between Bt-susceptible insects from the refuge and potential resistant insect ensures that susceptibility to the Bt toxin is passed on to the next generation. Without a refuge, target insect populations that are exposed to Bt corn each growing season over multiple generations will eventually become resistant to Bt.

Planting a refuge is required by law through the U.S. Environmental Protection Agency (EPA) as a condition of Bt corn hybrid registration and market availability. The refuge must be planted to 20% of the corn acreage on each farm where a Bt hybrid is planted, and there are specific configuration and distance requirements. If planting a “stacked” Bt corn hybrid that contains one Bt trait for caterpillar pests (e.g., corn borers, western bean cutworm) and another Bt trait for corn rootworms, then the 20% refuge requirement must be met for both types of pests at the same time.

This overview and update presentation will address common questions such as: What is IRM? What happens if I don’t plant a refuge? Who checks for IRM compliance? How do I implement the refuge for two types of pests (corn borers and corn rootworms) at the same time when planting stacked Bt hybrids? Where are Bt traits expressed in the corn plant? What if the Bt corn hybrid is not controlling the targeted insect? Presently, there are no changes for the 2009 growing season to the mandated 20% refuge and configuration and distance requirements. Some seed company registrants have applied to the U.S. EPA for approval to market Bt corn hybrids with different planting arrangement and reduced refuge percentage. This presentation will give a brief overview of the proposed Bt IRM changes presented to U.S. EPA by seed company registrants. Until EPA rules on any such change, the current Bt IRM refuge requirements stand and should be implemented in 2009.

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DIAGNOSING HERBICIDE RESISTANT WEEDS

Richard T. Proost[1]

Determining if a weed control failure is due to resistance or some other factor is an investigational process that involves asking a lot of questions in order to rule things out. It's important to remember that weed control failures are usually not an indication of resistance development. Weed control failures can and do occur from multiple and interacting factors including weather and application errors. Resistance should not be assumed to be the cause of a weed control failure; other reasons must be investigated first. This paper presents information that can help you determine if herbicide resistance should be suspected for a weed control failure, or if it is due to other factors.

One of the first things you need to determine is if a field is at risk for the development of herbicide resistance. Do field records indicate that the same herbicide mode of action has been used in previous years? If herbicide modes of action have been rotated consistently from year to year, it is less likely herbicide resistance has developed (unless introduced by contaminated equipment, manure, etc.). Secondly, make note of the weed species that have escaped control. Are there multiple weed species present, or just one? Since it is unlikely that resistance will show up in several weed species at the same time, multiple weed species escaping control suggests other reasons may be the cause. On the other hand, if only a single species escapes control, a species that has normally been controlled, resistance could be a concern.

The first set of questions that you need to ask will rule out herbicide application errors. Check to make sure that the correct herbicide and herbicide rate and adjuvant were applied and that it was applied within the recommended weed growth stage. For postemergence applications, was the weed present at time of application or did it emerge after the application? For preemergence applications, was an activating rainfall received before weed emergence or had the weed already emerged prior to the application? Was the sprayer equipment clean and in good working order, including nozzles (i.e. no plugged or worn nozzles)? Was the sprayer calibrated properly? Was the recommended water volume used for application?

Secondly, rule out the effects of weather. Certain weather conditions shortly before, during or after application can affect herbicide activity. It takes moisture to activate some herbicides. Lack of moisture can decrease herbicide activity. Further, a weed under heat, cold, or moisture stress may not absorb enough herbicide to be effective. Conversely, rainfall shortly after a postemergence application can wash off the herbicide before it enters the weed.

After ruling out application errors and weather effects, make sure to carefully note field observations. Were the weeds in the field actually a second flush of weeds? Did the weed escapes appear in irregular patches rather than in strips or in a pattern that would indicate an application problem? Have you noticed a general decline in weed control over recent years? Are weed escapes in the same area of the field as in previous years and this area appears to be getting larger? Has the uncontrolled weed been successfully controlled in the past by the herbicide used this year? Did the same herbicide mode of action fail in the same area of the field in the previous year? Is weed control poor on only one or two weed species, but good on others? Do you see healthy weeds mixed with controlled weeds of the same species? Do the healthy weeds appear to

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be of the same age as the ones that were controlled? Are there resistant weeds in an adjacent field or farm? Answering yes to many of these questions raises the suspicion that herbicide resistance could be or has developed in that field.

If you suspect that you have a case of a herbicide resistant weed, what is your next step? Contact your local crop consultant or extension agent, state weed specialist, and the appropriate chemical company to further investigate the reason for the escaped weeds. They may try to confirm herbicide resistance in the field using a spot test. A spot test treats both a susceptible population of weeds and the weeds species that escaped, with the same herbicide that was used in the field. It's important that both weed populations be of the growth stage. If the susceptible population of weeds dies but the escaped weeds remain alive, for all practical purposes, the escaped population is resistant to that herbicide. If resistance is confirmed with a spot test, control the weeds with a herbicide having another site of action or use an appropriate nonchemical weed control methods to prevent the weeds from going to seed.

One last point needs to be made on diagnosing herbicide resistance in the field and that is the level of resistance. Weeds resistant to herbicide modes of action such as ALS and ACCase inhibitors express a very high level of resistance to those herbicides, often surviving rates 50 times higher the normal field rate. Weeds resistant to glyphosate express lower levels of resistance, in the neighborhood of 4 to 8 times the normal rate. Low levels of resistance can easily be confused with non-performance. The only way to distinguish between low level resistance and herbicide performance problems is to carefully investigate and rule out factors relate to non-performance as outlined. If you suspect glyphosate resistance, contact your local crop consultant, extension agent, state weed specialist and the appropriate chemical company for confirmation.

Hopefully you won't have to investigate escaped weeds for herbicide resistance. By practicing good herbicide stewardship you may be able to delay the development herbicide resistance in your fields. The following practices can help to delay the development of herbicide resistant weeds.

1) Rotate crops. Crop rotation usually means using a diverse herbicide program, making it difficult for resistant weeds to increase.

2) Rotate and tank mix herbicides. Using herbicides with different modes of action keeps weeds in check with little opportunity for them to go to seed. Strongly consider using a preemergence herbicide program with a postemergence herbicide program. Preemergence herbicides reduce the number of weeds being sprayed by the postemergence herbicide. The fewer weeds sprayed with the postemergence herbicide the less chance for them to become resistant.

3) Use short-residual rather than long-residual herbicides. Herbicides that last for a long time in the soil increase the selective pressure on resistant weeds. The longer susceptible types are suppressed and resistant ones allowed to grow, the more likely resistant weeds will increase enough to dominate the species.

4) Where practical, use tillage in conjunction with herbicides. The best weed management program uses a balanced variety of control methods, including herbicides with different modes of action and tillage.

SURVEY OF POSTEMERGENCE WEED MANAGEMENT IN WISCONSIN FIELDS

Chris M. Boerboom, Nathanael D. Fickett, and Clarissa M. Hammond [1]

Introduction

Wisconsin corn and soybean growers and their advisors understand that weeds need to be controlled before the critical period of weed removal, which is the time when early-season weeds begin to compete with crops and cause yield loss. Despite this knowledge, the potential for yield loss from weed competition exists because of cropping systems that rely on postemergence herbicide programs. In particular, the adoption of glyphosate-resistant corn and soybean allows weeds to be controlled exclusively with postemergence glyphosate applications. If glyphosate is applied to these crops before the critical period of weed removal, full yield potential can be achieved. However, if glyphosate applications are delayed, yield losses will occur. The potential for such yield losses is significant in Wisconsin because over 90% of soybeans are glyphosate-resistant and estimates of glyphosate-resistant corn may exceed 70%. Of course, the potential for yield losses associated with postemergence herbicide programs can also occur in conventional or LibertyLink crops. The yield loss is a function of the timing of weed management, not the herbicide or genetic trait of the crop.

To better understand the magnitude of yield losses associated with postemergence weed management programs in Wisconsin, we conducted a survey of corn and soybean fields in 2008. Our specific objectives were to characterize the weed species present in the fields and their densities and heights at the time when the weeds were controlled with a postemergence herbicide treatment.

Field Survey Methods

During the early summer of 2008, fields were selected in Grant, Iowa, Dane, Columbia, Jefferson, Dodge, Fond du Lac, Washington, Sheboygan, Winnebago, and Outagamie counties that had emerged weed populations. These fields were likely to be treated with postemergence herbicide programs and likely had not received a previous preemergence treatment. Approximately five fields per county that were at least 3 miles apart were randomly selected to be surveyed. A total of 48 corn fields were surveyed in 10 counties and 30 soybean fields were surveyed in eight counties. For each field, a surveyor walked a horseshoe pattern through the field starting and ending at the field's edge. Heights and densities of predominant weed species were estimated in 10 1-m^2 quadrats, which were spaced at intervals of 30 paces. The surveys were repeated every 3 to 4 days until the fields were treated with a postemergence herbicide, which marked the end of early-season weed competition.

The densities of the most common weeds were estimated and recorded within the ranges 1-5, 6-10, 11-50, 51-100, 101-500, and greater than 500 plants/m^2. The heights of these weeds were recorded in 2-inch increments up to 12 inches and the heights of weeds taller than 12 inches were recorded. These density and height categories were used to speed the survey procedure and allow for more fields to be surveyed. Other weed species that were observed in the fields were also recorded. The crop stage of growth and height were recorded for each field. A

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leaf sample from each field was tested for the glyphosate-resistance trait using a commercial Elisa-test.

Weed density data were summarized using the average of the range for selected category. Average weed height for a field was weighted by the density of each weed species. The data are summarized in tables listing the minimum and maximum values for individual fields, the median (value where 50% of fields have more than this number), and the overall average among fields.

Results and Discussion

The field survey provided an interesting characterization of weed populations in corn and soybean fields in southern and eastern Wisconsin. At the time of postemergence herbicide treatment, corn and soybean fields averaged over 7 weed species per field (Table 1). The average was similar between corn and soybean, which was expected as fields are likely to be rotated between both crops and both crops were surveyed across a similar geographical area.

Table 1. Number of weed species, total weed density, and average weed height in fields at the time of postemergence treatment for 48 corn fields and 30 soybean fields surveyed in Wisconsin in 2008.

	Crop	Minimum	Median	Average	Maximum
		Number per field			
Number of	Corn	2	7	7.7	16
weed species	Soybean	3	8	7.6	12
		Number per m^2			
Weed density	Corn	7	47	102	582
	Soybean	3	33	107	526
		Inches			
Weed height	Corn	2.0	5.6	5.9	11.7
	Soybean	3.0	7.6	8.5	26.9

The average weed density in corn and soybean fields had an extremely large range, but the average across fields was similar with 107 and 102 plants/m^2, respectively (Table 1). Over 50% of the corn fields had a weed density of 47 plants/m^2 and over 50% of the soybean fields had a weed density of 33 plants/m^2. The heights of these weeds were taller than desired if being managed with postemergence herbicides. In corn, weeds averaged 5.9 inches tall when the postemergence herbicide was applied (Table 1). Based on field research across the Midwest, weeds typically need to be removed from corn before they exceed 4 inches in height to avoid yield loss. In this survey, over 75% of the corn fields had weeds that were 4 inches tall or taller when sprayed (data not shown). Weeds in the corn field with the tallest weeds averaged over 11 inches tall when sprayed. In soybean, weeds averaged over 8 inches tall when the postemergence herbicide was applied. Extension specialists generally recommend that weeds need to be removed from soybean before they exceed 6 inches in height to avoid yield loss. In this survey, nearly 75% of the soybean fields had weeds that were 6 inches tall or taller when sprayed (data not shown). Weeds in the soybean field with the tallest weeds averaged 27 inches tall when sprayed.

The five most frequent weeds in both corn and soybean fields were common lambsquarters, grass species (not identified to species, primarily annuals), velvetleaf, dandelion, and common ragweed (Tables 2 and 3). In both crops, 75% or more of the fields had grasses that were taller than the 4- and 6-inch weed removal timing that is recommended in corn and soybean, respectively (data not shown).

Table 2. Five most frequent weed species in corn and summary data of their densities and heights.

Weed species	Minimum		Median		Average		Maximum	
	Density	Ht.	Density	Ht.	Density	Ht.	Density	Ht.
	No./m^2	inch	No./m^2	inch	No./m^2	Inch	No./m^2	inch
Common lambsquarters	0.3	2	7	4	28	5	260	9
Grass spp.	0.3	2	18	7	59	7	503	12
Velvetleaf	0.3	2	3	4	7	4	40	6
Dandelion	0.3	2	1	6	3	5	14	8
Common ragweed	0.3	2	3	4	6	4	24	8

Table 3. Five most frequent weed species in soybean and summary data of their densities and heights.

Weed species	Minimum		Median		Average		Maximum	
	Density	Ht.	Density	Ht.	Density	Ht.	Density	Ht.
	No./m^2	inch	No./m^2	inch	No./m^2	inch	No./m^2	inch
Common lambsquarters	0.3	2	3	5	12	8	76	23
Grass spp.	0.3	2	25	8	82	9	525	27
Velvetleaf	0.3	2	4	4	12	6	57	20
Dandelion	0.3	2	1	4	9	4	94	6
Common ragweed	0.3	2	2	6	5	7	39	24

The data from these surveyed corn and soybean fields suggest that yield loss may be occurring because some herbicide applications were made to weeds with sufficient size and density. To obtain an estimate of potential yield loss, the median and average values of the three most common weed species were analyzed using WeedSOFT, a bioeconomic yield loss model. In these scenarios, giant foxtail was used as the grass species because it is common in Wisconsin. The predicted yield loss in corn was over 6 and 9 bu/a using the median and average densities and heights of these three weed species (Table 4). Based on a 150 bu/a yield potential and $4/bu corn price, controlling these weeds at this time could translate into a $26 to 39/a loss. The predicted yield loss in soybean was 2.5 and 3.3 bu/a using the median and average densities and heights of these three weed species. Based on a 50 bu/a yield potential and $8/bu soybean price, controlling these weeds at this time could translate into a $20 to 26/a loss.

This survey of weed populations in corn and soybean fields provides evidence that management of postemergence herbicide programs in Wisconsin is likely resulting in yield losses and is reducing potential profits of growers. Weed management programs should be reviewed to determine if either the herbicide applications can be made to smaller weeds or if residual herbicides should be applied in more fields, which would reduce the density and heights of weeds when postemergence applications are made.

Table 4. Predicted yield and profit losses using WeedSOFT predictions based on the median and average densities and heights of the three most common weeds in corn and soybean fields. Corn yield and price were set at 150 bu/a and $4/bu and soybean yield and price were set at 50 bu/a and $8/bu for the analysis.

	Corn				Soybean			
	Median		Average		Median		Average	
	Density	Ht.	Density	Ht.	Density	Ht.	Density	Ht.
Weed species	No./ 100 ft^2	inch	No./ 100 ft^2	Inch	No./ 100 ft^2	inch	No./ 100 ft^2	inch
C. lambsquarters	65	4	260	5	28	5	111	8
G. foxtail	167	6	548	7	232	8	762	9
Velvetleaf	28	4	65	4	37	4	111	6
Crop stage	V5				V4			
Crop yield	150 bu/a				50 bu/a			
Crop price	$4/bu				$8/bu			
Predicted yield loss	4.3% or 6.45 bu/a		6.5% or 9.75 bu/a		5% or 2.5 bu/a		6.6% or 3.3 bu/a	
Predicted profit loss	$26/a		$39/a		$20/a		$26/a	