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OVERVIEW OF SOIL QUALITY FOR SUSTAINING EARTH AND ITS PEOPLE

John W. Doran[1]

Background

Interest in soil quality and health has grown with awareness that *soil is central to the cycle of life on earth.* Soils support the growth of plants and microorganisms, regulate the flow and storage of water in the biosphere, and serve as a primary interface with the global environment affecting quality of both the water we drink and the air we breathe. The thin layer of soil covering the Earth's surface represents the difference between survival and extinction for most terrestrial life. One tablespoon of fertile soil contains up to 9 billion microorganisms, 1 and ½ times the human population of the earth. Soil health (quality) has been broadly defined as the capacity of a living soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health (Doran *et al.*, 1996).

Sustaining Earth and Its People

Two major threats to sustainability in the 21st century are: Population growth and increased demand for agricultural land and resources and over dependence on fossil fuels and the increased monetary and environmental costs of these non-renewable resources. In a 2003 report entitled 'Frontiers in Agricultural Research', the National Research Council of the US National Academy of Science recently defined the need for a new research model to meet the dramatic changes occurring in the last 30 years. To meet the food and nutrition needs of a growing world population, agriculture will need to move beyond the past emphasis on productivity to also encompass improved public health, social well being, and a sound environment.

Developing sustainable agricultural management systems, however, is complicated by the need to consider their utility to humans, their efficiency of resource use, and their ability to maintain a balance with the environment that is favorable both to humans and most other species (Harwood, 1990). More simply stated by a Midwestern farmer in the USA, *" a sustainable agriculture* - *Sustains the People and Preserves the Land."* We are challenged to develop management systems that balance the needs and priorities for production of food and fiber with those for a safe and clean environment. Assessment of soil quality or health is invaluable in determining the sustainability of land management systems (Karlen *et al.*, 1997). Soil quality is conceptualized as the major linkage between the strategies of conservation management practices and achievement of the major goals of sustainable agriculture (Acton & Gregorich, 1995; Parr *et al.*, 1992). In short, the assessment of soil quality or health, and direction of change with time, is the primary indicator of sustainable land management

Agriculture needs economic soil management practices that provide sufficient food and fiber yet maintain environmental stability, ecological integrity, and the quality of essential soil, water, and air resources. Our journey towards sustainable land management starts with identification of our final destination or goals, the strategies or course by which we will get there, and the indicators that we are going the right direction. Strategies for sustainable management include conserving soil organic matter, minimizing erosion, balancing production with environmental needs, and making better use of renewable resources (Table 1). These strategies

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include a more generic set of indicators to assess soil quality and health that are practical for producers. A study conducted in the northern United States corn and dairy belt used a similar approach to determine how farmers assess soil quality and health. Farmers ranked soil organic matter, crop appearance, and risk to erosion as the three most important properties for describing soil health and sustainable management (Romig *et al.*, 1996).

Table 1. Strategies for sustainable management and the crop, soil, and environmental indicators most useful to producers (After Doran *et al.*, 1996; Doran, 2002).

SUSTAINABILITY STRATEGY	INDICATORS FOR PRODUCERS
CONSERVE SOIL ORGANIC MATTER *through* Increase C & N levels by reducing tillage, recycling plant and animal manures, and increased plant diversity. where C inputs > or = C outputs	**DIRECTION AND CHANGE IN ORGANIC MATTER** levels with time using visual or remote sensing by color or chemical analysis OM potential for climate/soil/vegetation Soil water storage/infiltration/aggregation
MINIMIZE SOIL EROSION *through* Conservation tillage and increased protective cover such as crop residue, stable aggregates, cover crops, and green fallow	**VISUAL** (gullies, rills, dust, etc.) **& SURFACE SOIL PROPERTIES** (topsoil depth, organic matter content, texture, water infiltration, runoff, ponding, % surface cover)
BALANCE PRODUCTION & ENVIRONMENT *through* conservation and integrated management systems that optimize tillage, residue, water, and chemical use and by synchronizing available N and P levels with crop needs during year	**CROP CHARACTERISTICS** (visual or remote sensing of yield, color, nutrient status, plant vigor, and rooting characteristics) Soil physical condition/compaction Soil and water nitrate levels Amount/toxicity of pesticides used
BETTER USE OF RENEWABLE RESOURCES *through* relying less on fossil fuels and petrochemicals and more on renewable resources & biodiversity (crop rotations, legumes, manures, integrated pest management)	**INPUT/OUTPUT RATIOS OF COSTS AND ENERGY** (renewable/non-renewable ratio) Use soil electrical conductivity for Leaching losses / Soil Acidification Crop characteristics (as listed above) Soil and water nitrate levels

Translating Science into Practice

Soil and land management practices are primary determinants of soil quality and health. Consequently, indicators of soil quality and health must not only identify the condition of the soil resource but also define the economic and environmental sustainability of land management practices to assist governmental agencies in formulating realistic agricultural and land-use policies.

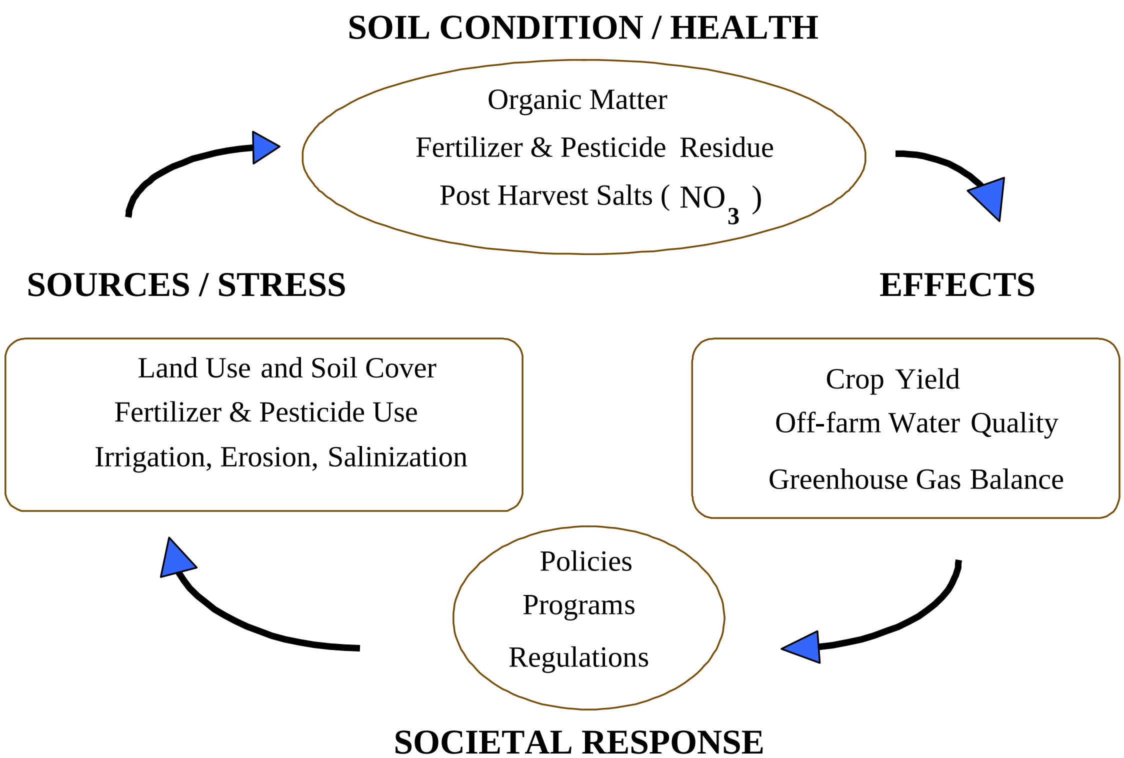

Figure 1. The politics of soil quality and health (After Doran & Gregorich 2002).

The theme of an international conference in Australia, "Soil Quality is in the Hands of the Land Manager," highlights the critical importance of the land manager in determining soil quality (MacEwan and Carter, 1996). A cotton grower at this conference shared his frustration with the direction soil quality indicators were taking - "I need help from scientists more with tools for management than with indicators of soil quality." Economic viability and survival are the primary goals of managers of the land, even though most recognize the need for environmental conservation. Its hard to be green when you're in the red.

Although much remains to be done, useful models exist for translating soil science into practice. Gomez *et al.* (1996) provide a unique framework for determining the sustainability of hill country agriculture in the Philippines. It employs indicators of both the satisfaction of farmer needs (i.e., productivity, profitability, stability, and viability) and those needed for conservation of soil and water resources. On a given farm, indicator values were deemed sustainable if they exceeded a designated threshold level. Sustainability thresholds were set relative to average local conditions for crop yield, profit, risk of crop failure, soil depth, percent soil cover, and soil organic matter content. This framework for assessment of sustainability can be expanded to include other needs of society and environmental conservation as illustrated in Table 2. Adding a category for balancing input and output of energy and monetary costs would better assess short and long-term sustainability and the value of depending more on renewable resources and less on fossil fuels and petrochemicals. This would enhance economic, ecological, and environmental resources. Also, expanding resource conservation variables to include leachable salts (especially NO_3), measured as soil electrical conductivity at time of fertilization and after harvest, would permit land managers to better quantify the impact of agricultural practices on air and water quality. Soil electrical conductivity can also estimate the release of 'small molecules' to the environment and verify if agricultural management systems enhance sustainability by minimizing system entropy (Addiscott, 1995).

Table 2. Simple tool for on-farm assessment of economic and environmental sustainability (After Gomez *et al.*, 1996 and Doran, 2002).

FARMER & SOCIETY NEEDS, *Acceptable*	**RESOURCE & ENVIRONMENTAL CONSERVATION**, *Adequate/Acceptable*
YIELDS relative to locale, climate, and soil type	**SOIL ORGANIC MATTER** change with time, relative to local potential
PROFITS relative to net return and degree of subsidization	**SOIL DEPTH** of topsoil and rooting relative to local potential
RISK / STABILITY economic shortfall in 1 of 5 years	**SOIL PROTECTIVE COVER** (%) effective – continuous or stratified
INPUT / OUTPUT RATIO of energy (amount and type: renewable and non-renewable) and monetary costs	**LEACHABLE SALTS** (NO_3) at planting and post-harvest as indexed by soil electrical conductivity

Conclusion

Soil quality is a major indicator of the success of strategies for conservation management and sustainable agriculture. Confirmation of the effectiveness of integrated systems for residue management, organic matter formation, nitrogen and carbon cycling, soil stability, and biological control of pests and diseases will assist in finding approaches that are both profitable and environmentally sound. Ultimately, the indicators of soil quality and strategies for sustainable management must be linked to development of systems that optimize inputs of nonrenewable fossil fuels and petrochemicals, achieve acceptable levels of productivity, and maintain the quality of our air, water, and soil resources.

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DOES ORGANIC MATTER MATTER?

Donald Genrich[1]

Soil organic matter comprises a small part, usually less than 5%, of a given soil by weight. Its influence on biological, chemical and physical properties of soil is far greater than you would expect, considering the small amounts present in most soils. In earlier times the depletion of soil organic matter often resulted in a "worn out" soil. Within the last 70 years, the development of inexpensive fertilizer, large machinery, pesticides and irrigation have produced a set of agronomic practices that largely ignores soil organic matter and considers it irrelevant in modern crop production. One of the difficulties with this way of thinking is that as soil organic matter levels decrease, it is taking larger and larger amounts of more expensive inputs to "fix" the problems of fertility, disease, compaction, water availability and erosion.

Farmers and agronomists need a new way of thinking about soil. They need to consider soil as being alive, as having a life of its own. Organic matter is what keeps a soil alive. Those producers that are striving for very high crop yields have long since realized that more nutrients and larger pieces of tillage equipment are not going to guarantee the yields they want. They realize that modification of the soil through organic matter management is the key to sustainable high yields over many years.

Soil organic matter can be thought of as the living, the recently dead and the long-time dead. The organisms that live in soil recycle nutrients, assist plants in obtaining needed nutrients, control levels of disease organisms, and produce chemicals that "glue" soil particles into aggregates. The recently dead provide a food source for all the organisms that live in the soil as well as nutrients to be used by plants. The long-time dead organic material, often called humus, holds plant nutrients and prevents them from leaching out of the soil.

Soil organic matter profoundly affects the biological, chemical and physical properties of soil. Soil physical properties such as amount and strength of aggregation, water infiltration rate, porosity and water holding capacity can be increased through management of soil organic matter. We can create a soil that is easier for roots to penetrate, has a greater rooting zone, has a source of slow release nutrients, is drought resistant and is resistive to erosion. We can do this by continually adding organic material to our soils and by eliminating as much tillage as possible.

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Agronomy Guide

Purdue University Cooperative Extension Service

SOILS/PHYSICAL CONDITION AY-279

Earthworms and Crop Management

Eileen J. Kladivko, Soil Scientist, Department of Agronomy

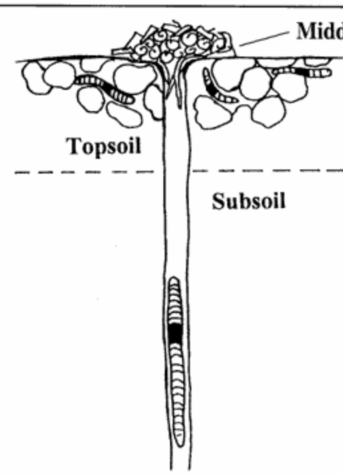
Earthworms have long been associated with healthy, productive soils. In his 1881 book entitled "The Formation of Vegetable Mould through the Action of Worms," the great biologist Charles Darwin stated that, "It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly, organized creatures." Although earthworms are known to be beneficial to soils, their degree of importance in different agricultural systems is poorly understood. This publication provides basic information on earthworm ecology, the effects of earthworms on soil properties and processes, and the influence of soil management practices on earthworms. It concludes with a section on how to encourage the buildup of earthworm populations in agricultural fields, as well as some remaining questions that require further study.

General Ecology

There are thousands of species of earthworms in the world. Those that live in the soil can generally be grouped into three major behavioral classes: the litter-dwellers, shallow soil dwellers, and deep-burrowers. The litter-dwelling species live in the litter layer of a forest, for example, and are generally absent from agricultural fields. Typical agricultural fields may have one to five different shallow-dwelling species and perhaps one deep-burrowing species.

The deep-burrowers ("nightcrawlers") build large, vertical, permanent burrows that may extend 5 to 6 feet deep or more. They pull plant residues down into the mouth of their burrow, where the residues soften and can be eaten at a later time. Nightcrawlers construct *middens* over the mouth of their burrows. Middens are a mixture of plant residues and castings (worm feces) and probably serve as protection as well as a food reserve. Because nightcrawlers require residues at the surface to pull down into their burrows, we do not expect to find any nightcrawlers in fields which routinely leave no surface residue cover (i.e. moldboard-plowed). The species of nightcrawler in the north-central region is *Lumbricus terrestris*. The length of adult nightcrawlers is usually 4 to 8 inches or more.

Figure 1.



The shallow-dwelling worms (known as redworms, grayworms, fishworms, and many other names) are comprised of many species that live primarily in the top 12 inches of soil. Adult length is usually 3 to 5 inches. They do not build permanent burrows, but instead they randomly burrow throughout the topsoil, ingesting residues and mineral soil as they go. Because they do not require residues at the surface specifically, we do not expect them to be as sensitive to residue management as are the nightcrawlers. However, they are affected by the amount of surface mulch because of the impact on soil temperature and moisture extremes. This is discussed in more detail in the section on tillage.

Earthworms are seasonal in their activity. The shallow-dwellers are active in spring and fall but generally enter a resting state in summer and winter. As the soil starts to heat up and dry out in late spring (typically May in the North Central states), the shallow-dwellers move a little deeper (perhaps 18 inches), curl up in a ball, and secrete a mucus to try to keep from drying out. They spend most of the summer in that state. In fall, when the soil starts to cool and become wetter, they become active again, but then often enter into a hibernation state for the winter. The nightcrawlers also tend to be more active in spring and fall, but they may not go into a complete resting state in summer or winter since they can retreat to the bottom of their burrows during extremes of heat or cold. The best time to observe or count earthworm populations is early- to mid-spring (often April in North Central states), or late fall (November).

Earthworms have both male and female sexual organs. Most species require a partner for mating. During mating, sperm are exchanged and stored in one of the segments of the worm. The cocoon casing is then produced by the *clitellum* (the band seen on mature worms), and the worm "backs out" of the casing, depositing the sperm and eggs into the casing as it passes over the appropriate segments. The cocoon (2-4 mm in diameter) then incubates in the soil for several months, depending on soil conditions, before one young worm (or two for some species) emerges. New worms will generally only emerge when soil moisture and temperature conditions are suitable.

Effects on Soil Properties

The degree of importance of earthworms in maintaining soil and crop productivity will vary depending on circumstances. Earthworms are almost always beneficial, when present, but they may not be necessary. Some soils can be very productive without the presence of earthworms. The worms have sometimes been shown to improve crop growth and yield directly, but more often their activity affects crop growth indirectly through their effects on soil tilth and drainage.

Earthworms can have significant impacts on soil properties and processes through their feeding, casting, and burrowing activity. The worms create channels in the soil, which can aid water and air flow as well as root development. The shallow-dwelling worms create numerous small channels throughout the topsoil, which increases overall porosity and can help improve water and air relationships. Nightcrawlers create large vertical channels, which can greatly increase water infiltration under very intense rainfall or ponded conditions. Nightcrawler channels can also aid root proliferation in the subsoil, due both to the ease of root growth in a pre-formed channel and the higher nutrient availability in the cast material that lines portions of the burrow. Earthworm casts, in general, are higher in available nutrients than the surrounding mineral soil, because the organic materials have been partially decomposed during passage through the earthworm gut, converting the organic nutrients to more available forms.

Earthworms improve soil structure and tilth. Their casts are an intimate mixture of organic material and mineral soil and are quite stable after initial drying. The burrowing action of the worms moves soil particles closer together near burrow walls, and the mucus secreted by the worms as they burrow can also help bind the soil particles together. Increased porosity, plus mixing of residues and soil, are additional ways that earthworms improve soil structure.

The mixing of organic materials and nutrients in the soil by earthworms may be an important benefit of earthworms in reduced tillage systems, especially no-till. The earthworms may, in effect, partially replace the work of tillage implements in mixing materials and making them available for subsequent crops. In *natural* ecosystems such as forests, organisms recycle last year's leaf litter into the soil for release of nutrients. With no-till planting we may also depend more on earthworms and other soil organisms to do this mixing for us. It seems appropriate, therefore, to try to determine how we can manage soils to encourage the organisms and their activity.

Management Impacts on Earthworms

When we manage soils for crop production, we are also managing the habitat in which earthworms and other organisms live. Management practices affect earthworm populations by affecting food supply (location, quality, quantity), mulch protection (affects soil water and temperature), and chemical environment (fertilizers and pesticides). By considering how these factors are changed in different management systems, we can often predict the general effects on earthworm populations for systems that have not been studied.

Productive pasture fields will usually have much higher earthworm populations than row-cropped fields, primarily because of the large amounts of organic materials that are continually being added to the soil. Continuous root growth and subsequent death and decay, plus animal manure, provide a large food supply that can maintain high earthworm populations. In addition, the pasture plants act as a mulch to buffer the soil against rapid changes in temperature. Pasture fields are also not usually tilled, and thus burrow systems are left undisturbed.

Within row-cropping systems, using tillage systems which leave surface residue, is one of the most important ways that earthworm populations can be influenced. No-till systems usually have higher earthworm populations than do conventional moldboard plow systems, due to increased food supply and mulch protection. With residues on the soil surface, the food supply is available to the earthworms for a longer time than if residues are incorporated with a tillage implement. In addition, the surface residues act as a mulch and slow the rate of soil drying in late spring and freezing in late fall. This can lengthen the active periods for the worms, allowing them to feed and reproduce a little longer in both spring and fall. Surface residue also gives the earthworms more time to acclimate to the summer or winter and move down into their resting state. No-till is even more important for nightcrawlers than for the shallow-dwelling worms. Because nightcrawlers feed primarily on residues at the surface, pulling them into their permanent burrows, a clean-till system is not very conducive to nightcrawlers. The surface food supply is not present in plowed soils, and the top portion of the permanent burrow must be reformed after any tillage operation. Although a few nightcrawlers may be present in plowed fields, often they will not be present at all.

Tillage systems that are intermediate between the extremes of moldboard plowing and no-till will tend to have intermediate populations. The amount of surface residue cover is the key factor to consider when assessing different possible tillage practices for a field, as well as establishing conditions which encourage earthworm populations.

Data collected in Indiana and Illinois over the past 10 years confirms the generalizations just discussed. Earthworm populations were counted after 10 years of tillage plot history on a dark, poorly-drained silty clay loam soil near West Lafayette (Table 1). Very few worms were found in the continuous corn plots under either plow or no-till, and there were no statistically significant differences between the two treatments. Populations were surprisingly low and may have been affected by drought conditions the summer before the survey.

The continuous soybean plots had higher populations than continuous corn, with no-till having more than twice the worm population that moldboard plowing had. Earthworms generally prefer legumes as a food source over grasses, and this is probably the main reason for the higher populations found in the soybean plots. The continuous corn plots also received applications of corn rootworm insecticide and anhydrous ammonia, both of which can kill some earthworms. However, the effect of these chemicals on overall field populations of worms is probably small. Ammonia will kill a few worms right in the zone where it is injected, but some limited observations and counts before and after injection have suggested that less than 10% of the population is affected. Likewise, some corn rootworm insecticides kill earthworms, as can be seen by dead earthworms at the soil surface over the seed row. The overall effect on field populations is probably small, however, as long as the material is banded or in-furrow so that only a small zone of soil is affected. A rotation of corn and soybeans will generally have higher earthworm populations than continuous corn, probably due in part to elimination of the rootworm insecticide use, but mainly due to inclusion of a legume in the system.

Earthworm populations were much higher in a pasture than in the row-cropped fields (Table 1). Where the manure of the grazing animals was augmented by heavy applications of manure from the barnyard, populations were very high. Animal manures, sewage sludges, and other organic wastes will usually help build earthworm populations, although there may be an initial detrimental effect if there is a high concentration of ammonia in a slurry material.

Data from a poorly drained silt loam soil, low in organic matter, in southeastern Indiana illustrates some intermediate tillage practice effects as well as

Table 1. Earthworm populations on silty clay loam soil near West Lafayette, IN.

Crop[a]	Management[a]	Earthworms/m^2
Cont. corn	Plow	10
Cont. corn	No-till	20
Cont. soybeans	Plow	60
Cont. soybeans	No-till	140
Bluegrass-Clover	Alleyway	400
Dairy pasture	Manure	340
Dairy pasture	Manure (heavy)	1300

[a]Crop and management systems had been continuous for at least 10 years.

Table 2. Earthworm populations (April) under corn-soybean rotation on silt loam soil in southeastern IN.

Tillage	Earthworms/m2		
	1987	1988	1989
Chisel	—	44	67
Ridge-till	—	189	178
No-till	156	133	211

year-to-year variations (Table 2). Earthworm populations were counted in spring in a corn-soybean rotation. The fall chisel system had less worms than either ridge-till or no-till, due to much less residue cover. Ridge-till and no-till populations were comparable, with ridge-till having slightly more worms in 1988 and no-till slightly higher in 1989. *Populations will vary from year to year as well as within a year, due to weather conditions and food availability.* There were no nightcrawlers present in any of these plots.

In April 1992 earthworm populations were surveyed on 14 pairs of farmers' fields in central Indiana and Illinois. Each pair consisted of a no-till and tilled (usually chiseled) field on the same soil type, in a corn-soybean rotation, as close together as possible (usually less than 1 mile apart). Most of the no-till fields had been in no-till for at least 5 years. Soil types included two sandy loams, one loam, and the rest silt loams and silty clay loams. Shallow-dwelling earthworms were counted by excavating and hand-sorting soil. The presence or absence of significant nightcrawler populations was determined by observing whether nightcrawler middens were present in the field.

Results of the survey confirmed that no-till management generally leads to increases in earthworm populations. Eight of the 14 sites had higher populations in no-till than in tilled fields, with increases ranging from 25% higher to 10 times higher. Four sites had roughly equal populations under both systems, and two sites had slightly lower populations with no-till. Populations ranged from a low of 2 to a high of 340 earthworms per square meter over all the sites and tillage systems surveyed. In addition, nine no-till and only three tilled sites had significant nightcrawler activity, again confirming the strong influence of surface residues on nightcrawlers. We don't know whether or not the other no-till sites will develop nightcrawler populations after more time in the system.

Managed and/or ChemicallyTreated Fields

As discussed earlier, there are many conventional fields where nightcrawlers are completely absent, presumably due to lack of surface food supply. When these fields are switched to a no-till system, the habitat is better for the nightcrawlers, but the only way a population can get started is by overland movement from nearby places that have nightcrawlers, such as fencerows, roadsides, grass waterways, etc. This is a slow process and may take many years before a field is populated. In addition, not all roadsides and fencerows have nightcrawlers either, so there may not be a "source" of nightcrawlers adjacent to every field. Finally, we don't know whether or not nightcrawlers will survive in all soil types, so some fields may be unsuitable even when *managed* for the worms. Much more study and observation of nightcrawlers in agricultural fields is needed in order to answer these questions.

The impact of agricultural chemicals on earthworm populations varies with the chemical. Inorganic nitrogen fertilizers promote greater plant production than in unfertilized fields and therefore higher earthworm populations. Although anhydrous ammonia will kill a few worms in the narrow band where injected, field effects are probably minimal due to the small area affected. There is little information on other nitrogen sources commonly used in the Midwest, but effects are probably small when used at typical field rates. *Most herbicides used in crop production in the Midwest are harmless or only slightly toxic to worms and should not be a great concern.* As discussed earlier, some corn rootworm insecticides are toxic to worms, but their effects can be reduced by keeping the application band as narrow as possible. In general, the organophosphate and pyrethroid insecticides are harmless to moderately toxic, while the carbamate insecticides and fungicides are highly toxic. Nematicides in general are also highly toxic.

How to Encourage Earthworms

Earthworm populations can be increased by applying the concepts discussed earlier about food supply and surface mulch protection (Table 3). Leaving a surface mulch, by no-till or other conservation tillage systems with plenty of residue cover, will generally increase populations. Growing winter cover crops may augment the mulch protection as well as provide additional food for the worms. Adding or growing organic matter is a great way to build earthworm populations. Animal manures and sewage sludges, and rotations with hay or set-aside fields, are also possible ways to provide more food for the earthworms and help increase populations. Soil pH should be maintained between 6.0 and 7.0

Table 3. Methods to increase earthworm populations.

Leave surface mulch:	
	no-till
	ridge-till
	cover crops
Add or grow organic matter:	
	manure
	hay
	set-aside
	cover crops

for optimum conditions, although lower pH's are tolerated by most species. Although management can increase earthworm populations on many soils, some soils will not support high earthworm populations, regardless of management, due to inherent soil texture and drainage properties. Very coarse sands and perhaps high water table heavy clays are two examples.

The question often arises, "Is it worthwhile to "seed" earthworms in fields with low populations?" The first principle to remember is that the shallow-dwelling species are already established, and their current population is what can be supported by the current management system. If the management system is changed to something more suitable for the worms, their populations will increase quickly (1 or 2 years) to the level that can be supported by the new practices. Thus, there is little evidence to suggest that seeding these worms is worthwhile.

Nightcrawlers, however, may be a slightly different story. Since many conventional fields have no nightcrawlers present, a change in management from conventional to no-till does not guarantee that nightcrawlers will become established (see earlier discussion). Under these circumstances, there may be some benefit from establishing a few sources of nightcrawlers in the field, and several farmers have claimed success in establishing nightcrawlers in this way. Whether nightcrawlers would have established themselves in these fields without the farmer's assistance is not known. If you want to try this practice, collecting local nightcrawlers from country roads or pastures on rainy spring nights or mornings is a good way to start. Purchasing nightcrawlers is expensive, and they may not be adapted to local soils and climates. A small-scale, low-cost trial is highly advisable, since we don't know whether or not nightcrawlers will survive on all soils. Protect the worms from the sun, and place 4 or 5 together under some mulch or residue in a spot every 30 or 40 feet in the field, preferably on a cloudy, wet, cool day. Record the location of the seeded spots, and then observe those spots for evidence of midden activity over the year to determine whether the nightcrawlers survived and if the patches are growing.

Remaining Questions and Further Information

Many questions about earthworms and agricultural fields remain to be explored. How much do earthworms contribute to nutrient cycling and availability to an annual crop? How much improvement in soil physical properties can be expected from both shallow-dwelling species and nightcrawlers? Why are nightcrawlers present in some no-till fields and not others? What practical management strategies might be used to help establish nightcrawlers in areas that have none? These and other questions have potential importance for increasing the sustainability of agricultural systems.

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Lee, K. E. 1985. *Earthworms: Their Ecology and Relationships with Soils and Land Use.* CSIRO, Sydney Australia. 411 pp.

Reynolds, J.W. 1977. *The Earthworms of Ontario.* Royal Ontario Museum, Toronto. 141 pp.

This last book includes primarily morphology and taxonomy, including diagrams and a taxonomic key, for serious students of earthworm speciation. Most of the common species in agricultural fields of the central Cornbelt are included.

IMPACT OF TILLAGE ON SOIL PROPERTIES

R.P. Wolkowski [1/]

Tillage is defined as the physical manipulation of the soil for the purposes of managing previous crop residues, preparing a seedbed for planting, controlling competing vegetation, and incorporating fertilizers and other crop production inputs. Tillage, when done at the correct soil moisture, allows the soil to fracture along the existing soil structural planes. The soil moisture should be such that soil aggregates will separate easily when worked, without the smearing or destroying the aggregates, which would occur if the soil is too wet. Tillage, and the subsequent residue management effects, will have a profound effect on soil processes and properties that directly impact crop production. Examples of these processes and properties are soil structure, water infiltration and movement in the soil, bulk density, aeration, soil warming, biological activity, and residue and organic matter relationships. Tillage also affects plant nutrient availability. This topic was discussed at the WFCA Conference in 2004 and will not be covered in detail in this paper.

The interest in soil conservation has resulted in increased production under conservation tillage. Researchers have found increased crop yield after several years of conservation tillage (no-till), even though some measured soil physical properties appear unfavorable (Hill, 1990). Some of this effect has been related to increased continuity of pore space, more favorable soil water relationships, and the maintenance of soil organic matter (Karlen et al., 1990). Others have noted a "yield drag" associated with no-till that has been related to cooler soil conditions. This paper will outline some of the effects of tillage on soil physical and biological properties and how they may impact crop production.

Aggregate Stability

Aggregation, or the development of soil structure, is an important property of the soil. Mineral soils are composed of a distribution of sand, silt, and clay size particles that produce a definitive soil texture. In medium- and fine-textured soils these particles are held together by chemical and physical processes, in much larger units known as aggregates. Sands and loamy sands do not form aggregates and are described as single-grained soils. For this reason medium-textured soils have a lower bulk density and higher porosity than sands. Stable aggregates, which are important for maintaining porosity, aeration, and favorable water relationships, are critical for sustaining soil productivity. Typically the strength of structural units is greater in soils having higher clay contents due to greater attraction between particles as they compete for cations. Claims are often made regarding the effect of calcium on soil structure. Most Wisconsin soils have adequate calcium, either natively or from the addition of lime, and there is no conclusive evidence that addition of calcium containing amendments will improve structure.

The decomposition of organic materials such as crop residue, manure, compost, and other organic residuals produce compounds which bind soil particles. Fresh organic materials which have low C:N ratios will have a larger, but shorter-lived influence on aggregate stability, than higher C:N ratio materials that decompose more slowly. For example, researchers demonstrated greater erosion

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losses following soybean when compared to corn (Laflen and Moldenhauer, 1979). Some are beginning to question the sustainability of the corn/soybean rotation. In addition to the increased erosion that could be attributed to the lower residue level following soybean, Kladivko et al. (1986) found a relationship between rotation and aggregate size (Table 1). Aggregate size was further reduced as the tillage intensity was increased.

Table 1. Water-stable aggregate size in the 0- to 3-inch depth prior to spring tillage.

	Previous two crops			
Tillage system	C-C	C-Sb	Sb-C	Sb-Sb
	-------------------------------- mm ---------------------------------			
Fall moldboard	0.9	0.9	0.9	0.6
Fall chisel	1.7	1.2	1.1	0.8
No-till	2.7	1.7	1.7	1.5

Adapted from Kladivko et al. (1986).

Crop residues and other organic amendments serve as the energy source for soil microorganisms, therefore soil aggregation will be the greatest where organic residues are concentrated, such as the surface. Maintaining good aggregation at the surface is important for aeration, infiltration, root growth, and resistance to crusting. This observation suggests that long-term reduced tillage or no-till may enhance soil tilth. Karlen et al. (1994) evaluated a southern Wisconsin soil after 12 yr of either moldboard, chisel, or no-till for several soil quality factors. Average crop yield for the period was 3 bu/acre lower on the no-till when compared to the moldboard. They observed that while the surface of the no-till treatment had a slightly lower porosity, it had greater aggregate stability, total carbon, and earthworm population when compared to either chisel or moldboard. Estimated soil loss was significantly lower on the no-till when compared to moldboard, which could be attributed to both crop residue and improved physical condition.

Most conservation tillage systems will employ some form of secondary tillage to create a seedbed, the most popular being the tandem disk or the field cultivator. Adam and Erbach (1992) compared these two implements over a range of soil moisture content and found that the disk tended to produce larger, stronger aggregates then the C-shanked field cultivator. Their research suggests that the tandem disk will create a more cloddy soil condition, especially as the soil becomes wetter. The tandem disk has also been considered to be a tool that compacts due to the pressure exerted along the edge of each disk.

It should be emphasized that aggregate stability is a complex matter and is likely due to interactions between organic and inorganic components. It is believed that polyvalent cations such as Ca, Mg, Fe, etc. act as bridges between soil particles. Natural events such as freezing/thawing and wetting/drying will promote aggregation as the soil will tend to fracture along planes of weakness. The complexity of aggregation increases when soil management factors such as tillage, crop production, and compaction are introduced. Maintaining the proper soil fertility, especially pH, will maximize crop residue production and optimize conditions for soil microorganisms.

Water Relationships

The type of tillage used may influence both the movement of the water into the soil (infiltration) and the movement of water within the soil (hydraulic conductivity). Water infiltration will be dependent upon the characteristics of the soil surface, including the amount of crop residue, the degree to which the surface of the soil is crusted, and the existence of large pores open to the surface. It is well known that the maintenance of surface crop residue will reduce surface crusting by absorbing energy from raindrop impact. Surface crop residue, because of the greater microbial activity it supports, also helps maintain greater aggregate stability. These factors, which are consistent with reduced tillage, help maintain large, continuous pores at the soil surface which are necessary for infiltration. Earthworm channels, moisture cracks, and root channels represent some of the sources of macropores in soils. Earthworm populations are influenced by tillage and rotation as Kladivko (1993) has shown (Table 2). In addition to enhancing infiltration, earthworms recycle nutrients within their zone of activity in the soil. The earthworm most affected by tillage is the night crawler (*Lumbricus terrestris*) which form large vertical channels and pull residues down into their burrows, forming a midden, or deposit of soil and residue, at the entrance.

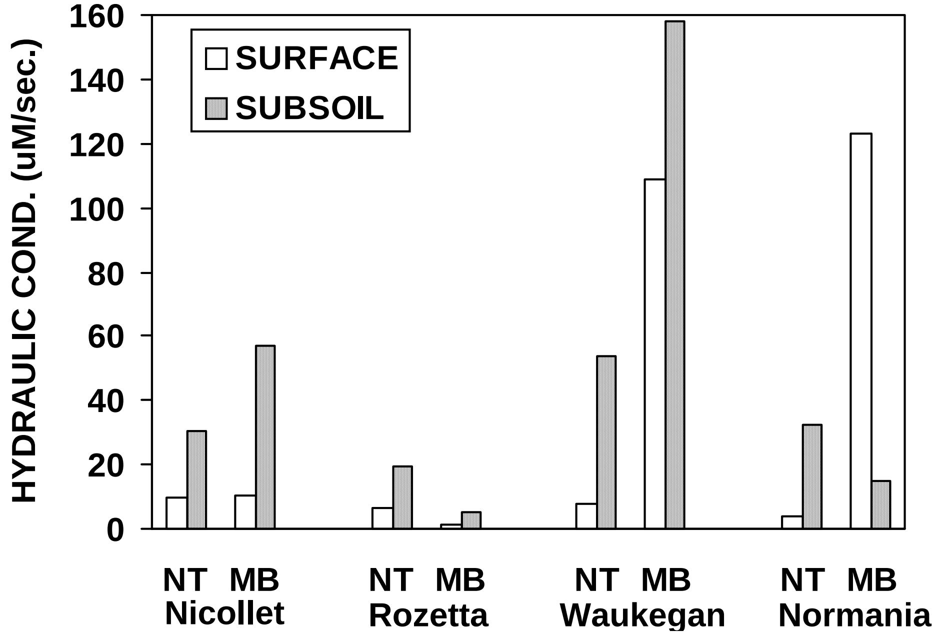
Table 2. Earthworm numbers found in a silty clay loam soil in Indiana following following 10 years of continuous management.

Crop	Management system	Earthworms/m^2
Continuous corn	Plow	10
Continuous corn	No-till	20
Continuous soybean	Plow	60
Continuous soybean	No-till	140
Pasture	Dairy (light manure)	340
Pasture	Dairy (heavy manure)	1300

Adapted from Kladivko (1993).

Unger (1992) concluded that tillage systems that significantly disturb the soil result in lower infiltration rates as the season progresses due to the loss of aggregate stability. Datiri and Lowery, 1991a found that the wetting front moved fastest following large natural storm events in no-till and chisel, when compared to moldboard or ridge-till suggesting more favorable porosity in the no-till and chisel systems. Similarly, Ankeny et al. (1990) found that early season infiltration was greater in chisel plow, when compared to no-till in the un-trafficked portion of the field, but that this relationship reversed where trafficked. Because of the temporal effect, it is critical to identify the

Figure 1. Saturated hydraulic conductivity from two depths of four Midwestern soils under



moldboard plow and no-till cropping systems (adapted from Logsdon et al., 1990).

antecedent conditions when infiltration is measured. Logsdon et al. (1993) found that infiltration rate will also be affected by seasonal effects, not just residue management, making a one-time measurement risky. They found greater variation in infiltration rates between measurement times than they did between tillage systems. They concluded that infiltration was dependent upon the formation of a crust, which they found to be affected by storms with high rainfall intensity, and partially ameliorated drying periods which induced cracking.

Macroporosity is also an important property relative to the movement of water through the soil profile. Evaluations of saturated hydraulic conductivity in soils under different tillage regimes have shown mixed results. Usually no-till soils are found to have a higher bulk density in the surface layer when compared to plowed soils, leading to lower porosity in this system. However, because no-till soils are relatively undisturbed more macropore channels have been found to be continuous with depth in no-till (Heard et al., 1988). Logsdon et al. (1990) measured the saturated hydraulic conductivity in undisturbed cores taken from four upper Midwest soils and found mixed results (Figure 1). These data show considerable variation between sites. For example, the Rozetta soil (Lancaster, WI) had greater flow in the no-till soil at both depths, while the plowed soil had much greater conductivity at both depths in the Waukegan soil (Rosemount, MN).

Conservation tilled (chiseled or disked) soils are often found to have a higher soil moisture content when compared to moldboard plowed soils, because of a greater proportion of smaller pores (Hill et al., 1985) and the shading/mulching effect of the residue. Conservation tilled soils generally had more plant available water, which could be important to a crop in times of moisture stress (Datiri and Lowery, 1991b).

Soil Temperature

Cooler soil temperatures are usually associated with high residue cropping systems. Crop residue will have two major impacts on heat energy. The first is the reflection of incoming solar energy from a relatively lighter colored material, and the second is the insulating effect the residue provides. Several years ago much of southern Wisconsin experienced a frost on Father's Day when most corn was about knee high. Damage from the frost was more severe where there was significant surface crop residue. This residue reduced the diffusion of heat stored in the soil into the crop canopy. Recently cultivated ground suffered a similar fate, because the tilled layer dried out and reduced the heat conductivity from the soil.

Several investigators have measured soil temperatures and the movement of heat energy in the soil. Potter et al. (1985) noted that thermal conductivity was about 20% greater in a no-till soil because of a more continuous arrangement of the soil matrix when compared to the plowed system. They also measured soil temperature shortly after planting at 1, 2, and 6 inches at two sites comparing moldboard, chisel, and no-till systems throughout a 24-hr period. The no-till system at one site was ridge-tilled. They found temperatures at each depth to be similar in the middle of the night across all tillage systems. However, during the mid-day they found more than 10 ^{o}F greater in moldboard than no-till at one site at the 1-inch depth, with chisel intermediate. In contrast, soil temperature in the row in ridge-till was warmer at mid-day than those in chisel. The authors noted that in ridge-till most of the residue was in the inter-row, with the ridge nearly devoid of residue, whereas in the chisel as much as 35% cover was equally distributed over the surface. Overall, temperature differences between tillage became less apparent as the depth in the soil increased. Hatfield (1996) noted that no-till fields have a smaller difference between their daily minimum and maximum temperature, because of the insulating effect of the residue. No-till fields also cool more slowly in the fall. He suggests that the fall temperatures be measured in no-till fields to insure that soil temperature is below 50^{o}F where the fall application of anhydrous ammonia is planned.

Like other researchers, Johnson and Lowery, 1985 found that seed zone soil temperature changes greatly over time in the early season. Figure 2 shows the diurnal fluctuation of soil temperature taken in early June at the two inch depth for four tillage systems at Arlington, WI. The moldboard plow treatment varied by as much as 28^{o}F over a 12-hr period, whereas no-till varied by 21^{o}F.

If soil temperatures differ greatly between tillage systems, there may be differences in the distribution of corn roots in the soil. Kovar et al. (1992) examined corn root growth in a long-term tillage study in a moldboard and ridge-till system in first-year corn following soybean. They found more roots in the inter-row zone under ridge-till. They suggested that this finding may warrant the need for a broader distribution of fertilizer (e.g., banding both in the row and inter-row) in ridge-till.

One method of counter-acting the effect of crop residue on soil warming is to use some form of residue clearing in the row. Today most "no-till" cropping systems include some type of residue clearing usually conducted by disks mounted ahead of the planting units. This practice will be

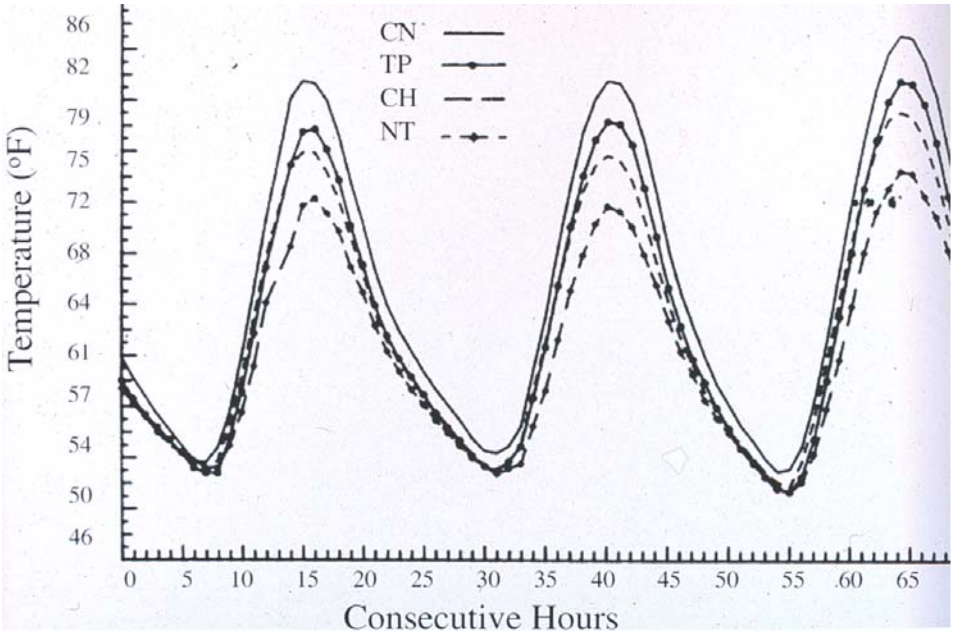


Figure 2. Soil temperature at 5 cm (2 inches) for a 3-day period starting at midnight on June 2, 1982 for four tillage systems (from Johnson and Lowery, 1985).

especially important on erosive soils, where it is vital to maintain crop residue to protect the soil. Research in Iowa demonstrated that a band of six to twelve inches reduced the yield drag associated with no-till (Cruse, 1985). Similarly, work reported by Wolkowski et al. (1996) at Arlington, WI. has shown that residue clearing significantly increases the early growth of corn over that observed with no-till (Table 3).

Table 3. Effect of row clearing on the mean maximum soil temperature for the 3 weeks after planting and the early growth of corn, 1994-1995 (2-yr average).

Tillage	Temperature	Emergence	V6 wt.	V12 wt.	Silked
	°F	plts/ft	---------- g/plt	----------	%
Fall zone	62	1.6	1.1	28	62
Spring zone	N/A	1.5	1.0	26	51
Chisel/disk	63	1.8	1.1	29	80
No-till	54	0.7	0.7	18	36

Adapted from Wolkowski (1996).

Soil Strength

High soil strength, as measured by increased penetration resistance, is indicative of compacted conditions that have been shown to limit root growth. As mentioned earlier, no-till soils often have a greater soil bulk density, resulting in the recommendation that fields should be plowed occasionally. This would disrupt established root channels that researchers have suggested to be beneficial for crop growth in no-till systems.

Larney and Kladivko (1989) evaluated the effect of tillage on soil strength at three Indiana locations following several years in each system. They found that row position has a substantial effect on penetration resistance. Their data showed that the penetration resistance in the row was relatively similar to that found in the moldboard plow. The authors conclude that controlling traffic will be critical in the no-till and ridge till systems to maximize the volume of uncompacted soil for crop growth. Likewise, Voorhees and Lindstrom (1984) found that in the long-term, the negative effect of compaction on the soil porosity can be alleviated. Their southern Minnesota study showed improved aggregation and increased porosity after 4 to 5 yr when wheel traffic was controlled. Unfortunately, the authors did not include yield data in this report, but it can be assumed that the soil tilth was more favorable in the untracked treatment.

Among the methods of controlling compaction in reduced tillage systems is the use of tractors running on tracks instead of tires. Theoretically, a tracked vehicle will have more surface area contact with the soil. Brown et al. (1992) compared a steel-tracked and rubber-tracked implement with both 2- and 4-wheel drive tractors on a silty clay loam soil that had been moldboard plowed and disked. The mass of the tracked vehicles and the 4-wheel drive tractor was similar. However, the 2-wheel drive tractor weight about 50% of the other vehicles. Their study showed, as expected, that the tracked vehicles had less of a compacting effect than the wheeled tractors at the 2- to 5-inch depth (Table 4). The wheeled tractors had a similar effect, despite their weight differences. No difference between vehicle types was observed in the 5- to 8-inch depth.

Some producers have resorted to subsoiling when it appears that crop production has resulted in the formation of a compacted layer. The procedure is energy intensive and has been shown to produce mixed results. Soane et al. (1986) found that the soil bearing capacity after subsoiling was reduced in that sinkage of subsequent traffic was increase 150%. Soane et al. (1987) after evaluating subsoiling at 16 locations concluded that: (1) soils with higher bulk densities would benefit the most from subsoiling; (2) subsoiled fields re-compact with time; (3) controlled or reduced traffic increased the longevity of subsoiling effects; (4) subsoiling was most effective if it alleviated moisture stress; and (5) subsoiling silty soils created negative effects in wet years because of the breakdown of aggregates. Tilled soils may become more compacted compared to a similarly trafficked no-till soil. The tilled soil has much less bearing strength than the no-till soil and if future traffic is not managed the soil may become more resistant to penetration.

Table 4. Effect of tracked and wheeled vehicle on the bulk density, saturated hydraulic

conductivity, and air-filled pore space at the 2- to 5-inch depth and 4-yr average yield.

Vehicle type	Bulk density	Hydraulic conductivity	Air-filled pore space	Yield*
	g/cc	Fm/sec	%	bu/acre
Untracked	1.28	26.0	17.8	166
Steel tracked	1.38	13.0	9.7	148
Rubber tracked	1.46	7.8	7.7	--
Wheeled	1.50	2.7	4.7	139

*Yield for tracked treatments averaged among vehicle type.

One final consideration that is sometimes given to what is considered to be unfavorable conditions associated with reduced tillage is the use of occasional plowing. Pierce et al. (1994) followed the effects of plowing or not plowing on a site that had been in no-till for the previous six seasons. They found that plowing decreased bulk density and increased macroporosity in the year after tillage. The year following tillage these properties were intermediate to the tillage systems, but after a few years they were similar to the continuous no-till treatment. They also noted that plowing redistributed nutrients and stimulated N mineralization.

Summary

One of the purposes of tillage is to improve the soil condition for crop production. Environmental and economic concerns have encouraged a reduction in the intensity of tillage to maintain surface crop residue for soil conservation. The reduced soil disturbance, along with the greater surface residue will have a profound effect on soil properties and crop growth. In the northern grain production region, lower soil temperature in high residue systems often reduce growth and yield. This negative effect can be offset by improved soil water properties such as increased infiltration and plant available water. Controlling wheel traffic is important in conservation tillage. Procedures to remove compacted layers have shown mixed results. Innovative approaches to residue management, such as zone-tillage, offer the potential to balance conservation needs with production and profitability.

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THE ECOLOGY OF NITROGEN CYCLING

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In order to truly understand the behavior of nitrogen in the soil, it is important to understand the reasons *why* it cycles; why and how soil microorganisms use nitrogen. For example, unlike plants soil bacteria can use some forms of nitrogen as an energy source rather than simply for biomass production. Their nitrogen needs and ability to compete for it in the soil are unique. In this talk, we will take an alternative view and explore the hows and whys of the nitrogen cycle from the perspective of soil microorganisms. We will see that nitrogen cycling is a consequence of the growth and activity of microorganisms, and that an understanding of how to 'think like a microbe' can help us have a greater understanding of plant-soil nitrogen dynamics.

First, we'll take a look at the N cycle. We've all seen this before, but have we ever really looked at it from the organisms' perspective? We'll examine some of the reasons nitrogen cycles in the soils, and where are the important points of control. Finally, we'll discuss how the ecology of soil organisms might contribute to soil quality, and management issues. Our ability to manage soil and fertilizer inputs for sustainable yield and environmental quality may depend on a greater understanding of soil ecology.

Talk Summary Points

1) We will investigate the *pools* of N in soil, and examine the fluxes between pools.

2) We will focus on a couple of the processes more specifically.

3) Nitrogen fixation is the first process in the N cycle. N must be fixed from N_2 gas to an organic form. This is an incredibly energy intensive process. This is why nitrogen is so often limiting in terrestrial ecosystems.

4) Mineralization is the transformation of N-org to NH_4^+. It is carried out by nearly all organisms in soil (all heterotrophs). It happens whenever N is in excess of carbon needs. If there is too little N to use up the carbon present, then N must be immobilized from the soil surrounding, or else growth stops.

5) Mineralization only happens when microorganisms are forced to give up the nitrogen – usually when they are eaten or killed. Plants may have ways to force microbial N turnover – as can be seen in examples of rhizosphere carbon and nitrogen dynamics.

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6) The transformation of NH_3 to NO_2^- to NO_3^- is 'nitrification'. We care about this transformation because NO_3^- is far more readily lost from the system than NH_4^+. Also, some plants prefer NO_3^- as an N source.

7) Nitrification happens in two steps, and is a 'narrow' taxonomic process (carried out by a limited number of organisms). Nitroso and Nitro genera are examples of specialized Gm- bacteria that fill an ecological niche – using NH_3 as an energy source, and fixing CO_2. Oxygen is the terminal electron acceptor, thus oxygen is required.

8) The form of the ion is important: NH_3 is volatile, and is the only form that can be nitrified. The enzyme responsible is AMO, or ammonium monooxygenase. Thus nitrification is pH dependent (lower pHs favor NH_4^+ over NH_3).

9) NO_2^- (nitrite) is extremely reactive, and is thus rarely found in solution. Nitrification depends on the availability of substrate – ammonium oxidizers must be found in close proximity to nitrite oxidizers (e.g., a mini-consortium).

10) Generating energy using NH_3 as an electron donor is a very inefficient way of making a living – for every one mole of N fixed as biomass, nitrification requires approximately 16 times the NH_3 to generate energy. Thus ammonia oxidizers (and nitrite oxidizers) grow very slowly in soil, and have been thought to be poor competitors for nitrogen.

11) Addition of ammonia-based fertilizer tends to favor nitrifying activity by alleviating some of the competition for nitrogen among heterotrophic micro-organisms, plants and nitrifiers.

12) Denitrification closes the cycle – NO_3^- gets transformed back to N_2 gas. It happens in several steps. It is carried out by facultative anaerobes, using NO_3^- etc. as alternative electron acceptors. Under ideal conditions, NO_3^- goes straight to N_2. When conditions aren't ideal, then trace gases get released at points along the way.

13) Soil quality might be a function of the microbial community present as much as it is other factors. Our ability to manage soil and fertilizer inputs for sustainable yield and environmental quality may depend on a greater understanding of soil ecology.

IN-FIELD MEASUREMENT OF SOIL QUALITY AND SUSTAINABILITY (2-3-2005)

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Background

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Agriculture is challenged to develop soil management practices that economically provide sufficient food and fiber yet maintain environmental sustainability and conserve the quality of essential soil, water, and air resources. Strategies for sustainable management include conservation of soil organic matter, minimizing soil erosion, balancing production with environmental needs, and making better use of renewable resources.

Tools for Measuring Soil Quality for Sustainable Management

Our research has developed tools and approaches, accessible to both agricultural specialists and producers, to assess soil quality and health and the sustainability of agricultural management practices. Development of the soil health test kit, tools for on-farm assessment of sustainability, and interpretive guidelines have aided research/NGO/farmer partnerships in areas of *Nutrient Management* and development of *Sustainable Soil Management Systems*. We are also developing methods for assessing biological soil properties using equipment and techniques available to non-specialists, and developing and assessing a simple tool for on-farm assessment of sustainability as discussed by Doran (2005).

The USDA Soil Quality Test Kit provides tools and approaches for in-field assessment of soil quality and sustainability by scientists, conservationists, and producers. Commercially marketed by Gemplers, the kit is a valuable resource to agricultural professionals and teachers and over 650 test kits have been marketed to date. Over 10,000 copies of the USDA Soil Quality Test Kit Manual and Interpretive Guide (USDA, 2001) were printed and distributed to field staff, agricultural professionals, and producers since 1999. Copies are also available in English or Spanish on the Internet.

While the USDA test kit is very useful to scientists, consultants, and conservationists it is generally too involved for practical use by farmers. Consequently, a soil quality 'Vest' and a pocket pencil probe for soil electrical conductivity are currently under development by Gemplers and Hanna Instruments for use by consultants and producers.

The USDA soil quality test vest is affordable and easy to use and measures the basic soil properties needed to assess soil quality for sustainable management. This vest also greatly facilitates specialists working directly with producers in the field. In many cases the producer can use this equipment themselves for quick evaluations of questions that arise in the field. This enables decisions to be made in the field while circumstances are fresh in mind rather than waiting days or weeks for a laboratory analysis on a soil sample. If a 'quick' test identifies that a problem may exist, the farmer can submit a sample to a testing lab for a certified verification of the preliminary field test. A listing of the components of the soil quality vest and their relationship to indicators of sustainability is given in Table 1.

Table 1- Strategies for sustainable management as assessed by indicators of soil quality and sustainability in the USDA test vest.

SUSTAINABILITY STRATEGY	SOIL QUALITY 'VEST' INDICATOR
CONSERVE SOIL ORGANIC MATTER *through* Increases with reduced tillage, plant and animal manures, and increased soil cover where C inputs > or = C outputs	**Illinois SOM COLOR CHART** Field comparison of OM over time and between management systems **RING** for measuring **SOIL BULK DENSITY** for accurate C & N measurements
MINIMIZE SOIL EROSION *through* Conservation tillage and increased residue protective cover	**VISUAL** (gullies, rills, dust, etc.) **&** **RING/ROD** for measuring **WATER INFILTRATION, POTENTIAL RUNOFF, & COMPACTION**
BALANCE PRODUCTION & ENVIRONMENT *through* conservation and integrated management systems that optimize tillage, residue, water, and chemicals Synchronizing N and P with crop needs during year	**NITRATE & PHOSPHATE TEST STRIPS** for soil and water **RING & TROWEL** for soil compaction/plant rooting/**WFPS** **SOIL EC PROBE** for nutrient balance/losses
BETTER USE OF RENEWABLE RESOURCES *through* less fossil fuels and petrochemicals, renewable resources & biodiversity (crop rotations, legumes, manures, integrated pest management)	**SOIL EC/TEMP. PROBE** For optimal biological range and potential NO_3 leaching losses **pH PAPER** - Soil acidification with inefficient N use Soil and water **NITRATE** levels **SOIL RESPIRATION** (Mineralization)

After Kleinschmit (2003)

Figure 1. Soil Quality Vest and small Aluminum ring (2.9”x 5”) with many uses

Soil Bulk Density & WFPS

Soil Compaction

Water Infiltration

Water-holding Capacity

3-hour Soil Respiration

Incubated at field Temperature

Potential N Mineralization

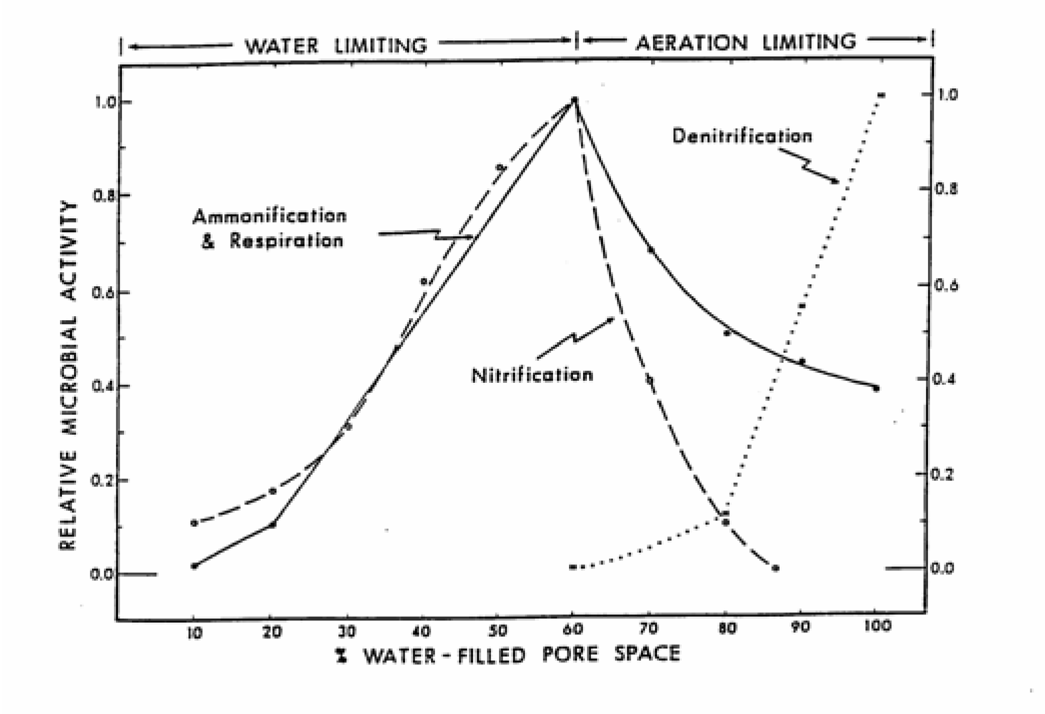

Figure 2. Aerobic and anaerobic microbial processes and % WFPS (Parkin et al, 1996)

The ability to measure soil bulk density using the aluminum ring allows calculation of soil water-filled pore space and determination of the relative proportion of aerobic and anaerobic processes such as nitrification and denitrification.

Soil electrical conductivity (EC) is an easily measured yet reliable indicator of soil health and biological activity and can serve as a quick indicator of plant available nitrate-N. In general, an EC range of 0 to 1 units (dS m^{-1}) indicates good soil health but values between 1 and 2 or higher result in reduced growth of salt sensitive plants and disruption of the microbial processes of nitrification and denitrification (Smith and Doran, 1996). Soil EC can also be used to estimate soil nitrate-N levels in low lime soils (pH < 7.2).

Rapid estimator of Soil Nitrate-N

(low lime soils, pH < 7.2)

140 X EC <= ppm Nitrate-N

Late Spring Nitrate-N Test for
non-limited corn yield

(Early June, top 30 cm soil, corn 30 cm tall 4-6 leaves)
EC differential: of 0.15 units (21 ppm nitrate-N) in fertilized corn or
0.10 units (14 ppm nitrate-N) with manure or after soybean or alfalfa.

Nitrate loss after heavy rain and water logging
If soil EC is 0.01, the Nitrate-N content is < 1.4 ppm

We have identified that a soil electrical conductivity value above 1 salt unit (1 deci Siemen per meter) can result in increased loss of fertilizer and available nitrogen as the potent greenhouse gas nitrous oxide. Increased greenhouse gas emission to the atmosphere can negate remediation of global warming that is offset by increases in soil organic matter levels with reduced tillage management. Nitrous oxide production from nitrification, an aerobic process (60% WFPS), is inhibited by soil EC values greater than 1 but production from denitrification, an anaerobic process (90% WFPS), is increased by soil EC values above 0.8.

Soil Electrical Conductivity (EC):

Indicator of Soil Health and activity of Plants, Microorganisms, and Nematodes;

Range of units (dS/m) in wet soil:

0 to 1 units: best soil health

1 to 2 units: Caution, problem for:

- **Sensitive plants** (d.e. bean, cowpea, pepper, orchardgrass, berseem clover, and potatoes)
- **Nitrogen bacteria** (more Nitrous Oxide evolved offsets benefits of tie-up of atmospheric CO_2 in SOM; 1 N_2O = 300 CO_2)
- **Plant parasitic nematodes** (may have a selective advantage at EC>1)

Soil electrical conductivity (EC) is also useful for estimating N-mineralization during the growing season. We have demonstrated the potential for using measurement of soil electrical conductivity for estimating growing season N mineralization and the effectiveness of cover crops in recovering available nitrogen from manure and fertilizer.

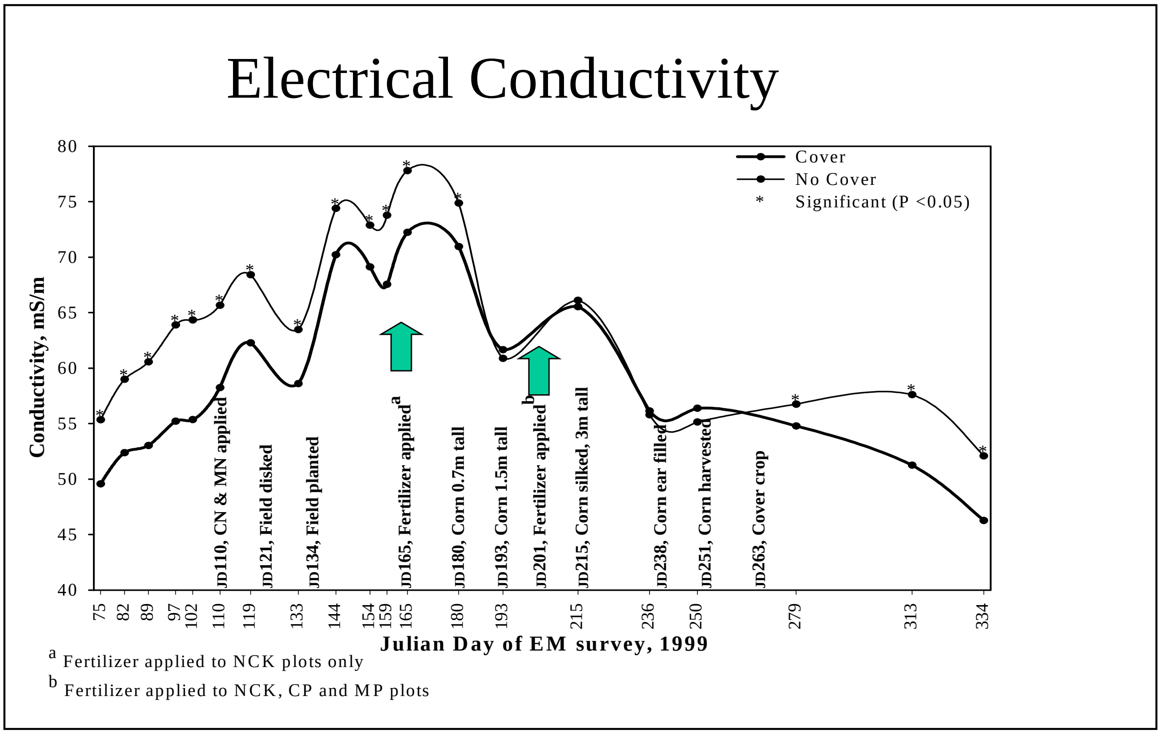

Figure 2. Comparison of growing season soil electrical conductivity with and without a rye cover crop. (After Eigenberg et al., 2002)

Soil EC is also useful in rapidly making late spring estimates of available nitrogen and in determining the potential for loss of environmentally important forms of N as nitrous oxide to the atmosphere or as soluble nitrate in surface and groundwater. Assessment of EC as a tool for managing soil spatial variability within a field and the its potential as a ‘scouting tool’ for determining association with plant disease and nematode infestations needs further evaluation.

Conclusion

Soil quality assessment is a valuable tool for determining the sustainability of land management systems. In the near future farmers will be able to use soil electrical conductivity to assess the nutrient and soil conditions for plant growth each time they pass through a field with a tractor at planting, during cultivations, and at harvest. Until such technologies are fully available to farmers, the soil quality test vest can provide simple field assessments for making on-the-go decisions to help determine the sustainability of their management practices.

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NEMATODES AS INDICATORS OF SOIL HEALTH

Ann MacGuidwin[1]

Why nematodes? Soil provides many ecological services essential for agriculture. Some services, such as soil mixing and the recycling of nutrients, are supplanted by farming practices. Other services, such as biodegrading pesticides and impeding nitrate leaching, are difficult to mimic so farmers rely on natural soil processes. The quality and 'health' of a soil can be evaluated by measuring variables reflecting the service, e.g. plant-available N, rates of decomposition, nitrate levels in groundwater, or by taking stock of the soil organisms that collaborate to provide the service. Microbes, particularly bacteria, are the life forms most responsible for mineralization, decomposition, regulation of noxious organisms, and immobilization of nutrients destined for groundwater, but they are difficult to capture and even more challenging to quantify. Larger life forms, such as beetles and earthworms, are relatively easy to study and their population dynamics may track that of microbes, but only loosely since they do not rely on microbes for their diet. The search for easy-to-study organisms with activities and abundance reflective of microbial communities led ecologists to nematodes, a most diverse and successful phylum only one step above microbes in the soil food chain and represented in every soil on earth.

Nematodes are worm-like invertebrates that number more than any other multi-cellular animal on earth. Nematodes live in animal or plant hosts, water, and soil. Although some nematode parasites of large animals can measure meters in length, most nematodes are less than one millimeter long, which accounts for soil populations as high as fifteen thousand per cup of soil. The majority of nematode species in soil eat bacteria, but some dine on fungi, some on plants, and others on animals, including fellow nematodes. They are perfectly suited for census studies because all soil dwelling nematodes, no matter their diet, are about the same size and captured in a single soil assay. Another feature that makes them amenable for study is that they can be 'sorted' into their different types by amateur taxonomists because their transparent bodies reveal mouthparts and digestive systems that are distinctive for the food they eat. Nematodes that eat bacteria have mouthparts completely different from those that eat fungi, which facilitates assigning specimens a trophic level function.

Nematodes that eat bacteria and fungi are not only useful to soil scientists as indicators of microbial abundance, but also to the microbial populations they eat. Nematodes ingest excess nitrogen in order to fulfill their need for carbon so even as they eat bacteria they expel nitrogen-rich wastes that are immediately available to the surviving bacteria (and plants) for growth and reproduction. Studies of microbial activity and biomass in the presence and absence of nematode predators show the value of predation for microbes, rates of decomposition, and nutrient turnover in soil. Given the diversity of diets within the nematode community, nematodes play vital roles in the soil food webs that provide infrastructure for ecological services. Indices based on nematode communities provide important insights into "who" is in the soil and importantly, "who" are they interacting with.

Procedures for using nematodes as ecological indicators: Soil samples are collected using standard practices for evaluating soil fertility. A general recommendation is to represent five acres by no fewer than 20 soil cores that can be bulked, mixed, and subsampled for nematode assay. Nematodes are collected from 100 cc of soil using only an incubation technique or a

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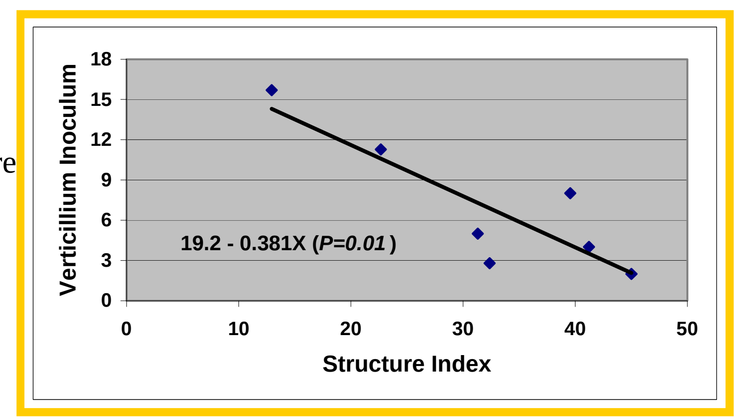
combination of sieving/centrifugation and incubation techniques. The nematodes recovered are stored in water and observed using a microscope. Only a portion of the nematodes, generally 100-200, are identified to the appropriate taxonomic or trophic grouping. These procedures are identical to those used to assay for plant pathogenic nematodes and can be performed at the same time.

Indices based on nematode communities: The total abundance of nematodes in a soil reflects general soil conditions and varies with percent organic matter, sand, pH, soil moisture, and other general attributes. Some nematodes are vulnerable to disturbance or pollution with pesticides or other chemicals and one active area of research is to identify species whose presence or absence is indicative of particular conditions. Indices based on taxonomic diversity, richness, and evenness have been applied to nematodes and the analyses consistent with studies for other organisms. The most widely used application of nematode census data involves grouping nematodes according to their ecological strategy. A "maturity index" (MI), developed by T. Bongers, is computed by calculating a weighted average for the community based on five groups that range from colonizers (short life cycles, high reproductive rate, ability to quickly exploit ephemeral resources) to persisters (long-lived nematodes that require more stable environments). Soils with low MI nematode communities tend to have suffered recent tillage or pesticide disturbance and have short simple food chains with a disproportionate representation of bacteria in the microbial community. The MI has been refined and serves as the basis for other indices that estimate the predominant decomposition pathways, food web status, and disturbance as reflected by the presence of opportunistic nematode species.

Application in Wisconsin: We've used nematode community analysis to compare the impact of different corn-based cropping systems on soil health, to monitor change due to the incorporation of cover crops, and to study the impact of soil fumigation on soil-borne disease in potato cropping systems.

Figure 1 shows the correlation between the nematode structure index, an estimate that increases in value when long-lived species with low fecundity predominate the community and the inoculum potential of the fungus responsible for Verticillium wilt, a chronic disease in Wisconsin potato fields. These data suggest that stable environments favoring nematode species susceptible to disturbance also favor the Verticillium fungus, which is known to be a poor competitor with other soil fungi. We are now determining if monitoring these soils for nematode community structure has predictive value for the potato early dying disease. This relationship could have practical value since it is much easier and reliable to monitor the abundance of nematodes versus fungi.

Figure 1. Propagules of *Verticillium dahliae* per gram of soil from potato fields with nematode communities composed primarily of short-lived opportunistic species (low structure index) or long-lived species sensitive to disturbance (high structure index).



Looking ahead: The impact of several plant parasitic nematodes for crop yields underscores the importance of evaluating soil for nematodes. The fact that a single assay can be used to diagnose the status of the soil food web as well as a specific pest problem encourages advances that facilitate the process. There are several labs that now offer nematode community analyses and more are likely to in the future. Currently, the technology is most used for research – to understand relationships among soil organisms and the impact of farming practices on soils. These studies reveal the biological complexity of soil and help us understand the "who, where, and why" of the ecological services we depend on. The challenge is to use this understanding to develop the means to monitor agricultural soils to protect those that are productive and to restore ecological functions to those degraded by misuse.

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USING RUNOFF MONITORING DATA TO REFINE THE WISCONSIN PHOSPHORUS INDEX

Laura Ward Good [1/]

The Wisconsin Phosphorus (P) Index is a nutrient management planning tool for assessing the risk of P contamination of surface water through runoff from individual agricultural fields. In the current draft NRCS Nutrient Management Standard 590, the P Index is one of two options for planning applications of animal manure P. If the P Index is used for planning, manure applications can be made as long as the assessed risk of P delivery to nearby surface water over the crop rotation remains within an acceptable range. The other option uses soil test P as the sole indicator of the pollution potential of a field, and it restricts manure P applications at high soil test P levels. Planning with the P Index gives producers with high soil test P fields the ability to choose management options appropriate to their operations to maintain each field's P loss risk at an acceptable level.

The P Index is designed to be a better indicator of the potential for P contamination from a field than soil test P. This is because it takes into account both the P sources in a field (soil P, fertilizer, manure applications) and the likelihood that runoff from the field will carry that P to a nearby stream or lake. It uses readily available crop, soil, P application rate, and site information to estimate potential annual P delivery from field to stream. The purpose of this P Index delivery estimate is to guide P management decisions by correctly assessing the relative effects of different management practices on P contamination. It is not intended to be a tool for actually predicting P loading to surface water. Information on how the P Index is calculated and a link to computer software that includes the P Index can be found at http://wpindex.soils.wisc.edu/.

Year-round runoff P monitoring sites on agricultural fields on Discovery Farms throughout Wisconsin were established in 2003. As the calculations in the P Index that estimate runoff volumes and sediment loss for a particular site are based on averages of long- term weather conditions, it is not appropriate to attempt to compare P Index values with monitored data for these components in any given year. The monitoring data can, however, be used to give an indication of the P Index's ability to predict the relative effects of different management and site conditions on P losses. Preliminary data from these monitoring sites indicate that the P Index risk assessment for 2003-2004 was well correlated with annual P loads measured in the field. In contrast, total annual P loads were not related to soil test P.

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THE ROLE OF PIONEER FARM IN THE WISCONSIN PHOSPHORUS INDEX

Christopher A. Baxter [1/]

Abstract

As part of the Wisconsin Agricultural Stewardship Initiative (WASI), Pioneer Farm serves as an applied systems research and education farm with a mission to collect and disseminate high-quality environmental and economic baseline data to students, producers, researchers, and regulatory personnel. The water monitoring data being collected at Pioneer Farm are providing a method for evaluating the effectiveness of the Phosphorus Index (PI) at predicting the risk of P losses, and for testing specific assumptions of the PI. Measured annual runoff sediment and P loads from single-use watersheds in 2003 and 2004 have demonstrated that the PI can effectively assess the risk of P losses, but further refinement of the PI is needed to account for factors such as gully erosion. Data collected at Pioneer Farm are also being used to evaluate specific components of the PI, including the prediction of soluble P delivery based on soil test data, seasonal changes in soluble P, development of a sediment P enrichment ratio, and the impact of acute (single runoff event) losses. The runoff data generated by Pioneer Farm, along with data from the Discovery Farms and University component research, are providing a scientific basis for the development and refinement of the PI, which will play a major role in the future of nutrient management in Wisconsin.

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ATCP 50 NUTRIENT MANAGEMENT REVISIONS

Kevin C. Beckard[1]

Background

In 1997, Wis. Act 27 passed and the legislature directed the Wisconsin Department of Natural Resources (DNR) to prescribe performance standards and prohibitions that farms in Wisconsin will need to meet. The legislature mandated that these performance standards must be designed to reduce non-point source pollution and improve water quality. Act 27 also directed the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) in conjunction with DNR to promulgate rules that prescribe technical standards and best management practices farmers must follow to meet the performance standards. In October 2002, the rules were promulgated into law. DNR administrative code NR 151 identifies the agricultural performance standards for Wisconsin and DATCP administrative code ATCP 50 sets the technical standards that farmers will need to follow to implement the performance standards.

ATCP 50 also sets the statewide standards for nutrient management. At the time the rules were promulgated into law Wisconsin was in the process of developing a phosphorus based nutrient management standard. Since the standard was not completed at the time the rules were taken to public hearing DATCP incorporated the existing USDA Natural Resources Conservation Service (NRCS) 590 technical standard dated March 1999. This standard primarily limits manure applications based on the nitrogen need of the crop to be grown. As a part of ATCP 50, the department made a commitment to initiate rulemaking by January 1, 2005 to adopt the new phosphorus based nutrient management standard if NRCS has a standard by that date. In 2004 NRCS updated their 590 standard to include phosphorus management strategies and came up with a draft NRCS 590 nutrient management standard dated November 2004. This is the 590 standard that DATCP is proposing to incorporate into ATCP 50 in 2005.

Why Phosphorus Based Nutrient Management

In order to get consistency in programs, alleviate confusion and move forward with implementing nutrient management in Wisconsin we need one nutrient management standard for all of our programs. Currently Wisconsin is using multiple nutrient management standards for our various programs. Below are examples of rules and programs that do or will require phosphorus based nutrient management plans:

- **EQIP -** USDA NRCS cost share program
- **NR 243 -** WPDES permit CAFO regulations
- **NR 151 -** Agricultural performance standards
- **ATCP 51 -** Sets statewide standards for new or expanded livestock operations
- **ATCP 50 -** Incorporate P-based 590 standard
- **ATCP 40 -** Distribution of manipulated manure will need a license, exempt from license and paying tonnage fee if going to fields complying with ATCP 50.04

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ATCP 50 Code Revisions

DATCP is proposing to make the following changes to Administrative Code ATCP 50 in 2005.

- Incorporate the draft November 2004 version of the NRCS 590 standard. This standard includes two phosphorus management options: use of the Phosphorus Index or base nutrient applications on the soil test phosphorus levels in the soil.

- Re-formulate one of the qualified nutrient management planner options. A person may no longer qualify by being on the American registry of certified professionals in agronomy, crops and soils. But a person may qualify by being registered as "a soil scientist by the Soil Science Society of America, or as a professional agronomist by the American Society of Agronomy." This reflects a change in registration practices by the relevant professional societies.

- Manure nutrient values in a nutrient management plan need to be based on one of the following:

    1. Standard "book values" specified in Wisconsin Conservation Planning Technical Note WI-1, Companion Document to NRCS Field Office Technical Guide Standard 590, Nutrient Management.
    2. Manure analyses conducted at a laboratory that meets the following standards:
        - The laboratory participates in the manure analysis proficiency program administered by Colorado State University, and provides copies of proficiency reports to DATCP upon request.
        - The laboratory can perform manure analyses according to methods prescribed by the University of Wisconsin-Extension in "Recommended Methods of Manure Analysis," UWEX Publication A3769 (2003).

- Nutrient applications in a nutrient management plan must follow the recommendations in UW Publication A2809, Soil Test Recommendations for Field, Vegetable and Fruit Crops unless one of the following situations justifies a deviation from the recommendations.

    1. Soil or tissue test reveals a specific nutrient deficiency
    2. Excess nutrients are the result of an unforeseen change in the type of crop to be planted
    3. Excess nutrients are the result of manure applications made in the last year prior to writing or implementation of the nutrient management plan
    4. Other special agronomic conditions documented by the planner

The proposed revisions to ATCP 50 will have no effect on the previously established effective dates for the nutrient management rules nor does it change the current cost share requirements. Enforcement of nutrient management standards will still be contingent on the availability of cost sharing. There will be some livestock operations that will need to comply with nutrient management requirements regardless of cost sharing. Those who will be required to comply without cost sharing will include:

- Operators who need a WPDES pollution discharge permit under NR 243 (mainly operations over 1000 animal units)

- Operations who need a permit, under a local manure storage ordinance, for voluntarily construction of a manure storage facility
- Operators who need a local permit for a new or expanded livestock facility with 500 or more animal units according to DATCP's proposed livestock facility siting rule (ATCP 51).

Rule documents for the proposed ATCP 50 revisions may be viewed at the following website: http://www.datcp.state.wi.us/arm/agriculture/land-water/conservation/nutrient-mngmt/planning.html

Other Rules Affected by ATCP 50 Revision

ATCP 51 LIVESTOCK FACILITY SITING LAW - In 2004, the Wisconsin legislature passed the Livestock Facility Siting Law (2003 Act 235). This law is designed to set statewide standards for siting of new or expanded livestock facilities in Wisconsin. This law applies to only new or expanded livestock facilities that are in areas that require local approval and have more than 500 animal units (or exceeds a lower threshold incorporated into local zoning ordinance prior to July 19, 2003). Nutrient management is one of the standards these operations will need to meet in order to get approval under this rule.

ATCP 51 Waste and Nutrient Management Requirements
Livestock operators must manage manure and other waste responsibly. A waste and nutrient management worksheet must accompany every application for local approval. The completed worksheet must include all of the following:

- The types and amounts of manure and other organic waste that the livestock facility will generate when fully populated.

- The types and amounts of waste the operator will store, the waste storage facilities and methods the operator will use, the intended duration of waste storage, and the capacity of waste storage facilities.

- The final disposition of waste by landspreading or other means.

- The acreage available to the operator for landspreading (adequate acreage helps prevent excessive nutrient applications).

- A map showing where the operator proposes to landspread nutrients.

- A nutrient management checklist. This checklist is not required for a livestock facility with fewer than 500 "animal units" unless the operator's ratio of acres to "animal units" is less than 1.5 for dairy and beef cattle, 1.0 for swine, 2.0 for sheep and goats, 2.5 for chickens and ducks, and 5.5 for turkeys.

A qualified nutrient management planner must complete the nutrient management checklist (if required). The planner must answer key questions to show that the livestock operation will comply with NRCS nutrient management standards (proposed NRCS 590 standard dated November 2004). However, a livestock operator is not required to submit a complete nutrient management plan with the application for local approval.

The nutrient management planner must have documentation to support the planner's answers to checklist questions. The planner is not required to submit that documentation with the checklist. But the political subdivision may ask the planner to submit the planner's documentation for one or more answers, as necessary.

ATCP 40 FERTILIZER AND RELATED PRODUCTS – Wisconsin's fertilizer rule, administrative code ATCP 40 is undergoing revisions and is planned to go out to public hearing in 2005. The proposed revision redefines manipulated manure and also creates a license and tonnage fee exemption for the distribution of manipulated manure in certain circumstances.

New manipulated manure definition contained in proposed ATCP 40.

- Manure that is ground, pelletized, mechanically dried, packaged, supplemented with plant nutrients or other substances, or otherwise treated in a manner designed to facilitate sale or distribution as a fertilizer or soil or plant additive. "Manipulated" manure does not include unpackaged manure that is modified solely as an incidental result of normal on-farm practices such as the following:
  - (a) Addition of bedding, sand or water for purposes of animal husbandry or barn cleaning.
  - (b) Shredding, grinding or agitating for purposes of manure handling or removal from a manure storage system.
  - (c) Drying incidental to mechanical ventilation of animal confinement areas.

The proposed rule also creates a license and tonnage fee exemption for bulk manipulated manure that is applied to land currently implementing a nutrient management plan that complies with ATCP 50.04 (proposed NRCS 590 standard dated November 2004). Manure that is manipulated and distributed to lands not complying with ATCP 50.04 will need a fertilizer license and will also need to pay tonnage fees on that manure.

Conclusion

Wisconsin's goal to have a nutrient management plan in place on every cropland acre in the state is a daunting task. This task can be made easier by streamlining these rules and requiring one nutrient management standard for the state. Having one nutrient management standard that applies to everyone will lead to greater consistency in all programs and allow all producers to know where they stand and what they will have to do in the future.

SOURCE EFFECTS ON PHOSPHORUS AVAILABILITY

Larry G. Bundy[1/]

Introduction

Phosphorus (P) availability differences among sources, especially those between commercial fertilizer and manure or other organic P sources, are of increasing interest to farmers, agronomists, and nutrient management planners. While the traditional interest in maintaining adequate P supplies for crop production continues, P availability effects on the risk of P loss in runoff and the environmental implications of these losses are receiving increasing attention. This is particularly true since soil test P and the characteristics of P in manures and organic materials are important factors in P-based nutrient management planning.

The purpose of this paper is to review potential P source differences in the following areas.

- P availability to plants
- Effects on soil test P
- Effects on productivity and soil characteristics
- Effects on P losses in runoff

Since most studies of differences between P sources involve comparisons between commercial fertilizers and manures or between manures from different animal species or management systems, it is important to recognize that characteristics of manures and other organic P sources are quite variable. Some of the manure characteristics that could influence P availability relative to other P sources include: (1) animal species and management; (2) water soluble P content; (3) mineralization rates of organic P components; and (4) manure constituents that may react with soil or with inorganic P.

Phosphorus Availability to Plants

Numerous comparisons of plant availability of P from fertilizers relative to manures have yielded results showing both higher and lower availability of manure P compared to fertilizer P. Manure P is generally assumed to be 60 to 90% as available as fertilizer P, since the inorganic P in manures is viewed as having availability equal to fertilizer P while the organic P component of manures must be mineralized before plant use. Goss and Stewart (1979) compared manure and superphosphate fertilizer as P sources for alfalfa in greenhouse and field studies. Alfalfa grown with fertilizer P removed a higher percentage of added P than where manure was used as the P source. However, alfalfa grown with manure P had a greater yield increase per unit of P uptake (efficiency) than with fertilizer P. Greenhouse yields were higher with fertilizer P, but no yield differences were observed between P sources in field experiments.

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Sharpley and Sisak (1997) reported higher P availability from fertilizer P than from poultry manure leachate (Table 1). Phosphorus availability assessed in a 7-day incubation with 193 soils was inversely related to the ratio of soil clay/organic carbon content which provides an estimate of reactive surface area involved in P sorption and availability. The availability index reported was calculated from the relationship between a soil P test value and the amount of P added. The difference in P availability between the fertilizer and poultry leachate sources was attributed to reaction of P with calcium or with soluble organic compounds in the poultry leachate.

Table 1. Comparison of P availability from fertilizer and poultry litter leachate (Sharpley and Sisak, 1997).

P source	Calcareous soils n = 56	Slightly weathered n = 74	Highly weathered n = 63
	------------ availability index	--------------	
Fertilizer (KH_2PO_4)	0.56	0.57	0.36
Poultry leachate	0.34	0.33	0.19

Several studies have shown greater P availability with manure than with fertilizer P. During and Weeda (1973) found that manure P applied at equivalent rates with fertilizer P decreased P sorption by soil and increased recovery in pastures. Similarly, Abbott and Tucker (1973) compared the residual effects of manure and fertilizer P on calcareous soils and found higher availability where P was applied as manure. They attributed this higher availability to P association with organic compounds possibly involving organic acid production during manure decomposition resulting in reduced P sorption. In an incubation study, Laboski and Lamb (2003) found that P in swine manure was more available than fertilizer P. They suggested that manure P availability was enhanced by organic acid formation during manure decomposition which reduced P sorption to the soil. In subsequent work, Marshall and Laboski (2003; 2004) found that P in dairy manure was less available than fertilizer P, but swine manure P was more available than fertilizer P. These animal species effects on manure P availability were attributed to: 1) differences in P sorption by soil due to differences in organic/inorganic distribution of P in the manures; 2) preferential blocking of sorption sites or displacement of sorbed P by organic acids; and 3) reactions of desorbed iron (Fe) or aluminum (Al) with soil or manure constituents to increase P sorption.

Effects on Soil Test P

The influence of various P sources on change in soil test P (STP) was determined in a 64-week laboratory incubation study using a Ringwood silt loam soil from Arlington, WI (Ebeling et al, 2003). In this work, several dairy manures differing in animal diet and manure handling were applied to soil along with an inorganic P fertilizer and biosolids from the Madison Metropolitan Sewerage District. All P sources were applied at rates of

90, 180, and 360 lb P/acre based on the total P content of the P source, and mixed with the soil. The influence of these treatments on Bray P-1 soil test values after 64 weeks of incubation are shown in Table 2. The soil test values reported are the averages of the three P application rates. All of the P sources increased STP compared to the unfertilized soil. Soil test P with the fertilizer P source was higher than for the other sources suggesting greater availability form the fertilizer. The influence of the dairy manures on STP suggests that their effects are related to the water soluble P content of the manures. For example, STP was increased most by the high P diet manures with higher water soluble P contents, while the fiber fraction from a manure separation process had the smallest increase in STP. Although biosolids had a relatively high total P content, this source increased STP less than fertilizer P or the manures from high P diets. This suggests that biosolids P may react differently than the other P sources when added to soil.

Table 2. Effect of dairy manures, biosolids, and fertilizer P on soil test P after 64-wk incubation (Ebeling et al., 2003).

	Manure P content (%)		Bray P-1
P source	Total P	Water soluble	(ppm)[1/]
Manure –high P diet	1.31	0.37	59b
Manure medium P diet	1.09	0.21	55bc
Manure low P diet	0.66	0.13	46d
Fiber fraction	0.28	0.03	34e
Whole manure	0.85	0.25	58b
Biosolids	3.97	0.22	52c
Fertilizer – $CaHPO_4$	--	--	70a
Control (no P added)	--	--	22

[1/] Bray P-1 soil test P values are averages from 3 P rates (90,180, 360 lb P/acre)

Effects on Productivity and Soil Characteristics

Edmeades (2003) reviewed results from 14 long-term field trials (20 to 120 years) that compared the effects of fertilizers and manures on crop productivity and soil properties. The experiments examined in this study included many of the well-known long-term field experiments such as Morrow (IL), Sanborn (MO), Magruder (OK), Breton (Canada), Broadbalk-Rothansted (England), and Askov (Denmark). Edmeades (2003) concluded that although long-term manure applications increased many of the parameters (eg., organic matter content, soil biological activity, porosity, hydraulic conductivity, and aggregate stability) typically used as indicators of soil quality relative to fertilizer treatments, productivity as measured by crop yields was not significantly different between fertilizer or manure treatments. Manured treatments had higher levels of nutrients including N and P in the topsoil, and thus may have greater potential for losses of P in runoff or nitrate by leaching. Only when manures applied at high rates for many years resulted in large accumulations of organic matter, such as in the Rothamsted experiments, did the manured treatment have significant productivity advantages.

Motavalli and Miles (2002) compared long-term (111 years) fertilizer and manure treatments in continuous corn plots at the University of Missouri Sanborn Field for their effects on soil P fractions. Using a sequential soil extraction procedure, they found that the two P sources clearly affected the amounts and forms of soil P compared with the initial native prairie soil and the cropped control treatment (Table 3). Both P sources increased soil P content in all fractions. The manure treatment increased the labile (active) and slowly available inorganic P fractions compared with the fertilizer treatment. Manure treatments also increased organic P incorporated in soil aggregates (occluded) compared with plots receiving fertilizer P. The authors concluded that conventional soil test P methods such as the Bray P-1 procedure provide an assessment of P availability that is at least equal to measurements of individual P fractions.

Table 3. Long-term P source effects on soil inorganic P fractions from Sanborn Field continuous corn plots (Motavalli and Miles, 2002).

Treatment	Available	Labile	Slow	Occluded	Weatherable
	--------------------------------	--------------------------------	ppm P	--------------------------------	
None	3	18	19	14	1
Fertilizer	54	55	76	39	25
Manure	56	181	149	41	23
Prairie	4	7	22	10	7

Effects on P Losses in Runoff

Kleinman et al. (2002) compared runoff P losses from surface-applied and incorporated fertilizer (DAP) and manures using simulated rainfall and runoff boxes packed with representative soils (Table 4). Results showed that all surface-applied P sources (90 lb P/acre) increased soluble P (DRP) and total P concentrations in runoff relative to the control and that DAP had similar runoff P concentrations as poultry and swine manures. Dairy manure had lower runoff P concentrations that the other P sources. When P sources were incorporated before rainfall, DAP, and poultry and swine manures had no effect on runoff total P concentrations, and only dairy manure had a higher total P concentration than the control.

Phosphorus source effects on runoff P losses were also evaluated by Withers et al. (2001). They found that P loads (total amount of P lost), total P concentrations, and soluble P as a percentage of total P concentration in natural runoff from plots with surface-applied fertilizer and organic P sources were higher where P was applied as triplesuperphosphate (TSP) and liquid cattle manure compared with the control and dewatered sewage sludge (Table 5). In this study, P sources were applied at 54 to 80 lb P/acre, depending on the nitrogen content of the P source. Particulate P losses were not affected by application of the P sources. Incorporating the P sources into the soil lowered soluble P concentrations in runoff from all sources and particulate P was the dominant contributor to losses.

Table 4. Runoff P concentrations from surface-applied and incorporated P sources on a high-P soil (Kleinman et al., 2002).

Treatment	Surface-applied		Incorporated
	Soluble P (DRP)	Total P	Total P
	---------------------------- ppm	---------------------------------------	
Control	0.2a	4a	5a
Fertilizer (DAP)	13b	20b	5a
Dairy manure	2c	3.5a	9b
Poultry manure	11b	21b	7ab
Swine manure	14b	16b	7ab

Table 5. Effect of surface-applied P sources on P in natural runoff (Withers et al., 2001).

Treatment	Cumulative load		Total P (TP)	DRP as a % of TP
	Soluble P (DRP)	Particulate P		
	-------------- mg/plot	--------------	ppm	
Control	5	19	0.89	24
Fertilizer (TSP)	63	19	4.79	74
Cattle Manure	62	26	3.99	62
Dewatered	8	25	1.19	28

In both of the studies summarized above, Kleinman et al. (2002) and Withers et al. (2001) noted that P runoff losses were related to the water-soluble P content of the P source applied. Similar observations emerged from a recent simulated rainfall runoff study with three manures conducted at the University of Wisconsin Arlington Research Station in 2004 (Andraski and Bundy, 2004, unpublished data). In this study, poultry manure from an egg laying operation, and liquid and semi-solid dairy manures were surface-applied to corn residue at a uniform rate of 60 lb P_2O_5/acre (first-year available P) and runoff from simulated rainfall was collected and analyzed. Results showed that runoff volumes and soluble P concentrations with semi-solid and liquid dairy manures were higher than with the poultry manure (Table 6), and that all P sources increased P concentrations compared to the control. Runoff soluble P concentrations ranged from 0.22 to 4.72 ppm and followed the order: no manure < poultry < dairy slurry < dairy semi-solid. Runoff total P concentrations ranged from 1.36 to 8.51 ppm and followed the order: no manure = poultry < dairy slurry = dairy semi-solid. Treatment effects were the same for soluble and total P loads and followed the same order as runoff total P concentrations. Water extractable P application rates in the three manures were significantly different and were well correlated with soluble P concentrations in runoff. These results suggest that water extractable P content of manures may provide an improved method of assessing the risk of P losses from various P sources especially manures from different animal species and handling practices.

Table 6. Phosphorus in simulated rainfall runoff from various manures and manure handling practices, Arlington WI, 2004.

Manure	Runoff volume	P applied		Soluble P		Total P	
		Avail. P_2O_5	WEP[1/]	Conc.	Load	Conc.	Load
	mm	------- lb/acre --------		ppm	g/ha	ppm	g/ha
Control	9b	0	0	0.22d	19b	1.36b	130b
Poultry 2.7 t/acre	7b	60	9	1.24c	88b	2.60b	181b
Dairy semi-sol. 31.1 t/acre	20ab	60	27	4.72a	1031a	8.51a	2086a
Dairy liquid 17,340 gal/acre	35a	60	24	3.42b	1260a	6.88a	2463a

[1/] WEP = water extractable P

Summary

Phosphorus in manures can have either greater or lower plant availability than fertilizer P. Dairy manures usually have lower availability than fertilizer P while swine manures may have greater availability. The relative availability of P in manures depends on several factors including soluble or water extractable P content, organic P mineralization rates, and reaction of manure constituents with soil or P. Results from long term comparisons of fertilizer or manure P sources show no clear differences in terms of crop productivity. However, the amounts and forms of P in soils can be influenced by long-term additions of various P sources. Experiments with dairy manure, fertilizer, and biosolids indicates that soil test P is increased more by fertilizer than by dairy manure or biosolids, and the increase may be related to the water soluble P content of the various P sources. Observed differences in P runoff losses with various P sources are often due to placement method, dry matter content of the P source, and water extractable P application rate. Substantial differences in runoff P losses can occur due to animal species and manure handling variables. Water extractable P appears to provide useful information for assessing P runoff losses from land-applied manures.

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Dairy Manure and Air Quality: The Issues

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INTRODUCTION

Why the Concern?

The trend towards fewer and larger livestock farms has heightened public concern about pollution. Over the past several years, environmental policy related to animal agriculture has focused on land application of manure, especially methods to stop or reverse soil phosphorus build-up, runoff, and the subsequent pollution of lakes, streams and other surface water bodies. Policy is now focusing on the reduction of air emissions from animal agriculture. For dairy operations, ammonia is by far the most important potential air pollutant. The adverse effects of agricultural ammonia emissions extend to regional, national and global scales (NRC, 2003). Under the federal Consolidated Emissions Reporting Rule, all states are required to report agricultural ammonia-nitrogen (NH_3-N) gas emissions to the U.S. Environmental Protection Agency (EPA) by the end of 2004. The data EPA collects will be used in air quality regulations to control the air-borne particulates and haze that affect many regions of the country.

Environmental Impacts of Ammonia Losses

The environmental impact of ammonia emissions is dependant upon two issues:
(1) Response of different ecosytems to the amount of atmospheric N that is deposited, and
(2) Air quality consequences of ammonia-N emissions.

A proportion of manure ammonia-N emitted to air is deposited near its source (e.g., barn, lagoon, fields where manure has been applied) where it can be utilized by crops and other plants. However, a significant amount of manure ammonia-N is transported greater distances from the source. From a land perspective, when ammonia-N is deposited in natural ecosystems, the N contributes to ecosystem fertilization, acidification, and eutrophication (accelerated aging). While not a known concern in Wisconsin, this N input can cause dramatic shifts in the native vegetation, such as enhancing grass growth which can displace native species and create fire hazards in more arid (western) regions. From a water quality perspective, the ammonia gas produced by livestock farms in the upper Mississippi River basin is thought to be a major source of N contributions to the Mississippi river and, subsequently, to the hypoxia (oxygen depleted) zone in the Gulf of Mexico (Burkart and James, 1999).

Of more local concern is the potential for emitted ammonia to combine with acidic compounds in the upper atmosphere to form particulates. These particulates have been related to atmospheric haze, and also have been attributed to a variety of adverse human health effects, including premature mortality, chronic bronchitis, asthma, and other respiratory ailments.

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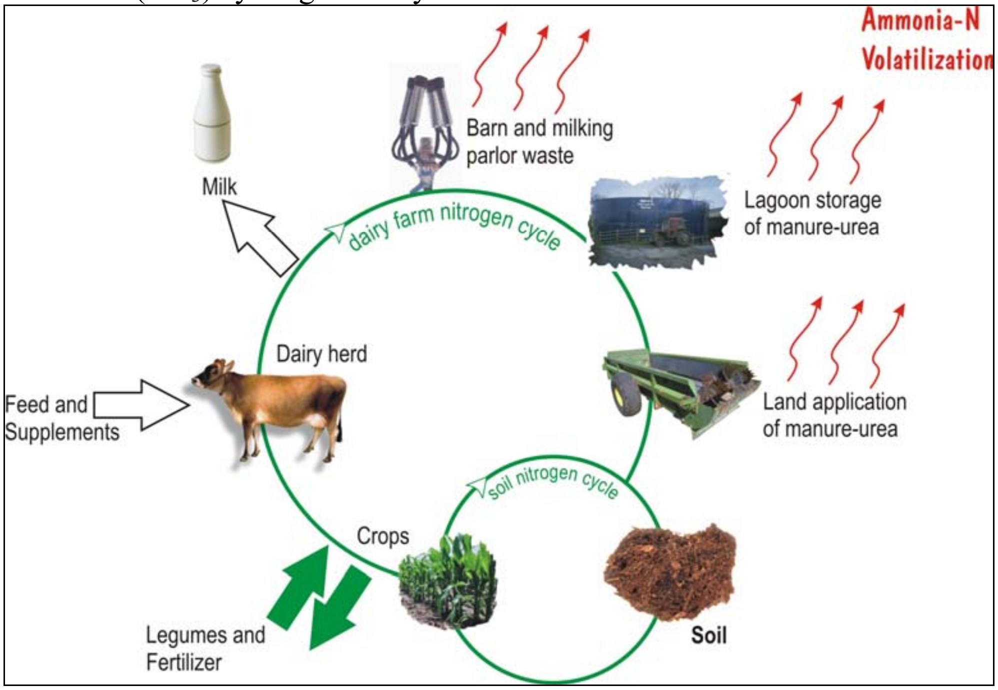
Figure 1. Ammonia (NH_3) cycling on dairy farms.



Ammonia (NH_3) Cycling: How NH_3 is Formed and Lost on Dairy Farms

Ammonia-N losses from dairy operations begin to occur immediately after feces and urine are excreted from the animal, and continue through manure handling, storage and land application (Fig. 1). Only 20 to 30% of the N (protein) fed to dairy cows is converted into milk. The remaining N is excreted about equally in urine and feces. About three-fourths of the N in urine is in the form of urea. Urease enzymes, which are present in feces and soil, rapidly convert urea to ammonium (NH_4^+). Ammonium is then transformed quickly into ammonia gas (Fig. 2). Ammonia gas can be lost to the atmosphere through a process called volatilization. Feces contain little or no urea. For this reason urinary N is much more vulnerable to ammonia volatilization than is fecal N.

Figure 2. Ammonia-N emission process.

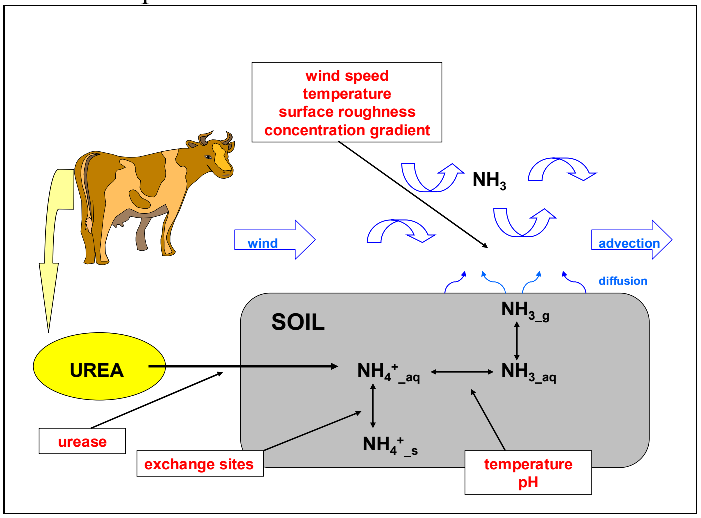
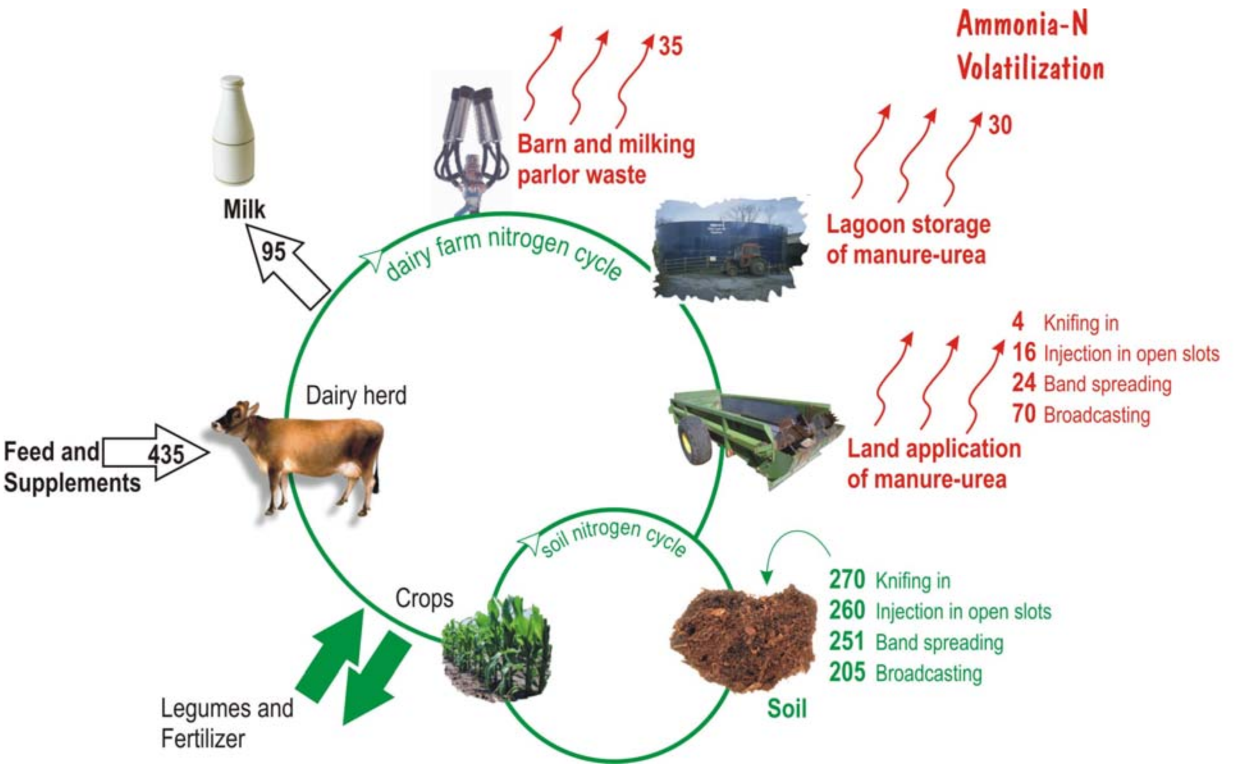


Figure 3 illustrates potential ammonia-N losses from a free stall barn, slurry manure system using an uncovered earthen pit for manure storage. Nitrogen flow through the system from feed through the cow, manure, field application of manure, and eventually back to feed is shown. Modeled losses from four different systems for field spreading manure are also shown. Of the field spreading techniques, atmospheric ammonia losses are highest with broadcast and lowest with knifing manure applications.

Figure 3. Model of annual N (lbs) inputs, outputs, and cycling for a typical lactating dairy cow.



<u>Assumptions</u>: The numbers represent one cow, producing 18,400 lbs milk per year containing 3.2% crude protein. The cow is lactating during 10 months of the year, and dry for two months. She consumes 15,920 lbs feed dry matter per year containing 17.5% crude protein while lactating and 13% protein while dry. To calculate N flows for the entire mature herd, multiply the numerical values in Figure 3 by the number of lactating cows plus dry mature cows in the herd.

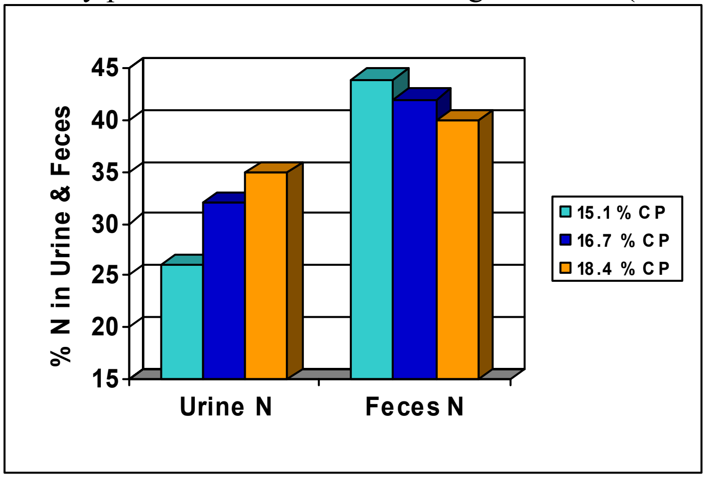
While this model of N flow through a dairy operation is indicative of what may be expected under average conditions in a confinement-based feeding operation in Wisconsin, many factors affect actual loss. Factors such as: 1) Farm size and animal density (cow number per unit land area); 2) Animal diet impacts on milk production and relative excretion of N in urine and feces; 3) Housing type; 4) Manure collection and storage; 5) Soil type and land application practices; and 6) Weather (short-term) and climate (long-term).

SOURCES OF AMMONIA-N LOSS

Amount of Protein Fed To Dairy Cattle

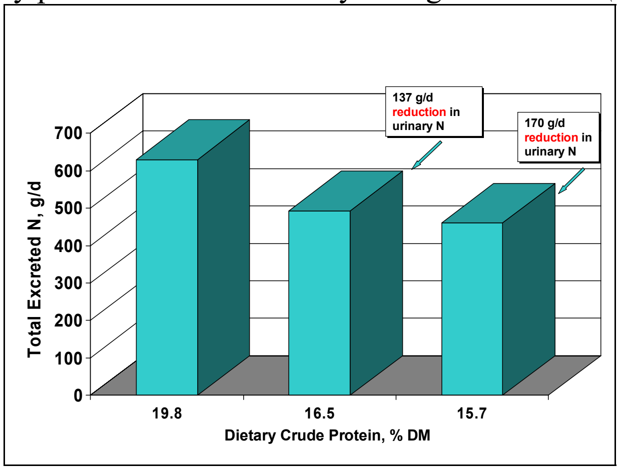
Nitrogen excretion by dairy cows via urine and therefore the amount of manure-N susceptible to loss as ammonia-N is highly influenced by the amount and type of protein fed. As the amount of protein in feed exceeds that which is required by the cow, relatively less of the N goes into milk and more goes directly into urine production (Fig. 4). Knowing the amount of N that dairy cows excrete in urine and feces is the first approximation of how much N is vulnerable to loss as ammonia.

Figure 4. Effect of dietary protein intake on urine-nitrogen content (*Broderick, 2003)*.



Significant reductions in urine-N production can be obtained by reducing dietary protein levels (Fig. 5). For example, if 17.5% dietary protein currently represents an industry average for lactating cows, careful reformulation of diets to contain 16.5 to 16.7% crude protein (which meets requirements for the lactating cow and still provides a reasonable margin of safety) would reduce N excretion in urine by about 20%. Diet formulation to eliminate excess protein usually reduces feed cost <u>and</u> is one of the most effective tools for reducing atmospheric emissions of N-containing compounds from dairy farms.

Figure 5. Impact of dietary protein intake on urinary-nitrogen excretion *(Broderick et al., unpublished).*



Ammonia-N Loss From Housing

Ammonia-N emissions from livestock housing and storage systems can range from 10 to 85% of the N excreted by a dairy cow (Table 1). The main factors that affect this value are manure handling and storage system, bedding type, frequency of manure removal, ventilation and temperature. Lowest ammonia loss occurs on farms that scrape and remove manure daily. Highest losses occur in outside areas where no manure is collected.

Table 1. Nitrogen lost in various types of manure handling and storage systems (*Adapted from MWPS, 2001*).

System	Nitrogen Lost (%)
- - - - - - - - - - Solid manure - - - - - - - - - -	
Daily scrape and haul	20 to 35
Manure pack	20 to 40
Open lot	40 to 55
- - - - - - - - - - Liquid manure - - - - - - - - - -	
Underfloor pit*	15 to 30
Above-ground tank*	10 to 30
Holding pond	20 to 40
Anaerobic lagoon	70 to 85

Dairy farms in Wisconsin typically have one or more of the following animal housing and manure collection systems:

1) <u>Confinement free stall</u>. Free stall systems are common on large dairy farms. Cows are under roof and are free to move between stalls. Sand or mattresses covered with a minimum of bedding are used in free stalls. Slurry manure is scraped two or three times per day from the concrete alleys, and is typically hauled daily for field application or stored in an earthen pit that is emptied two or more times per year. A few larger dairies separate manure solids from the slurry. The solids may be composted. The liquid is either irrigated onto fields or used to flush alley manure. Ammonia-N loss from free stall barn floors is greatest during the summer and lowest in winter.

2) <u>Stanchion or tie stall</u>. Stanchion or tie stall barns are most common on dairy farms having 100-125 cows or less. Cows are confined to a stall and manure is collected in a gutter behind the cows. Moderate to large amounts of straw, wood shavings, or crop residue are used for bedding. The manure mixed with bedding is typically removed with a gutter cleaner twice daily, and field applied daily or stored for later field application. Cows may have access to a small exercise lot, or may be allowed access to a pasture to graze for part of the day.

3) <u>Loose housing and manure pack</u>. This system is found on smaller dairies. Cows are housed in an open shed where large amounts of bedding material absorb moisture. The bedded manure pack may build up considerably in depth before being emptied once or twice per year. This system requires less capital, and often is used in conjunction with grazing.

4) Grazing with no housing. A system more common on smaller rather than larger dairy farms. When weather permits, some dairy operators only bring cows into a building to be milked and, possibly, offered some supplemental feed. The remainder of the day, cows are on pasture, and most of the urine and feces is deposited in the paddock. Ammonia-N loss from pasture is generally proportional to livestock stocking rates and the amount of time spent on pasture, which, in turn, is proportional to the amount of urine and feces deposited in these locations. The spatial location of manure deposition and soil, weather, and climatic conditions all affect the actual rate and extent of ammonia-N loss from these areas.

Ammonia-N Loss from Manure Storage

Solid and semi-solid dairy manure is stored in piles on concrete or earthen pads. Liquid manure is stored in concrete, earthen, or lined lagoons or above-ground storage tanks. Liquid manure systems in Wisconsin are typically not covered. However, in some European countries (e.g., The Netherlands and Denmark) manure storage structures must be covered. These lagoons may be covered with biological material (e.g., straw) or impermeable material (e.g., synthetic polymers) in an attempt to reduce losses of ammonia-N as well as odor. Ammonia loss from manure storage depends on the structure used (Table 1). Lowest N losses occur on farms that conserve urine-N in underground pits and in bedded packs. Very large amounts of ammonia are emitted from anaerobic lagoons, especially during agitation before manure tankers are filled for field application.

Ammonia-N Emissions from Land Application of Manure

Ammonia loss from land-applied dairy manure can vary tremendously depending numerous factors, including: 1) Weather conditions such as temperature, wind speed, rainfall; 2) Manure application methods such as degree of incorporation, rate of application, zone of application, and timing of application; 3) Manure characteristics including pH, dry matter and ammonium-N contents; and 4) Soil conditions such as moisture, texture, organic matter content, and surface residue cover.

Ammonia losses during field application of manure are usually expressed as a percentage of the total ammoniacal N (TAN) of the manure. TAN is the sum of the ammonium-N (NH^4+) content of the manure plus the ammonia-N content. Of manure-N, TAN is the portion that is susceptible to atmospheric loss. It is also the portion of N that is potentially available to plants. Ammonia losses can range from close to 100% of TAN for surface manure application during periods of optimal volatilization conditions, to only a few percent when manure is injected or incorporated immediately into the soil (Table 2).

Recommendations on how to apply manure to fields must consider the complete chain of events that affect manure-N, as well as other nutrients, cycling in soils. For example, if manure is injected or incorporated into soil to minimize ammonia-N loss, an increased risk for nitrate loss to groundwater may result. In addition, incorporation of manure has the potential to increase runoff and the associated losses of sediment and phosphorus (P) which could degrade surface water quality. The selection of appropriate manure management practices for individual farms needs to be tailored to the specific conditions existing at a site.

Table 2. Qualitative comparisons of major N loss pathways for manure application under various management regimes and environmental conditions (*Adapted from Meisinger & Thompson, 1996).*

Manure Management			Soil Drainage	Nitrogen Loss Processes	
Rate	Time	Placement		Ammonia	Leaching
		- - - - - - - - - - Placement Comparisons - - - - - - - - - -			
Medium	Spring	Surface	Well	High	Med.
Medium	Spring	Incorporated	Well	Low	Med.
Medium	Spring	Injected	Well	Low	Med.
		- - - - - - - - - - Soil Drainage Comparisons - - - - - - - - - -			
Medium	Spring	Incorporated	Excess	Low	High
Medium	Spring	Incorporated	Poor	Low	Med.
		- - - - - - - - - - Application Rate Comparisons - - - - - - - - - -			
Low	Spring	Incorporated	Poor	Low	Low
Medium	Spring	Incorporated	Poor	Low	Med.
High	Spring	Incorporated	Poor	Low	High
		- - - - - - - - - - Time of Year Comparison - - - - - - - - - -			
Medium	Fall	Surface	Well	High	High
Medium	Winter	Surface	Well	Med.	High
Medium	Spring	Surface	Well	High	Med.
Medium	Summer	Surface	Well	High	Med.

ODOR CONSIDERATIONS

Odor control during manure spreading is a concern in areas where dairy farms are in proximity to non-farming developments or communities. Many of the recommended measures for odor control also reduce ammonia-N loss. These include:

- Incorporate manure soon after land application or, in a liquid system, apply slurries using band spreading/injection techniques;
- Minimize the time that odor is released into the air by having machinery in good repair and labor ready before starting to unload manure from storage; and
- Minimize agitation and exposure of manure to air.

AMMONIA-N LOSS EFFECTS ON AVAILABILITY OF MANURE-N

Ammonia loss is important because it is a direct loss of N available for crop production on farms. The loss of ammonia also reduces the ratio of nitrogen to phosphorus (N:P) in manure. This increases the likelihood of manure-P applications exceeding crop needs resulting in the build-up of soil test P levels beyond agronomic optimum levels. This situation is common on many of

Wisconsin's dairy farms. Runoff of P from these fields and the subsequent potential for pollution of lakes and streams is a major environmental concern.

Reducing ammonia losses from dairy farms and making greater use of the conserved manure-N often makes economic sense as well. Natural gas accounts for 75-90% of the cost of making anhydrous ammonia. As the price of natural gas continues to skyrocket, the fertilizer-N value of manure, and therefore the conservation of ammonia-N will become more important.

MANAGEMENT PRACTICES TO REDUCE AMMONIA-N EMISSIONS FROM DAIRY FARMS

Substantial reductions in ammonia-N loss from dairy operations can be achieved by feeding less protein to dairy cattle, reducing in-barn losses, covering manure storage, and incorporating manure in the field (Table 3).

Table 3. Impact of improved management practices on reductions in ammonia-N emissions.

Management Practice	Mechanism for Decrease in Ammonia-N Loss	Decrease in Ammonia-N Loss (%)
Remove excess and/or feed balanced dietary protein	Decrease N output in urine	10 - 15
Cover manure storage	Decrease ammonia escape	20 - 30
Incorporate or inject manure	Reduce ammonia production and loss	30 - 50

The following steps, in descending order of potential benefit, can be a guide for action to reduce ammonia-N emissions from dairy farms:

1. Remove excess protein from the cow's diet. This also can save on the cost of feed.
2. Incorporate manure in the field. However, beware of concerns with nitrate leaching and/or the potential for increased erosion and P losses.
3. Cover manure storage structures. Organic bedding such as straw used in free stall barns will form a crust on the surface of the slurry pit. This reduces ammonia-N losses and odors. Excessive agitation during unloading of the slurry from storage should be avoided.
4. For new construction, floors that divert urine away from feces can reduce ammonia-N emissions. Slatted floors facilitate this, but there is still considerable loss of ammonia-N from the surface of the slatted floor.

Implementation of steps 1-3 above could potentially reduce ammonia-N loss to the atmosphere from about 115 lbs/cow/year to 30-40 lbs/cow/yr, a 65-70% reduction. This would result in an additional 70-80 lbs N per cow available annually for application to field crops.

KEY POINTS

Ammonia-nitrogen (NH_3-N) emissions from dairy farms are becoming an environmental concern. These losses greatly reduce the fertilizer N value of manure for crop production.

Key management practices that can reduce ammonia-N loss include:

1. Remove excess protein from the cow's diet;
2. Improve manure handling and storage; and
3. Incorporate manure in the field - - being mindful of possible tradeoffs with regards to nitrate leaching, soil erosion and phosphorus losses.

Implementation of these practices could reduce ammonia-N loss by 65 to 70%. The result would be an additional 70-80 lbs N per cow available annually for application to field crops.

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ON-FARM CONSEQUENCE OF CONVERSION FROM N- TO P-BASED NUTRIENT MANAGEMENT STNADARDS

Bill Stangel [1/]

Nutrient management plans were compiled from a pool of 13 farms across Wisconsin that had been developed by seven different crop consultants and implemented using the nitrogen-based NRCS-590 standard (1999 version). This data set consists of 10636 cropland acres with soil data, cropping information and available cost data attributed to specific field operations and management. Comparisons of the N based standard with the current phosphorus-based standard were made. Major differences between the versions of the standard relate to acreage impacted by proximity to surface waters and acceptable P management strategies where soil tests exceed 50 ppm soil test P. Surface water quality management areas (SWQMA) acreage increased from 665 to 1135 acres in current version of the NRCS standard. Soil test P levels for the cropland set are distributed as follows: 55% < 50 ppm; 30% > 50 ppm and < 100 ppm soil P; 15% > 100 ppm soil P. Impacts of the level of soil test P varies by farm and landscape and will be better defined through the implementation of the phosphorus index which is a component of the current standard. Impacts of the phosphorus index versus the soil test P strategy are being determined as well as the direct costs of nutrient management implementation on the participating farms.

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Fertilizer, AgLime and Pest Management Conference

Technical Service Providers

Presented by:

Ken Rismeyer - NRCS

TSP Coordinator

What are Technical Service Providers?

- Private businesses, individuals, non-profit organizations or public agencies that apply conservation systems on the land
- Provide technical service to landowners participating in the Farm Bill Programs
- Must be certified by NRCS and be listed on the TechReg Registry

Registration and Certification Process

1) Register for a e-Authentication account
2) Activate your e-Authentication account
3) Log in to TechReg
4) Apply for certification
5) Sign certification agreement

Step 1
Register for an e-Authentication Level 2 user account

- Go to the USDA e-Authentication site at http://www.eauth.egov.usda.gov/ and set-up a Level 2 user account.
- Make sure the information you enter is exactly the same as it appears on your WI drivers license or other government issued photo ID you will later use in Step 2.

Step 2
Activate your e-Authentication account

- Your e-Authentication account is a secure site for you to complete business with USDA electronically.
- To do that, you must now go to your local USDA Service Center and be Identity Proofed and have your identity validated by a Local Registration Authority (LRA).
- An USDA Service Center employees will assist you with this.

- They will first complete a Service Center Information Management System (SCIMS) search, if you are not already in SCIMS they will set up an account for you.
- You will then be asked to show them a photo ID.
- If the information you entered for Step 1 above matches the information on your photo ID, they will activate your Level 2 e-Authentication account.
- Your e-Authentication account will then be linked to your SCIMS account.

Step 3
Log into TechReg

- Using the User ID and Password you created in Step 1 above, you are now ready to log into TechReg.
- Log in to http://techreg.usda.gov/
- Click on the “log-on” button on the top left corner of the TechReg home page
- You will be prompted to a blue warning box, once you have read it, click on continue.
- Enter the user ID and password you created in Step 1 above.

Step 4
Apply for Certification

- Once in TechReg, you will be at a drawdown bar which lists 42 TSP categories.
- Highlight the appropriate certification category.
- Most categories have several options to choose from for certification.
- Select the option with the criteria that best meets your knowledge, skill and abilities.
- If you have a certification from a recommending organization, like the American Society of Agronomy, you will be prompted to go a different route than that of an individual that is applying for certification based on experience or education.

Step 4 Continued

- After selecting the appropriate option for your situation you will be prompted to answer a series of questions about how you acquired your qualifications.
- Once you are finished entering your information into the database you will be asked to review your entries for accuracy.

Step 5
Sign Certification Agreement

- The final step in the Certification process is to sign the Certification Agreement.
- Once you do that and you meet the Criteria for the Category which you are applying for certification in, your name will be added to the TechReg registry of Certified TSP for that category.

If for some reason you do not complete the certification procedure or if you do not meet the criteria for the Category in which you are applying for certification in, you will be placed in a “Pending” Certification status until which time you successfully complete the certification process.

2004 activities

- 270 participants across Wisconsin received additional funding from NRCS to hire a TSP in FY04, totaling $352,000
- 94% of total funding went to 590 practice
- Anticipate funding for TSP's to increase in FY05

Payment Process

- Not to Exceed Rate (NTE) Calculator

  www.tsp.nte.nrcs.usda.gov

  - Includes salary, overhead, travel but not profit
  - Varies by units applied-not a flat rate
  - Not intended to determine what TSP charges for their services
  - Rate is broken down by design, installation and checkout
  - By law, the NTE rate is the maximum amount NRCS can pay
  - For contracts between program participants and TSP

NRCS Reimbursement

- NRCS may reimburse participant for technical services received prior to contract if:
  - An agreement is signed by the State Conservationist prior to receiving services
  - TSP certified in TechReg before work begins
  - Landowner must accept NTE rates

TSP TA Payment Not Authorized

- Statements Of Work (SOW) deliverables lacking or practice obviously does not meet the NRCS practice standard
  - SOW are listed on the Wisconsin NRCS website under eFOTG, Section IV, Practice
- TSP not TechReg certified
- TSP work was completed PRIOR to an approved contract and without a written agreement with the State Conservationist
- For services not typically provided by NRCS

Verification of Credentials for new TSP Applicants

- Must be completed within 60 days
- Needs to be verified by the State Conservationist
- May need county level assistance for verifying qualifications of applicant

Quality Assurance Reviews

- NRCS will spot check 10% of work annually
- If deficiencies are discovered the TSP will be given the opportunity to demonstrate that they are capable of performing the required tasks before they are decertified

Release of Farm Bill contract information

Contract information can be provided by:

- Participant themselves
- NRCS office with a release signed by the participant
- No electronic release authorization will be accepted

TSP Warranty of Technical Services

- NRCS will require TSPs to be responsible for their work
- Final language has been modified to assure adequate protection for USDA while allowing TSPs to more easily obtain Errors and Omissions Insurance

Brochures are available at the NRCS exhibit

For additional information check these websites

http://www.wi.nrcs.usda.gov/programs/techpro.html

http://techreg.usda.gov/

http://www.tsp-nte.nrcs.usda.gov/

http://techprs.sc.egov.usda.gov/

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UPDATE ON NRCS 595 PEST MANAGEMENT STANDARD AND CONSERVATION PLANNING TECHNICAL NOTE 2

James D. Kaap [1/] and Richard T. Proost [2/]

Through the 2002 Farm Bill, NRCS provides eligible farmers financial incentives to implement soil conservation practices, including pest management. The current Wisconsin 595 pest management practice standard was completed in June 2003 and is designed to provide specific criteria for developing pest management plans (PMPs). A committee that developed the standard included representatives from crop consulting firms, University of Wisconsin Extension Service, Wisconsin Department of Agriculture, Trade and Consumer Protection, Wisconsin Department of Natural Resources, Natural Resources Conservation Service, and Wisconsin Land and Water Conservation Association. A companion document, the Wisconsin Conservation Planning Technical Note 2, was recently completed and designed to provide additional guidance for pest management planning. Many Wisconsin crop consultants are certified as Technical Service Providers (TSP) to develop PMPs for farmers.

This presentation discusses details of the standard, technical note, and NRCS programs for developing PMPs. A required component of PMPs is an environmental risk analysis of pesticides selected for use in the PMP that may affect surface and ground waters. TSPs can use either a Widows Pesticide Screening Tool (WIN-PST) computer model or a UWEX generated WIN-PST Risk Assessment Quick Guide Table to complete the risk analysis. The Quick Guide Table contains hazard ratings for 90% of all pesticides applied to Wisconsin farmland. USDA Farm Bill programs that provide financial incentives for developing PMPs include Environmental Quality Incentives Program and the Conservation Security Program.

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IMPACT OF POTASSIUM STRESS ON SOYBEAN APHID POPULATIONS

Scott W. Myers [1/]

A field experiment was conducted during the 2004 growing season to assess the effect of soil potassium on soybean aphid populations. Three K treatments were established in 10 ft x 25 ft plot with KCl fertilizer applications of 0, 50 and 100 lb K /acre. Each treatment was replicated 14 times. Phosphorus was applied at planting at a rate of 100 lb/acre to avoid P deficiency in the field. Leaf tissue and soil tests were taken during the growing season to quantify nutrient levels. Soybean aphid development and reproduction was monitored by placing neonate nymphs in small clip cages. Cages contained a single aphid and two cages were placed in each plot. Aphid development, the number of offspring produced, and mortality was measured daily for daily for 35 days. Soybean aphid population data were used to produce life tables to document aphid time to adulthood, mean generation time, survivorship, and rate of population growth.

Mean soil K levels were 59.8, 112.9, and 149.2 ppm for the low, medium and high K treatments respectively. Leaf tissue K levels expressed as percentage of dry matter were 1.6, 2.4, and 2.4 for the low medium and high treatments respectively. Soil P levels did not differ significantly among the three treatments and averaged 23.2 ppm.

Life table analysis showed no significant difference in mean generation time among the three treatments. Additionally, there were no differences in the intrinsic rate of population increase, and net reproductive rate between the medium and high K treatments. However, aphids on the low K treatment showed a significantly greater intrinsic rate of population increase, and net reproductive rate in comparison to the medium and high K treatments. These results indicate that soil K levels in the range of 60 ppm can result in increased soybean aphid populations and may increase the likelihood of soybean aphid outbreaks and yield losses in K stressed soybeans.

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Bean Leaf Beetle and Bean Pod Mottle Virus in Wisconsin – Where Do We Stand?

Eileen Cullen[1], Krista Lambrecht[2], and Anette Phibbs[3]

SUMMARY

Relatively mild winters, with fewer subfreezing temperature unit accumulations, have been correlated with increased survival of overwintered bean leaf beetle, *Ceratoma trifurcata*, populations in the Midwest in recent years (UW Soybean Plant Health, 2004; Lam and Pedigo, 2001). Bean leaf beetle adults emerging in the spring feed on wild and cultivated legumes, moving to early planted soybeans where they continue to feed and then deposit eggs of the first generation. While direct damage caused by early season defoliation (overwintered population) and pod feeding (second generation) can occur, beetle population density must be quite high to cause economic yield loss and treatment thresholds are available to suppress populations below damaging levels (Boerboom et al., 2005).

A more complex interaction occurs in the association between bean leaf beetle, bean pod mottle virus (BPMV) and the soybean plant. BPMV can reduce soybean yields between 3 and 52% (Gergerich, 1999) with infected plants producing fewer, smaller and lower weight seeds, along with potential for a mottled seed coat discoloration. Quantifying yield loss relationships that incorporate bean leaf beetle population density, feeding time, BPMV inoculum and overwintering potential (within the beetle; within the infected legume plant), and BPMV transmission efficiency, is complex. A dual bean leaf beetle and BPMV treatment threshold is not available. Therefore, it is important to assess BPMV incidence in Wisconsin on a regular basis to determine transmission potential to soybean as bean leaf beetles emerge each spring. In 2004, the Wisconsin Department of Agriculture Trade and Consumer Protection (DATCP) and the University of Wisconsin Entomology Department shared field survey information and research plot data on bean leaf beetle distribution and population density in relation to BPMV incidence in Wisconsin.

The Wisconsin DATCP pest survey team conducted a spring survey of overwintered bean leaf beetle and BPMV in alfalfa. Twenty-eight contiguous counties in the southern third of Wisconsin were surveyed, with 102 alfalfa field sites total. Bean leaf beetle sweep net samples were conducted between May 17 and June 10, 2004. Bean leaf beetle numbers were recorded at each site, and beetles were returned to the laboratory and tested for BPMV using Enzyme-Linked Immunosorbent Assay (ELISA). Bean leaf beetle BPMV results were negative at 92% (94/102) of the sites. These negative results consisted of zero beetles detected at 39 sites, and bean leaf beetles *without* BPMV collected from 55 sites. Bean leaf beetles *with* BPMV were recovered from 8% (8/102) of the sites. These eight positive results were restricted to first (six sites) and second (two sites) southern tier counties.

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Wisconsin DATCP conducted a summer survey of 293 soybean fields throughout Wisconsin between July 19 and August 24, 2004. Bean leaf beetle samples were taken in each field and beetles were returned to the laboratory and tested for BPMV by ELISA. In addition, trifoliate leaves were collected from 40 plants in each of the 293 soybean fields and returned to the laboratory to assess BPMV in soybean plants by ELISA. None of the bean leaf beetles collected in the July 19 – August 24 soybean survey tested positive for BPMV. Likewise, of the 293 soybean fields sampled none of the soybean plants tested positive for BPMV.

University of Wisconsin, Entomology Department established a bean leaf beetle and BPMV experimental plot in a southern tier county location at the Rock County Farm in 2004. One objective of the study was to investigate the interaction between bean leaf beetle population density in untreated plots and BPMV incidence in these plots following 1) overwintered bean leaf beetle population and 2) first generation bean leaf beetle population. Plots were planted in 30-inch rows on May 3, 2004 with the soybean variety NK S19-V2. Plot dimensions were 4 rows (10 ft.) wide by 25 ft. long. The untreated plots were part of a larger efficacy trial planted in a completely randomized block design replicated four times. Plots were sampled weekly from May 25 (V1-V2 soybean growth stages) through August 19. Each week, population density was enumerated as bean leaf beetles per row foot (BLB/ft) using whole plant counts early season, then switching to drop cloth samples as soybean foliage developed. UW Soybean leaf samples were collected from 20 plants in each plot (n=80 plants per treatment) on June 29 when weekly bean leaf beetle samples indicated the overwintered population had declined, and first generation had not yet begun to build in the plots. Leaves were returned to the laboratory to assess BPMV in soybean plants by ELISA. Soybean leaf samples were again collected from 20 plants in each plot (n=80 plants per treatment) on August 17 when weekly bean leaf beetle samples indicated that late season bean leaf beetle populations (first and second generation) had developed within the plots. Leaves were returned to the laboratory to assess BPMV in soybean plants by ELISA.

None of the June 29 untreated soybean plant samples (0/80 plants) tested positive for BPMV. Likewise, none of the August 17 untreated soybean plant samples (0/80 plants) tested positive for BPMV. These results indicate that BPMV incidence was very low during 2004, such that BPMV could not be detected in the UW Entomology soybean plant samples from overwintered population bean leaf beetle feeding or first and second generation bean leaf beetle feeding. Overwintered bean leaf beetle population density in the UW study peaked at 0.5 BLB/ft. in the untreated plots on May 25. First generation bean leaf beetle population density in this study peaked at 1.3 BLB/ft. in the untreated plots on July 27. Both population densities remained well below defoliation treatment thresholds (Boerboom et al., 2005). Mean yield for the untreated plots in this study was 60.2 bushels/acre.

Results from the WI DATCP bean leaf beetle and BPMV distribution survey documented that BPMV incidence in Wisconsin remained low (spring 2004 alfalfa survey) to non-detectable (summer 2004 soybean survey) during the 2004 season. Results from UW Entomology established that in a year with low springtime BPMV inoculum in a region, sub-threshold (defoliation thresholds) bean leaf beetle population densities have poor transmission efficiency of BPMV to soybean. Future collaboration will continue to investigate the relationship between bean leaf beetle population densities, the proportion/distribution of BPMV infected bean leaf beetles, and proportion/distribution of BPMV infected soybean plants in Wisconsin.

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SOYBEAN STEM HEALTH

Nancy C. Koval and Craig R. Grau[1/]

Importance of Soybean Stem Diseases

Soybean stem health is an understudied area of soybean pathology. With the exception of white mold (Sclerotinia stem rot), symptoms of brown stem rot and stem canker are often overlooked or confused with stress related to climatic conditions or with seasonal changes in the growth and development of soybean. Brown stem rot occurs each year, but severity and yield loss is favored by conditions ideal for soybean growth. Stem canker has increased in incidence and severity throughout the north central U.S. and Ontario, Canada. The recent resurgence of stem canker in the north central region has not been explained. However, likely factors are associated with reduced tillage, shortened rotation systems and changes in soybean germplasm. Additional considerations are that the stem canker pathogen has undergone genetic changes or that related fungi have emerged and are capable of causing symptoms along with the original causal pathogen. If considered as a complex, brown stem rot, white mold and stem canker occur across a range of climatic conditions that essentially ensure a high probability that one of them will be yield-limiting in a given year. Thus, the ideal soybean variety would have resistance to each disease.

Brown Stem Rot

The incidence and impact of brown stem rot on yield is commonly underestimated because symptoms are often not readily observed, or if foliar symptoms occur, are mistaken for premature, but natural senescence late in the season. These situations lead to an underestimation of the occurrence and yield robbing ability of brown stem rot. Brown stem rot is caused by a fungus that infects roots early in the season, but in time moves into the vascular system of the soybean plant. The pathogen causes a gradual disruption of the vascular system resulting in symptoms appearing during reproductive growth stages. Yield loss is generally greatest when foliar symptoms develop compared to only when symptoms are evident inside stems. The soybean cyst nematode (SCN) is also a widespread and destructive pathogen of soybean. In many areas, both brown stem rot and SCN diseases occur together in the same fields and both cause ‘hidden’ yield losses in the absence of clear symptoms. A brown stem rot management plan involves matching soybean varieties to crop rotation sequences, soil pH, tillage practices and planting date.

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Crop Rotation

The brown stem rot pathogen survives in soybean residue and does not form structures that enable it to survive for long periods in the absence of a host. Thus, crop management systems that favor the decay of soybean residue can reduce the survival of the pathogen. Since the host range of brown stem rot pathogen is limited to soybean, extended periods of cropping to nonhosts effectively lowers inoculum of the pathogen. The rate of inoculum decline is directly related to rate of soybean residue decomposition. The incidence and severity of brown stem rot is modified by ambient and soil environments, and crop management systems. The brown stem rot pathogen is not carried with seed and minimal inoculum is carried with soil adhering to equipment. Incidence and severity of brown stem rot is suppressed effectively by 2 or more years of corn or another nonhost crop. The popular rotation of alternating soybean and corn on annual basis is better than continuous soybean culture, but still maintains a risk of yield loss caused by brown stem rot. Other management practices, soybean varieties planted and climatic conditions modify the risk involved with the annual alternating rotation of soybean and corn.

Tillage Systems and Brown Stem Rot

The brown stem rot pathogen survives in soybean residue and does not form long-term survival structures. This situation places importance on how soybean residue is managed. The severity of brown stem rot is frequently, but not always, greater for soybean grown in no-till systems. Greater severity in no-till or minimal tillage systems is likely related to higher population densities of the brown stem rot pathogen. However, cool soil conditions may be a contributing factor to why brown stem rot is favored by none or less tillage.

Table 1. Effect of tillage and crop rotation on the severity of brown stem rot and soybean yield.

	Disease severity of variety		Yield bu/a	
Tillage	**Susceptible**	**Resistant**	**Susceptible**	**Resistant**
Conventional	21	1	51	59
No tillage	67	2	44	55

Disease severity rated on a scale of 0-11; 0 equals no foliar symptoms of brown stem rot and 11 equals 100% of the foliage expressing symptoms. Disease severity and yield values are the means of eight location years of data from 1989-1992 at the Arlington Agricultural Research Station.

Date of Planting and Row Width

Brown stem rot is a disease of greater importance in high yield potential environments. The severity of brown stem rot is generally not greater in management systems employing early planting date or narrow row systems. However, the yield advantage of resistant soybean varieties to susceptible varieties will increase with increasing yield potential. For example, there is a significant chance that yield of brown stem rot resistant variety will not respond to narrow row widths and an early planting date in fields with high potential for brown stem rot. However, in the presence of brown stem rot, a brown stem rot resistant variety can have a decisive yield advantage if planted in 7-inch row width versus 30-inch rows. The impact of brown stem rot is greatest when the environmental conditions and management are favorable for high yield potential of soybean.

Soil pH and Brown Stem Rot

The severity of brown stem rot is greatest if soil pH approaches 6.0 and is less severe as soil pH approaches 7.0 or greater. This conclusion is based on several years of small plot and large-scale on-farm trials. Furthermore, the effect of soil pH is regarded as significant and modifies effects of crop rotation and tillage on brown stem rot potential.

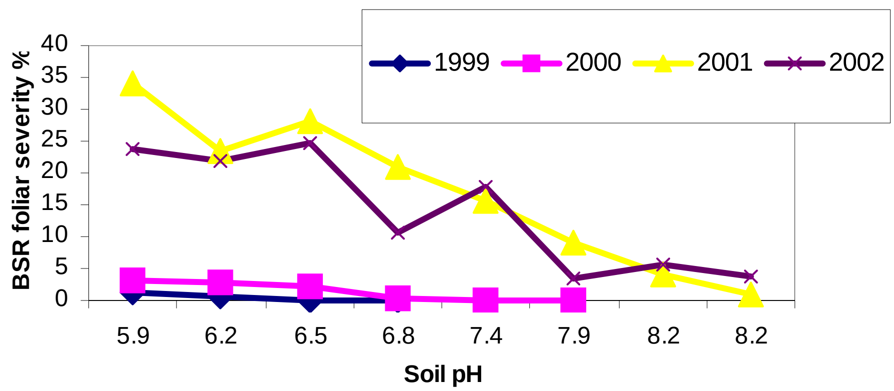

Figure 1. The severity of brown stem rot increases with rising soil pH. Data is from 4 years of field studies in Wisconsin.

Brown Stem Rot Resistant Varieties

The genetic yield potential of soybean varieties has increased through the efforts of soybean breeders. Much of the increased yield potential is linked to increased pod set and seed numbers. There is evidence that improved disease resistance is contributing to yield components correlated to increased yield potential. Resistance to brown stem rot is believed to be a contributing factor of greater yield potential of modern soybean varieties. The majority of yield loss due to brown stem rot is related to a reduction in seed number. Severely diseased plants lodge, which results in greater mechanical harvest loss in addition to physiological yield loss. The majority of newly released soybean varieties do not express a high level of susceptibility that was common a decade ago. Variety selection to manage brown stem rot relates the degree of resistance needed to match disease potential. The release of brown stem rot resistant varieties has opened new avenues of flexibility for farmers experiencing problems with brown stem rot. Varieties vary in degrees of resistance. Complete resistance to brown stem rot has not been reported, but many several sources of partial resistance are available to soybean breeders. However, many soybean varieties on the market today express good to excellent resistance that minimizes yield loss even in high brown stem rot potential fields. Partial resistance is defined as a plant reaction of mild to no foliar symptoms, and a lesser severity of internal stem symptoms. Complete resistance, which prevents infection, has not been identified at this time against the BSR pathogen. Soybean accessions rated as partially resistant support varying degrees of reproduction of the Brown stem rot pathogen.

Soybean varieties have improved greatly for resistance to both brown stem rot and the SCN. Resistance to both brown stem rot and SCN comes from several different and independent sources. Many SCN resistant varieties also expressed resistance to brown stem rot. In most cases, SCN resistant varieties with resistance derived from PI 88788 are also resistant to brown stem rot but varieties with SCN resistance derived from Peking are susceptible to brown stem rot.

Brown Stem Rot and Soybean Cyst Nematode

There are significant yield benefits for soybean varieties that are resistant to predominant genetic types of the brown stem rot pathogen and to SCN. Many SCN resistant varieties are derived from the PI 88788 form of SCN resistance. Researchers have observed that soybean varieties with resistance to SCN derived from PI 88788 express low symptom severity of BSR. Conversely, varieties with SCN resistance derived from Peking, expressed symptom severity similar to BSR-susceptible varieties. Development and release of new SCN resistant varieties pose the risk of increasing problems with SCN. For example, the variety Hartwig, derives its resistance from PI 437.654 and is being used extensively in public and private soybean breeding programs as a source of SCN resistance. Although Hartwig offers an advantage of broad spectrum activity to SCN control, studies in Wisconsin have found Hartwig and its parent, PI 437.654, to be susceptible to BSR in greenhouse experiments. These findings raise concern that the BSR control achieved with PI 88788-derived SCN resistance will be lost if Hartwig-derived SCN-resistant varieties displace the former varieties. Efforts will continue to select breeding lines with both the PI 88788 and Hartwig form of SCN resistance. Crosses will be made with Hartwig SCN sources and Wisconsin BSR resistant lines to develop breeding lines with both BSR resistance and Hartwig form of SCN resistance. This action does not involve the Cyst-X technology thus derived lines can be used without tech fees.

White Mold

Resistance to white mold takes on greater importance with the rise in soybean aphid and rust activity in Wisconsin. Early planting is a management recommendation for soybean aphid and virus control, and will likely emerge as a recommendation for rust management. However, early planted fields are more prone to have white mold problems. Thus, higher and more stable forms of white mold resistance are needed in order to effectively implement management programs for aphids and rust. Again, managing fields for maximum yield potential will assist with potential costs related to rust control.

The ultimate goal of our research project is to develop soybean lines that express complete and environmentally stable resistance to white mold. Soybean lines were identified that express superior resistance to the white mold pathogen. Sources of resistance will be studied to determine if different mechanisms of resistance operate in soybean. It is hypothesized that complete resistance can be achieved by combining genes regulating different mechanisms into an elite soybean line. These results have been achieved by an improved inoculation method for white mold pathogen. A greater chance of success will be increased by knowledge of genetic inheritance of resistance to white mold and how specific lines resist the white mold pathogen. Many soybean lines have been studied at several universities to determine genetics of white mold resistance in soybean. The general result is that many gene groups (QTL) have been identified but no one group contributes a high degree of resistance. A comprehensive understanding of partial resistance could lead to combining field relevant resistance genes into one breeding lines resulting in a more complete resistance than we have in the current commercial germplasm.

Summary of Recommendations to Manage White Mold

Factors that modify the effectiveness of recommendations: Weather and excessive soil fertility may promote excessive vegetative growth, or soybean varieties that lodge or produce dense crop canopies may modify the benefits of suggested tactics presented in the table. A summary of factors that may modify recommendations is presented in Table 2. A core set of recommendations is presented in Table 3 and could be modified after further research.

Table 2. Factors affecting the severity of white mold in soybean.

Seasonal risk factors	**Long-term risk factors**
Weather: cool temperatures (<85 F), normal or above normal precipitation, field capacity or above soil moisture; and prolonged morning fog and leaf wetness (high canopy humidity) at and following flowering into early pod development.	Field/cropping history: inoculum of pathogen will gradually increase if: other host crops are grown in rotation with soybean; interval between soybean crops is shortened; and white mold susceptible varieties grown.
Early canopy closure: due to early planting, high plant population, narrow rows, excessive plant nutrition and optimal climatic conditions. Dense canopy increases apothecia density.	Weed management systems: degree of broadleaf weed control; herbicides used in rotation systems may e suppressive to white mold.
History of white mold: population density of white mold pathogen; apothecia present on soil surface at flowering; distribution of pathogen/disease in field.	Topography of field: pockets of poor air drainage; tree lines and other natural barriers to impede air movement.
Soybean variety planted: physiological functions and plant structure govern reaction.	Pathogen introduction: contaminated and infected seed; movement of infested soil with equipment; wind-borne spores from apothecia from area outside fields.

Table 3. Core recommendations for management of soybean white mold.

Field History	Variety Selection	Canopy Modification	Crop Rotation	Agricultural Chemicals Grain Fields	Agricultural Chemicals Seed Fields
No white mold; Monitor fields closely	Variety of choice; plant pathogen free seed	Maintain current row width; plant population	Avoid crops susceptible to white mold	Adjustments to herbicide program not needed	Adjustments to herbicide program not needed
<5% diseased plants aggregated in field	Avoid suscept-ible varieties	Maintain current row width; plant population	Minimum of 1 year out of soybean	Adjustments to herbicide program not needed	Adjustments to herbicide program not needed
<5% diseased plants uniformly distributed in field	Consider partially resistant; avoid susceptible varieties	Maintain current row width; lower population for less resistant varieties	Minimum of 1 year out of soybean	Adjustments to herbicide program not needed	Adjustments to herbicide program not needed
5-25% diseased plants	Partially resistant varieties	Maintain current row width; plant population	Minimum of 1 year out of soybean	Adjustments to herbicide program not needed	Adjustments to herbicide program not needed
5-25% diseased plants	Moder-ately susceptible varieties	Widen row width; lower plant population	Minimum of 1 year out of soybean	Consider white mold suppressive herbicides	Consider white mold suppressive herbicides or fungicides
25-50% diseased plants	Partially resistant varieties	Maintain current row width; lower plant population	1 to 2 years out of soybean	Consider white mold suppressive herbicides	Consider white mold suppressive herbicides or fungicides
>50% diseased plants	Partially resistant varieties	May consider narrow row spacing for most partially resistant varieties; Wide row; 150,000 plants/acre	2 to 3 years out of soybean	Consider white mold suppressive herbicides	Consider white mold suppressive herbicides or fungicides

Stem Canker

Stem canker has been widely recognized as an important soybean disease, but recently has been divided into northern stem canker and southern stem canker based on two causal agents. Northern stem canker was first reported in the late 1940s in Iowa, and by the 1950s, the disease had spread into the upper Midwest and Canada. Southern stem canker was reported in the south in 1973, and by 1984, had been detected in all southern states. Northern stem canker and southern stem canker are caused by *Diaporthe phaseolorum* var. *caulivora* and *Diaporthe phaseolorum* var. *meridionalis*, respectively. The host range of both pathogens has not been study extensively, however, over 16 weed species are known to harbor *D. phaseolorum*.

Symptoms and Losses

Initial expression of symptoms occurs during the early reproductive stages, with the development of a small, reddish-brown superficial lesion at the base of branches or petioles. The lesion is first observable in the leaf scar after the petiole has fallen. The lesion elongates and becomes dark brown or black, sunken in appearance and often girdles the stem. As a result of a phytotoxin produced by the fungus, interveinal chlorosis and necrosis are expressed in the leaves and is soon followed by plant death. Above and below the canker, green tissue is present and the leaves on the dead plant wither but remain attached. A top dieback can occur and results in a characteristic shepherd's crook curling of the terminal bud.

Yield losses have been reported to be as high as 50 to 80% in naturally infested fields. Yield reductions resulting from stem canker have increased dramatically over the past 2 years. Estimated yield losses to stem canker were 3.3 and 2.2 million bushels in 1999 and 2000, respectively.

Stem canker over winters in colonized stems and infected seed. Long distance dissemination of the pathogen is made possible by the movement of infested soybean residue and to a lesser extent by infected seed. Seed infection by northern stem canker can be as high as 10 to 20%. In late winter, pycnidia (fruiting bodies) begin to develop and conidia (spores) are released beginning in late April continuing into June and serve as the primary inoculum. Splashing, blowing rain, and wind disperse spores up to 6 feet from the point source to petioles, petiole bases, stems, and leaves. The growth stage of the plant at the time of exposure to the inoculum heavily influences the incidence and severity of disease. Exposure to inoculum at V3 corresponds to the highest severity of disease. Disease severity is progressively reduced when first contact is delayed from V3 to V10 growth stages. Secondary inoculum is released from pycnidia present in stem cankers. Conidia produced at this time could be responsible for late season infections and thereby increase the inoculum potential for the next growing season.

Environmental conditions during the vegetative stages govern disease development. Temperature greatly influences infection, with the highest levels of infection occurring when the air temperature is between 82 and 93° F, with and optimal temperature of 83.5°F. Temperature and period of wetness are significantly related.

Rainfall during plant vegetative growth is critical for the development of stem canker epidemics. Cumulative rainfall, not the number of rainy days, is related to higher disease severity.

Management

Stem canker is effectively managed by the combination of planting resistant cultivars and reducing crop infested on the soil surface. Deep plowing can reduce crop residue prior to planting a soybean crop. Seed that are to be used for planting should not be harvested from fields with a history of stem canker. Fungicides applied to seed greatly reduce stem canker but will not completely eliminate the pathogen. Foliar fungicides can be effective when applied during vegetative stages, however, results are inconsistent, and in most cases, foliar fungicides would not be an economical management strategy. The benefits of crop rotation to reduce stem canker have not been demonstrated in production fields. Delayed planting can reduce the incidence and severity of stem canker; however, loss of yield potential that accompanies delayed planting makes this a questionable control strategy.

THE APHID-VIRUS COMPLEX IN WISCONSIN'S LANDSCAPE

Claudio Gratton [1/]

Soybean aphid is an invasive species that not only directly influences soybean plants through effects on yield, but also affects soybeans indirectly through its interactions with other species in the environment. Most notably, predators and other herbivores may be affected by the presence of soybean aphid. Fields with large populations of aphids are exporters of the predaceous multicolored Asian lady beetle. The presence of soybean aphids in the environment therefore could effect predation on other species susceptible to lady beetles. In addition, the way the soybeans cope with stresses is likely to be altered in the face of this new species. For example, soybeans plants that are challenged with aphids may be either less or more able to deal with pathogen infections. Alternatively, virus infected plants may become more or less preferred by aphids, potentially affecting the spread of pathogens within and among fields. Thus, in order to more fully understand the ways in which soybean aphids influence soybeans and their yields and to develop the best ways to manage these novel pests will require a multifaceted approach that integrates our knowledge of the biologies of aphids, pathogens, other herbivores, and predators.

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MAKING BEST USE OF WEATHER RADAR

Brian J. Good [1/]

Introduction

Radar is a useful tool for the analysis and short-term prediction of precipitation. Current National Weather Service (NWS) technology depends on the physical property of scattering. A beam is emitted by the radar antenna, strikes any objects in its path, and is scattered to return to the radar. The length of time between emission and detection is used to locate any echoes relative to the radar. Doppler radar, available at all NWS radar sites since 1995, uses the principle of the Doppler frequency shift to detect the motion of objects in the path of the radar beam.

In addition to the NWS sites, other Doppler radars are in use at some universities, airports, and television stations. However, the radar data most widely used by the public comes from the NWS. The following map shows the locations of the NWS radars serving Wisconsin.

NWS radar sites serving Wisconsin (from NWS Southern Region Headquarters)

A discussion of radar scanning methods, how radar works, limitations of radar, radar output, composite imagery, and storm tracking will help someone make the best use of weather radar.

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KEYS TO SPRAY DRIFT MANAGEMENT

Robert E. Wolf [1]

Proper application timing is very critical for getting the best biological results (efficacy) when applying crop protection products. Timing of the application can also influence off-target spray drift and damage to the environment.

Weather conditions at application time will have a major impact on both efficacy and spray drift. Weather conditions affecting spray drift include wind speed and direction, temperature, relative humidity and atmospheric stability. As an applicator you have a responsibility to monitor and record accurately the weather conditions at application time. The ability to have accurate data for the application records will depend on the methods used to gather the information. Modern, field-useable instrumentation is critical for that need. Applicators can no longer estimate weather conditions or use some far off data source to justify the legality of the application. Anything from simple hand-held devices to sophisticated computerized logging devices are available.

Off-target spray drift is a major source of concern. When spraying pesticides, there is always a chance some product will escape from the target area. Spray drift is a concern because it removes the chemical from the intended target, making it less effective and depositing it where it is not needed and often not wanted. When a pesticide is applied where it is not wanted, it becomes an environmental pollutant that can injure susceptible vegetation, damage wildlife and contaminate water supplies. Although spray drift cannot be completely eliminated, proper equipment (nozzles, etc.) and spraying techniques can help maintain spray drift deposits within acceptable limits.

Using approved application techniques and adapting technology designed to reduce spray drift will improve the performance of spray materials, benefit the environment and be cost-effective. Any one practice used alone may not suffice. Therefore, the best option would be include as many or all of the techniques as a regular part of your spray program **[see table].** As an applicator, do not put yourself into a position where you need to spray 'Right Now'. Schedule and plan so that you have an option 'not' to spray when the wrong weather conditions exist. Make sure the customer understands the importance of minimizing drift. Minimizing spray drift is in the best interests of everyone. Do your part to keep agrichemical applications on target.

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Recommended techniques for reducing particle drift

Recommended technique:	**Explanation:**
Select a nozzle to increase droplet size	Use as large droplets as practical to provide necessary coverage.
Use lower end of pressure range.	Higher pressures generate many more small droplets with greater drift potential.
Lower boom height.	Wind speed increases with height. A few inches lower boom height can reduce off-target drift. High field travel speeds may result in an unstable boom leading to high boom positions and drift potential.
Increase nozzle size – resulting in higher application volumes.	Larger capacity nozzles can reduce the amount of spray depositing off-target.
Avoid high application ground speeds or major speed changes across the field	Rate controllers adjusting to speed changes may result in pressure adjustments causing droplet size variability. Rapid speed increases may create high pressure resulting in more drift potential.
Avoid high wind speeds	More of the spray volume will move off-target as wind increases. Wind currents can drastically affect spray droplet deposition. Structures drastically affect wind currents: such as windbreaks, tree lines, buildings, hills and valleys.
Avoid light and variable winds	Light winds tend to be variable in direction making it hard to identify the sensitive areas.
Do not spray when the air is completely calm.	Absolutely calm air generally occurs in early morning or late evening and may indicate the presence of a temperature inversion. Calm air reduces air mixing, and leaves a spray cloud that may move slowly downwind at a later time.
Consider using buffer zones/no-spray zones. Be able to identify the sensitive areas.	Leave a buffer zone/no-spray zone if sensitive areas are downwind. Spray buffer zone when wind changes to a favorable direction.
Consider using new technologies	Consider using drift reduction nozzles, i.e. chamber and venturi style nozzles. Also, boom shields, hoods, electrostatics, air-assist booms, pulse width modulation valves are all designed to reduce drift potential.
Use an approved drift-control additive when needed.	Drift-control additives increase the average droplet size produced by the nozzles. However, these additives should not become your only drift reducing technique. They will not protect against otherwise poor spraying practices.

IMPACT OF TILE DRAINAGE ON NITRATE LEACHING

Eileen J. Kladivko[1]

Introduction

Subsurface tile drainage is a common water management practice in much of the Midwest. Although subsurface drainage has many benefits, it also may increase nitrate-N losses through the rootzone and out to surface waters. An appropriate balance between increasing drainage intensity (narrower spacing) to improve drainage and decreasing drainage intensity to reduce nitrate-N losses needs to be found in order to protect surface water quality. We have measured nitrate leaching into tile drains of three different spacings at a long-term research site in southeastern Indiana. Over the 15-yr period, we have sequentially changed management practices to try to reduce nitrate leaching from the rootzone. This report summarizes our major findings.

Site and Study Description

The study was conducted from 1984 to 1999 at the Southeast Purdue Agricultural Center (SEPAC) in Jennings County, Indiana. The soil is a light-colored, low organic matter, high silt soil (Clermont silt loam) with slow permeability and a high water table in spring. Tile drains (4-inch diameter perforated plastic drain tube) were installed in 1983 at three spacings (16, 33, and 66 ft) at a depth of 2.5 ft and a slope of 0.4%. From 1984 to 1993, continuous corn was grown with spring chisel tillage, while in 1994 a no-till soybean-corn rotation was begun with a winter wheat cover crop after corn to "trap" nitrogen remaining in the soil. Fertilizer N rates were decreased over the 15 years, as N fertilizer "philosophy" and recommendations changed. Preplant anhydrous ammonia rates were 250 lb/acre in 1984-88, 200 lb/acre in 1989-93, 175 lb/acre in 1995, and 155 lb/acre in 1997 and 1999, with small additional amounts of N applied as starter. Tile drainflow was monitored continuously and water samples were analyzed for nitrate-N beginning in 1985.

Rainfall and Drainflow

Annual rainfall varied from a low of 31 inches in 1987 to a high of 54 inches in 1995, with an average of 44 inches over the 15-yr period. Tile drainflow varied among years as a result of differences in annual rainfall and the timing of rainfall within each year. Tile drains removed between 2.6 and 12.8 inches of water per year, depending on drain spacing and rainfall. The narrower drain spacings removed more water per acre than the wider spacings, as expected. On average over the 15-yr period, the amount of annual rainfall removed by the tile drains was 20.6, 14.8, and 12.0% for the 16, 33, and 66 ft spacings, respectively.

Nitrate-N Concentrations

Nitrate-N concentrations in drainflow decreased greatly over the 15-yr period, as a result of the changes in management practices (Table 1). Concentrations were consistently in the 20 to 30 ppm range in the 1985 to 1988 period and in the 7 to 10 ppm range in the 1996 to 1999 period. Results show that on the low organic matter, silt loam soils at SEPAC, concentrations of nitrate-N

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in tile drainage can be reduced below the drinking water standard of 10 ppm, by a combination of lower fertilizer N rates and a winter cover crop after corn in a corn-bean rotation.

Year-to-year variations in nitrate-N concentrations were also caused by variations in weather and crop yields. During the first 5 yr of the study, preplant fertilizer N rates were 250 lb/acre. Several years of poor crop yields (1986, 1988) likely resulted in high amounts of N remaining in the soil, which contributed to an increasing trend in nitrate-N concentrations over the 1985 to 1989 period. Preplant fertilizer N rates were reduced from 250 to 200 lb/acre in the 1989 to 1993 period, and concentrations started to decrease in 1990, in the first "flow season" after the reduction in fertilizer rate. A rise in concentrations in 1992 probably reflects the poor crop yield in 1991, but concentrations decreased again in 1993 following a high crop yield in 1992. The 1994 change to a soybean-corn rotation and lower fertilizer N rates for the corn, did not result in an immediate decrease in concentration, but by 1996 the concentrations had declined again due to both the winter wheat "trap crop" after the corn and the lower fertilizer N rates.

Table 1. Drainflow, nitrate-N loads, and nitrate-N concentrations at beginning and end of 15-yr study period on tile drainage research site in southeastern Indiana.

	Drain spacing (ft)					
	1986-88			1997-99		
	16	33	66	16	33	66
Drainflow (% of rainfall)	20.2	13.7	10.4	20.4	18.6	14.8
Nitrate-N Load (lb/acre/yr)	43.9	32.5	23.2	14.1	13.8	11.2
Nitrate-N conc. (ppm)	26.9	29.2	27.1	7.6	8.0	8.1

Nitrate-N Loads

The total losses or "loads" of N are often of more concern than the concentrations, both from the agronomic efficiency perspective and for water quality concerns. The nitrate-N load is the product of the concentration times the total drainflow and is expressed in pounds of N lost per acre. Annual nitrate-N loads to drainage water decreased significantly over the 15-yr period, due to the large decrease in nitrate-N concentrations over the same time period. Annual nitrate-N loads averaged 33 lb N/acre in the 1986 to 1988 period and 13 lb N/acre in the 1997 to 1999 period. This 60% reduction in load occurred in spite of the fact that annual drainflow was 29% higher in the 1997 to 1999 period (7.2 inches) than in the 1986 to 1988 period (5.6 inches). The 71% decrease in concentrations, from 28 ppm (1986-1988) to 8 ppm (1997-1999) resulted in a large decrease in loads even with a moderate increase in flow in those years.

Generally the nitrate-N loads were greater from narrower spacings compared with wider spacings (Table 1), because the drainflow per acre was greater from the narrower spacings. The results suggest that wider drain spacings are preferable for reducing nitrate loads to surface waters, and that future drainage design should try to optimize drain spacing to reduce nitrate loads while providing adequate drainage for crop growth.

Seasonal Effects

The majority of the drainflow and nitrate-N loads occurred during the fallow season of November through March, prior to the start of any field work or fertilization for the next crop. This underscores the potential impact of growing winter cover crops as "trap crops" for N in the soil, by having a crop growing later in fall and earlier in spring than the typical corn-bean system.

Overall Conclusions

The primary findings from our site are:

- Nitrate-N concentrations and losses were significantly decreased over the 15-yr period, by a combination of reductions in N fertilizer rates, change in rotation and tillage, and growth of a winter cover crop as a "trap crop" after corn.
- Both drainflow volumes and nitrate-N loads were greater with more intensive drainage.
- The majority of the drainflow and nitrate-N loads occur in the fallow season. About 64% of the annual drainflow and nitrate-N loads occur in November through March, and 80% in November through April.
- Concentrations did not vary greatly by month within a year, but loads did vary due to the seasonal distributions of drainflow.

Current concerns about hypoxia in the Gulf of Mexico have focused attention on nitrate-N loads from tile-drained Midwestern soils. Some key points from our study that should be kept in context when comparing results across the Midwest region are highlighted here:

- The relatively shallow (2.5 ft) drain depth at our site, may affect concentrations and drainflow volumes, compared to sites where drains are installed at deeper depths (4 ft).
- The low organic matter content of this soil (~1.3%) contrasts with the dark "prairie" soils of much of the upper Midwest. The nitrate-N concentrations of less than 10 ppm achieved in the last 4 yr of our study may not be achievable on high organic matter soils growing the same rotation, due to higher mineralization rates from the soil organic matter.
- Drainage occurs all winter at our site. This contrasts with many Midwest drainage research sites (Minnesota, Iowa) where drainflow ceases during January through March.
- Fertilizer N is applied as spring preplant anhydrous ammonia, in the second half of April. This contrasts with sites receiving fall N applications or nitrate-containing fertilizers.

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SHOULD SOYBEAN N CREDITS BE TAKEN IN 2005?

Larry G. Bundy[1/]

High N fertilizer costs projected for the 2005 growing season provide an incentive for assigning appropriate N credits where soybean was grown in 2004. The 2004 growing season caused late soybean planting and delayed maturity for some areas resulting in low grain yields. Soybean production experiences ranged form normal grain harvest to abandoned acreage with all of the dry matter left in the field. In some cases immature soybean was harvested as a forage, again with all above ground dry matter removed. In other cases, soybean residue was removed for feed or bedding after grain harvest. With this variation in soybean production outcomes, questions on assigning appropriate N credits for the crops to be grown following soybean have emerged. The purpose of this paper is to provide soybean N credit recommendations for several of the production conditions encountered in 2004. The specific situations include the following:

- Normal grain harvest with expected grain yields.
- Soybean grain harvest, but low yields (less than 20-25 bu/acre).
- Soybean grain harvest, residues removed.
- Soybean harvested as forage with all top-growth removed.
- Abandoned acreage due to immaturity or low yield, dry matter left in field.

Research results from several Midwestern states (Vanotti and Bundy,1995; Green and Blackmer, 1995; Gentry et al., 2001) indicate that the apparent N contribution of soybean to subsequent crops results primarily from the effect of soybean on net mineralization of soil N in the year after soybean is grown rather than an addition of N from the soybean residues returned to the soil. This concept is important for understanding the effects of soybean production outcomes on the appropriate N credit for a subsequent crop. Soybean production usually results in more N being removed in the soybean grain than is fixed from the atmosphere by the soybean crop. Most of the N accumulated by soybean is stored in the grain (approximately 6% N by weight) while relatively little N is returned to the soil in the soybean residue. Schoessow (1996) determined forage and residue amounts and N contents for soybean in Wisconsin and these results are summarized in Table 1.

Normal Grain Harvest with Expected Grain Yields

Although the mechanism of the soybean N effect is likely different from that seen with forage legumes, there is strong evidence that the N needs of corn following soybean is lower than for corn following corn. In most Midwestern states a soybean N credit of 30-50 lb N/acre is suggested. The current 40 lb N/acre soybean credit recommended in

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Table 1. Average soybean residue and forage dry matter yields and nitrogen concentration and uptake at four Wisconsin locations, 1993 to 1995 (Schoessow, 1996).

			Nitrogen (N)	
Year	Material [1/]	Dry matter	Concentration	Uptake
		lb/acre	%	lb N/acre
1993	forage	5339	2.99	165
	residue	2839	0.84	24
1994	forage	10563	2.81	293
	residue	6679	0.83	54
1995	forage	9214	2.63	236
	residue	6259	0.83	53

[1/] Forage yields determined by harvesting top-growth at R6 growth stage; residue yields determined after grain harvest.

Wisconsin is an average of observed soybean N credits that vary across locations and years. Previous work by Schoessow et al. (1998) and Bundy et al. (1993) supported the current N credit recommendation of 40 lb N/acre, but showed that the apparent soybean N credit varied widely across sites and years and that no credit was observed on sandy soils (sands and loamy sands). The latter observation is in agreement with similar findings in Minnesota (Hesterman et al., 1986). Schoessow et al. (1998) also found that site and year variation in optimum N rates for corn following soybean could be lowered through use of a preplant soil nitrate test in addition to the 40 lb N/acre N credit. Recent Wisconsin data (Fig. 1) showing lower optimum N rates for corn following soybean than for corn following corn supports the need for a soybean N credit.

The size of the soybean N credit cannot be accurately determined from Fig. 1 because the corn-corn and soybean-corn experiments were not done at the same locations in the same years. However, at maximum yield levels in the two rotations, corn yields after soybean were maximized with 35 lb N/acre less than was needed for corn following corn.

With increasing N costs, corn:N price ratios are now in the range where the N rate recommendation is influenced more strongly by these prices than when the corn:N price ratio was at 10:1 or higher. The relationships between economic optimum N rate and corn:N price ratio is illustrated for corn following corn and corn following soybean in Fig. 2. This information also supports N credits for soybean and lower N application rates than are needed for corn after corn. However at current corn:N price ratios, current N rate recommendations are somewhat higher than the economic optimum based on corn:N price ratios.

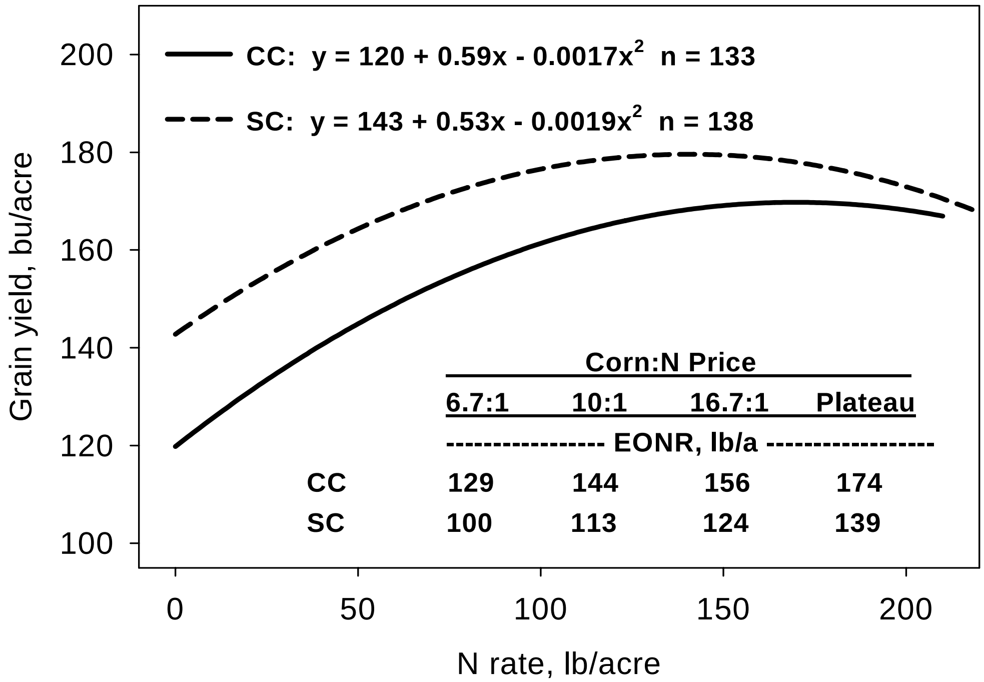

Figure 1. Corn grain yield response to N rate and EONR for various corn:N price ratios in 21 corn following corn and 26 corn following soybean experiments on silt loam soils in southern Wisconsin during 1991-2003.

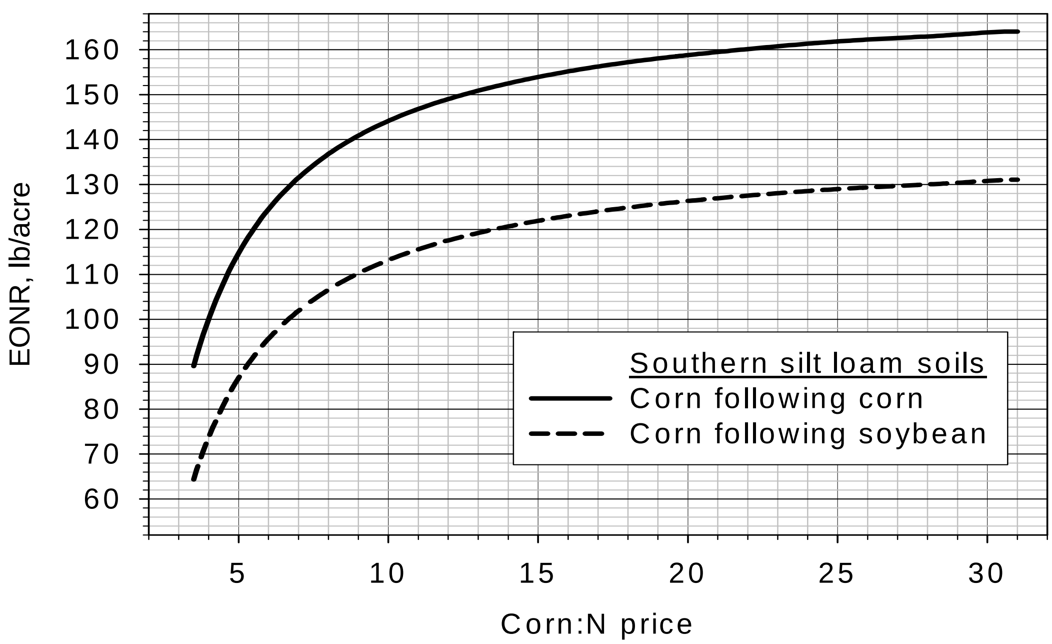

Figure 2. Relationship between economic optimum N rate (EONR) and corn:N price ratio based on 21 corn following corn and 26 corn following soybean experiments on silt loam soils in southern Wisconsin during 1991-2003.

Soybean Grain Harvest, but Low Yields (less than 20-25 bu/acre)

The influence of previous crop soybean grain yield on soybean N credits to subsequent crops was studied by Schoessow et al. (1998). Based on results from 15 experiments with corn following soybean at several Wisconsin locations where soybean yields ranged from 25 to 68 bu/acre. As shown in Fig. 3, there was no relationship between soybean yield and the optimum N rate for corn following soybean. Although few of the experiments had low soybean yields, the absence of a relationship between soybean yield and optimum N rates for corn following soybean is consistent with the conclusion that soybean yields do not influence the soybean N credit. Therefore, we recommend use of the 40 lb N/acre soybean N credit at all soybean yield levels.

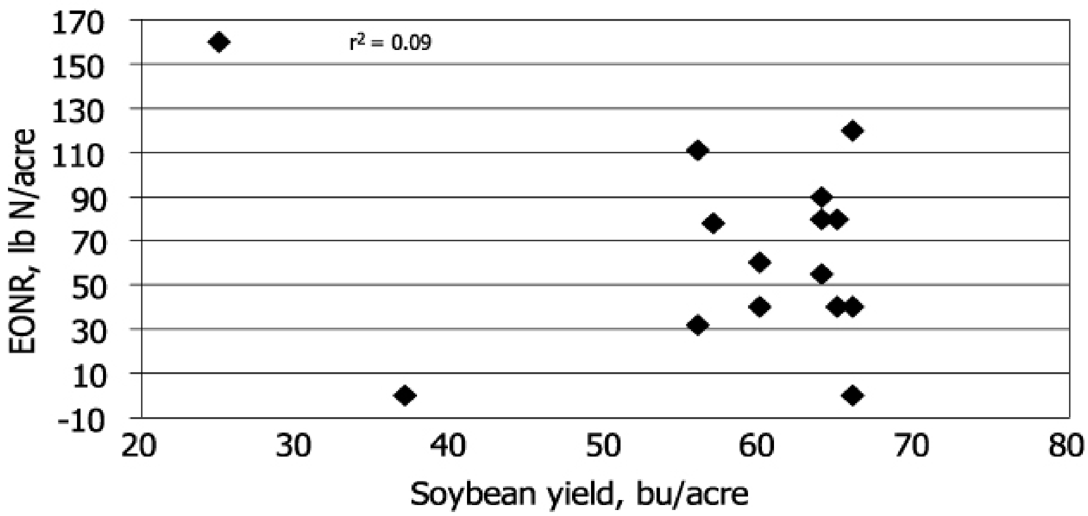

Figure 3. Relationship between economic optimum N rate (EONR) for corn following soybean and soybean yield in the previous year, 1994-1996.

Soybean Harvested as Forage or Residues Removed after Grain Harvest

Schoessow (1996) conducted a detailed study of the effects of soybean residue management on apparent N contributions to a subsequent corn crop. Results from this work showed that removing or returning soybean residue or removing soybean top-growth in a forage harvest at the R6 development stage usually had no effect on yield or N response of corn grown following soybean. Findings from this three-year study are illustrated in by the data from 1994 (Table 2). Where soybean residue management had a significant effect, corn yields were lower and more N was required to optimize yields where residues were returned than where residues were removed. These observations support the concept that soybean N credits do not depend on release of N from soybean residues, but are related to an increase in net N mineralization from soil organic matter. Early work by Fribourg and Bartholomew (1956) also showed that adding soybean residue where corn was grown the previous year had no effect on subsequent corn yield.

Table 2. Effects of soybean forage harvest and residue removal on corn yield and N response at three Wisconsin locations in 1994 (Schoessow, 1996).

		Nitrogen (N) rate, lb/acre	
Location	Residue mgmt.	0	120
		------------- Yield, bu/acre -----------	
Arlington	Returned	183	207
	Removed	180	200
	Forage	191	199
Lancaster	Returned	123	201
	Removed	122	216
	Forage	130	213
Belmont	Returned	175	214
	Removed	174	214
	Forage	194	208

Abandoned Soybean Acreage, Dry Matter Left in Field

Little research data exists to establish soybean N credits in the abandoned acreage situation, but information from some of the situations reviewed earlier in this paper can provide some guidance as to appropriate N crediting. It seems reasonable to assign a minimum of 40 lb N/acre for this situation since soybean was grown and previous work indicates yield has little effect on the soybean N credit when grain or forage is harvested. An additional adjustment for the un-harvested grain seems appropriate where maturity was sufficient to produce mature or immature grain. Since soybean grain is rich in nitrogen (6% N by weight) much of the N accumulated in the grain would likely be released to a subsequent crop. If we assume 15 bu/acre of grain remained un-harvested, the approximate N content of this grain would be 47 lb N/acre. While any additional adjustment will be influenced by how much grain was actually left in the field, an additional 20 to 25 lb N/acre seems justified, bringing the total N credit in the abandoned acreage category to 60 to 65 lb of N/acre.

Summary

Soybean N credits are an important component of effective N management in 2005. Where normal soybean grain harvest occurred, the 40 lb N/acre credit should be used. This credit is appropriate even where soybean yields were below expected levels. The credit can be fine-tuned through use of the preplant soil nitrate test. Adjustments for both the 40-lb credit and the results of the soil nitrate test should be used. Removing soybean residues or harvesting soybean as forage has no effect on the 40 lb N/acre credit. For abandoned soybean acreage, use the standard 40 lb N/acre credit and consider additional credits based on the amount of grain left in the field. Typical total credits for abandoned acreage would be 60 to 65 lb N/acre.

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IRRIGATION SCHEDULING AND UNIFORMITY FOR IMPROVED WATER MANAGEMENT

Scott Sanford [1]

Introduction

Irrigation is an important tool for reducing risks, increasing yields and producing higher quality crops. Ideally, we would like to keep the crops grown from being water stressed by maintaining the soil moisture in the root zone at a level that allows the plant roots to freely extract waters as needed. This paper will take you through the steps to determine the water holding capacity of soils, the water used by the plants and evaporation from the soil and discuss a methodology for estimating the available moisture remaining in the soil. An irrigation system will ideally apply water equally across the soil surface but in reality it doesn't happen. Gross variation can affect crop yields and effect the utilization of fertilizers and pesticides. A test method and equipment for determining the uniformity of water application is presented. The rate at which water is being applied to the field is often assumed based on the designed well pumping capacity. Periodic testing of the well pump is recommended to ensure it can supply the necessary water and it is operating efficiently. The paper will finish with a brief discussion of some energy saving opportunities that will reduce irrigation costs without reducing water being applied.

Soil Moisture determination

Plants require water, nutrients and mineral from the substrate their roots are growing in for survival and growth. For optimal growth, all nutrients and water need to be readily available. Water that is available in the soil for plant growth can is called "Total Available Water", refer to Figure 1. There is some water that is unavailable to plants because it is held tightly to the soil particles. The amount varies with soil type. After a long period of rain fall the ground would be considered "Saturated". An example of this would be water is a foot print after stepping on ground that had no visible water at the surface. After the excess water has drain from the soil profile the soil would be at "Field Capacity". As water evaporates from the soil surface or is used by the plants the soil moisture will decrease. If the soil moisture continues to decrease, eventually there will be a point at which the plant will not be able to uptake water as fast as it is used which will slow growth. A continued decrease in the soil moisture will lead to a slow down in photosynthesis in the plant and if the soil moisture decreases to the permanent wilt point the plant will die. If using a irrigation system to supplement crop water needs, the soil moisture is typically maintained above 50% of the "Total Available Water" (TAW) and is termed the "Maximum Allowable Depletion".

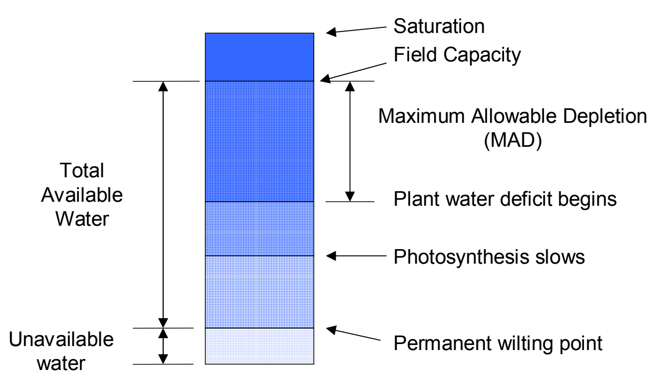

Figure 1: Soil Moisture Profile

Studies of water consumption by plants indicates that 40% of the water is extracted from the top 25%

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of the plant's root zone, 30% is extracted from the second 25% of the root zone and 30% is extracted by the bottom 50% of the root zone. The depth and distribution of roots varies greatly from cucumbers that have very shallow roots, most in the first 12 inches of the soil, to corn and alfalfa which may have roots 7 to 9 feet in depth. The root depth can be limited by things such as high water tables, rock, severe compaction or dry soils. Depending on the crop's root depth, we can manage some portion of that to ensure that plant growth is not limited by water. For most crops we will manage the upper 50% of the root zone where 70% of the water is extracted from the soil. This could vary from about 6 to 12 inches for turf grass to 36 to 48" for field corn. The maximum allowable depletion, the point at which we'd want to add supplemental water is typically 50% of TAW but for some moisture sensitive crops such as potatoes it could be as low as 30 to 35%. Some crops can benefit from changing the percent of the TAW maintain in the soil based on the stage of crop growth.

The field capacity or total available water will vary with soil type. The US Department of Agriculture Soil Conservation Service publishes a survey of soil types by county that is available from the Farm Service Agency in your county. The publication has maps of different sections of the county with topographical lines depicting the approximated locations of different soil types. First one needs to locate the field on the maps where the irrigated crops are being grown and note the soil type abbreviations. Then referring to table 8, Estimated Soil Properties, the available water capacities are listed for the different soil types in "inches of water per inch of soil". Most soil types will have a number of layers that have to be added up to get the total available water capacity for the root zone to be managed. For example, a Pecatonica soil would be expected to be made up of 10 inches of silt loam, from 10" to 21" is a silty clay loam, from 21" to 37" is a sandy clay loam and from 37" to 60" it is a sandy loam. The available water capacity is given as a range for each of these soil layers, for example the silt loam is estimated to have a water holding capacity of 0.18 to 0.22 inches of water per inch of soil while the silty clay loam layer has a water holding capacity of 0.16 to 0.20 inches of water per inch of soil. The water holding capacity for an 18" root zone would be determined as follows:

Silt Loam	10" @ 0.20 inches of water per inch of soil	2.00 inches of water
Silty clay loam	8" @ 0.18 inches of water per inch of soil	1.44 inches of water

In this case the total available water in the root zone would be 3.4 inches. If the crop grown used a maximum allowable depletion (MAD) of 40%, then we would try to maintain the soil moisture between field capacity and 2.0" TAW for a MAD of 1.4 inches of water. Many fields will encompass several soil types that may vary in the water holding capacities. You will have to make a decision if you want to irrigate for the soil that holds the least amount of water or for the average of all soil types found in the field.

Plant Water Consumption

There have been a large number of studies over the years to determine the water use by different plants under different conditions. This work has resulted in a number of different equations to estimate the water use by plants based on air temperature, humidity level, solar radiation, soil temperature. The UW-Madison Soil Science Department publishes the estimated ET values daily during the growing season that would estimate the water use by a crop with ample soil moisture and a canopy that covers 80% of the ground. The ET values are available on-line at www.soils.wisc.edu/wimnext/water.html or they can be emailed to you daily by sending an email to fewayne@facstaff.wisc.edu with the latitude and longitude of your farm. You can find the latitude and longitude of your farm by going to www.census.gov/cgi-bin/gazetteer and entering your town and state or your zip code and clicking on "search". The search will provide you with

the latitude and longitude for the post office(s) or the center of the municipality. If you want to get a more precise latitude / longitude, click on the "Map" link and a map will appear. The red pin indicates the location of the latitude/longitude indicated at the bottom of the map. Use the "+", "-" and compass below the map to find your farm's location. Then click on "Place Marker" in the top of the blue box to the right of the map, place the curser over your farm's location on the map and click; the latitude and longitude for the location you selected will appear under the map.
ET values in Wisconsin in June, July and August can reach 0.28" per day for several days. The ET values have to be adjusted for the amount the crop canopy covers the ground. This is done by referring to the Table 1 and looking up the adjusted ET value based on % canopy cover and ET value.

Figure 2: Low Evaporation Rain gauge

Water Measurement

Rain gauges should be located in each field to record rainfall and irrigation water applied. Gauges should have an opening of at least 3-1/2" for the most accuracy. Evaporation from rain gauges can affect the accuracy of the data if they are not read shortly after a rain event unless a low evaporation type gauge is used. The rain gauge pictured in Figure 2, design by Kansas State University, has a weekly evaporation rate of less than 1% and is low cost to build. It is recommended that three gauges be used in each field to determine the average water applied to the field by rainfall and irrigation.

Irrigation Scheduling

The checkbook method of irrigation scheduling is like balancing your checking account at the bank; rainfall and irrigation events are deposits and ET values are withdrawals. The objective is to keep adequate soil moisture in the plant's root zone, maximize the use of rain water and minimize leaching events. The soil moisture can not exceed the water holding capacity of the soil profile. If the total water holding capacity of the managed root zone is estimated at 2.5" and there is 1.75" of water content in the soil and a rainfall event or a combination of a rainfall event and irrigation exceeds 3/4" (2.5"-1.75"=3/4") of water, the excess will move through the managed root zone and out of reach of the plant's roots. This is termed a leaching event because the water will take water soluble nutrients with it such as nitrogen. The amount of water from the above example that can be credited to the checkbook water balance is 3/4". Ideally, one would like to keep the soil moisture level low enough to take advantage of rain fall and reduce leaching events but high enough to keep the plants growing without water being the limiting factor. The water balance can be done manually or there are programs and spreadsheets available to automate some of the record keeping.

Soil Moisture Sensors

The checkbook is only a good approximation of the soil moisture and needs to be checked and adjusted on occasion particularly if there has been a long period without a rain event that has saturated the soil. Checking the soil moisture with sensors or probes will provide the information to make adjustments. There are many types of soil moisture sensors that use a number of different technologies to sense the soil moisture. Some are probes that have a maximum depth of up to 8

Appendix Table C. Evapotranspiration (ET) estimates adjusted for % crop canopy cover (for use with WISP)

ET estimate in inches	% crop cover								
	0	10	20	30	40	50	60	70	80
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02
0.04	0.00	0.00	0.01	0.02	0.03	0.03	0.04	0.04	0.04
0.06	0.00	0.01	0.02	0.03	0.04	0.05	0.05	0.06	0.06
0.08	0.00	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.08
0.10	0.00	0.02	0.04	0.05	0.07	0.08	0.09	0.10	0.10
0.12	0.00	0.03	0.05	0.06	0.08	0.09	0.11	0.11	0.12
0.14	0.00	0.03	0.05	0.07	0.09	0.11	0.12	0.13	0.14
0.16	0.01	0.04	0.06	0.08	0.11	0.13	0.14	0.15	0.16
0.18	0.01	0.04	0.07	0.09	0.12	0.14	0.16	0.17	0.18
0.20	0.01	0.05	0.08	0.11	0.13	0.16	0.18	0.19	0.20
0.22	0.01	0.05	0.08	0.12	0.15	0.17	0.19	0.21	0.22
0.24	0.01	0.06	0.09	0.13	0.16	0.19	0.21	0.23	0.24
0.26	0.01	0.06	0.10	0.14	0.17	0.20	0.23	0.25	0.26
0.28	0.01	0.06	0.11	0.15	0.19	0.22	0.25	0.27	0.28
0.30	0.01	0.07	0.12	0.16	0.20	0.23	0.26	0.28	0.30
0.32	0.02	0.07	0.12	0.17	0.21	0.25	0.28	0.30	0.32
0.34	0.02	0.08	0.13	0.18	0.23	0.26	0.30	0.32	0.34
0.36	0.02	0.08	0.14	0.19	0.24	0.28	0.32	0.34	0.36

*To use this table, you must have an estimate of the current % crop canopy cover and the ET estimate provided by University of Wisconsin-Extension, Cooperative Extension. You can obtain the ET estimate by calling the toll-free IPM PEST Phone at (800) 236-4264. Outside Wisconsin, call (608) 262-4264.

To adjust the ET estimate for canopy cover, select the appropriate % crop cover value. Move right to the column headed by the ET estimate. The value at the intersection is the adjusted ET estimate.

inches ideal for turf grass, others have to be buried at the depth that the soil moisture measurement is desired. One of the newest moisture sensors can take readings at four different depths with the same probe. For monitoring a field, it is recommended that measurement be taken at a minimum of two locations and two depths. The first location should be at the beginning of a center pivot's rotation and the other location should be near the end. If using a different type of irrigation system, one location should be at the first area to be irrigated and the other at the last area to be watered. This provides the extremes of the soil moisture in the field. The first sensor should be placed at about 25% of the managed root zone depth and the second at 80 to 90% of the managed root zone depth. The upper sensor is in the root zone where 40% of the water is extracted by the plant while the deeper sensor will indicate leaching events and provide feed back on how deep the irrigation water is getting. Some growers who have started using moisture sensors have found that the amount of irrigation water that was being applied was insufficient to fill the managed root zone.

Managing Deep rooted crops versus shallow rooted crops

A deeper managed root zone depth, results in more total available water to manage. This can provide longer periods between irrigation events and the ability to utilize more rainfall events without leaching. Typically, the amount of irrigation per application should also be increased to provide for deeper penetration of the water. In arid area, continuous shallow irrigation, low water application depth, can cause root pruning and can lead to lodging of crops like corn.

Uniformity Testing

Can you look at an irrigation system and tell if it is applying water uniformly? Not likely. Gross problems can be seen visually, leaky pipes joints, nozzle not rotating or grossly plugged nozzles, but to determine if the water is being applied evenly to the soil surface across the irrigated area requires testing. Testing will provide an indication of areas of the irrigation system where water is being applied greater or less that the average. Ideally we'd like to have the water perfectly applied but this isn't practical but a well design and maintained system can achieve coefficients of uniformity of 90 to 95%. Nozzles do wear out over time, contrary to the belief of some growers. The nozzle will wear from particles in the water or may become restricted or plugged do to poor water quality. Testing can also provide information about the effect of pressure variations from end guns turning on and off or corner systems extending or wheel slippage. Uniformity testing is recommended every 3 to 5 years or sooner. Testing can also be used to check new center pivot irrigation systems that the nozzles have been placed in the correct order. Poor uniformity can affect crop yield because of too much or not enough water but also affects the utilization of fertilizers, herbicides and pesticides. Figure 3 below show a graph of the uniformity test data for a center pivot irrigation system. A system with a high coefficient of performance would have all measurements between the high and low deviation limit lines which represent a 10% plus or minus from the average.

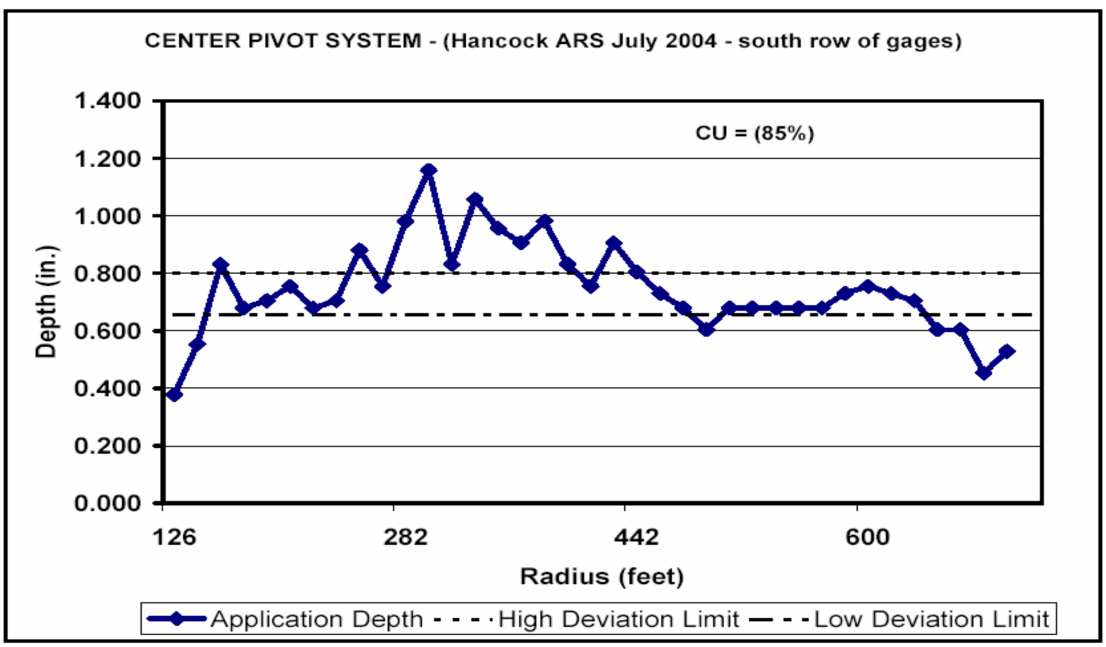

Figure 3: Gage data from uniformity test of center pivot irrigation system

Uniformity Test equipment

Uniformity testing requires a large number of identical collection cans with an opening diameter of at least 3.5" and a minimum depth of 7". The opening should have a sharp edge and be position so the opening is level during the test. The test involves setting up a row of rain gauges or cans at a distance between collection cans of no greater than 80% of the nozzle spacing or a maximum of 16 feet for impact sprinklers and 10 feet for spray nozzles. On large irrigation systems, this can amount to a considerable number of cans. To make it easier to do and to encourage uniformity testing, a test kit was put together in mid summer 2004. The kit contains 150 rain gages, stakes, measuring devices, instructions, data sheets and a spreadsheet program for data analysis. It is kept at the Hancock ARS and is available at no charge for Wisconsin growers. Contact Jeff at 715-249-5961 to reserve the kit.

Pump-Well testing

When a grower runs an irrigation system he is assuming some amount of water is being applied to the soil usually based on the design capacity of the pump-well system when it was installed or last refurbished. If the pump-well is not tested on a regular basis, every 2 or 3 years is recommended, the grower may not find out there is a problem until the crop starts to show sign of water stress. Testing typically costs between $150 to $300 per well and should include measurements of pump output versus pressure, drawdown level and energy consumption. If all of this data is collected then the pumping efficiency can be determined to compare the pump's performance to the Nebraska Performance Standard (NPS). Indirectly the test helps identify worn impellers, excessive impeller clearance, changes in water table levels, plugged well screens, insufficient net positive suction head and engine or motor issues. Studies in Wisconsin, Kansas and Nebraska indicated that pumping plants are typically operating at 75% of the NPS. A Kansas study estimated that 40% more fuel was being used than necessary if the irrigation equipment was properly sized, adjusted and maintained. A Nebraska study found that 57% of the pumping plants studied needed adjustment which resulted in a 14% cost savings. If a grower keeps accurate production records, the efficiency can be estimated from fuel or electric bills. Refer to KSU extension bulletin "Evaluating Pumping Plant Efficiency Using On-Farm Fuel Bills" (No. L-885) which can be found at www.oznet.ksu.edu/mil/toolkit.htm.

Other Cost Saving Opportunities

Lower system pressures
Lowering pivot pressure for an irrigation system from high pressure (80 psi +) to a lower pressure can reduce operating costs while providing the same amount of water. If the pressure was reduce from 80 to 50 psi, the savings would be approximately 25% while lowering the pressure to 30 psi can save up to 40% in energy costs. If your system is in need to new nozzles, you should consider the benefits of running at lower system pressures.

Time of Day Electric rates
Many electric utilities offer programs to encourage the use of electrical energy during off-peak hours, nights and weekends. If all irrigation can be moved to off-peak hours, a grower could reduce irrigation costs by 50% plus. This requires an irrigation system that can cover the irrigated area in 100 hours or less per week. Usually if 65% of the irrigation can be accomplished off peak, these programs will be advantageous to the grower.

Energy Conservation Grants

Focus on Energy is Wisconsin's energy conservation program that offers grants for conserving energy. The Agricultural program offers free energy audits using standardized audit tools to aid growers and producers in reducing energy costs. The program covers approximately 85% of Wisconsin's homes and businesses. The grants can be used to cover up to 25% of the cost of equipment and are based on the estimated first year energy savings. For irrigation system, the program covers the conversion of systems to lower pivot pressures and improving pumping plant efficiencies. For more information, call 1-800-762-7077 or access the web site at www.focusonenergy.com.

The 2002 Farm Bill also provides funds for renewable energy and energy efficiency projects. The Notice of Funding is usually published in May each year with applications due in mid-July. Grants cannot exceed 25% of total project costs and range from a minimum of $2500 to $500,000. Energy efficiency projects must demonstrate at least a 15% energy savings and an 11-year investment payback to be considered. Applications are handled by the USDA Rural Development office in each state. The Wisconsin office is located in Stevens Point and can be contacted at 715-345-7615. More information and applications can be found at www.elpc.org/farmenergy/9006FAQ.htm or www.rurdev.usda.gov/rbs/farmbill/index.html.

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APPLICATION OF PAPER MILL RESIDUAL TO POTATO/CORN/SOYBEAN

Kenneth Williams, Walt Stevenson, and Vaughan James [1/]

Introduction

Land spreading of various types of residual by-products from manufacturing as a means of disposing of these by-products is becoming more widespread throughout Wisconsin. Paper mill residuals, vegetable processing waste and various types of other products are increasingly spread on agricultural land as an alternative to landfill disposal or incineration. These various materials contain nutrients, primarily nitrogen but also various amounts of other primary, secondary and micronutrients. Many of these materials are also noted to be effective in varying degrees as liming agents.

This trial is a continuation of work that was started in 2002. Prior research on this topic conducted by Leslie Cooperband consisted of experiments in the Central Sands area of Wisconsin. Work done by Bowen and Wolkowski, December 1998, on the use of fresh and composted paper mill fiber residuals in potato production at the Rhinelander Experiment Station was also conducted on sandy soil. The soils in Langlade County used for potato production are primarily Antigo Silt Loam. The results of applications of fiber paper mill residual (PMR) to a silt loam soil may produce different results than applications to a sandy soil. In addition the composition of the paper mill residual may vary for each paper mill depending on what components have been blended into their composition. The effect of this material on the pH of the soil and the amounts of various soil nutrients were of concern since an increase in the pH could affect the incidence of potato scab and excessive amounts of any particular nutrient may cause problems. The second area was disease. Would this material affect the incidence of soil or foliar diseases of potatoes that would adversely affect their marketability? This is important since the primary market of potatoes produced in the Langlade County area is for use as seed.

Methods

A randomly replicated trial was set up using paper mill residual from the Wausau-Mosinee Paper Corp. Mill at Brokaw, Wis. Initial soil tests showed average values of; pH 5.4, organic matter 2.4, P-150 ppm and K-217 ppm. The material used was sampled and tested prior to application to determine correct application amounts. Sample results taken at time of application and tested by the Marshfield lab showed the nutrient availability per wet ton for the first year following application to be 3.26# N, 4.33# P_2O_5, .36# K_2O, and .57# sulfur. Average nutrient content over the past 3 years of the material used in these trials is 4.68# N, 5.9# P_2O_5, K_2O, and 1.85# sulfur. The samples have also been tested for dry matter content, ammonia N, total nitrogen, ash content, pH, calcium, magnesium and carbon to nitrogen ratio. The material used in 2004 had a calcium carbonate equivalent of 38.0% and a neutralizing index of 27.9%. Application amounts were calculated based on soil test recommendations indicating a fertilizer need of 150# N, 180# P_2O_5, and 165# K_2O per acre. This amount equaled 38 wet ton per acre (WTA). The trials have consisted of 5 different treatments plus an untreated control replicated four times. This year the entire plot received 500# /acre 3-3-30 with 16 oz Admire /500# /acre at planting.

[1/] UWEX Langlade Co. and Dept. of Plant Pathology, Univ. of Wisconsin-Madison, respect-tively.

The amount of material added to each 20' by 18' treatment plot was 314# for the 50% rate, 628# for the full rate and 942# for the 150% rate. The material added to each plot was weighed using a platform scale on a trailer at the field site. Soil samples were taken from each plot prior to application and again after harvest. Soil samples were tested for pH, organic matter, phosphorus, potassium, calcium, magnesium, estimated cation exchange capacity, boron, manganese, zinc, sulfur, and sample density.

Nutrients Available per Treatment		Total Nutrients Available (PMR plus com fert)
Treatment 1 – Control		
Starter	15- 15-150	
Added at planting 185# 46-0-0, 356# 0-46-0, 23# 0-0-60	85- 164- 14	
At Hilling 109# 46-0-0	50- 0 - 0	150-179-164
Treatment 2 - 50% rate		
Starter	15- 15-150	
19 WTA PMR, credited at 100%	62- 82- 7	
Added 158# /a 46-0-0, 178# /a 0-46-0, 12# 0-0-60	73- 82 - 7	150-179-164
Treatment 3 - 50% rate		
Starter	15- 15-150	
19 WTA, credited at 50%	31- 41- 3	
Added 226# /a 46-0-0, 268# /a 0-46-0, 17# 0-0-60	104- 123- 11	150-179-164
Total available nutrients at 100% credit		(181-220-177)
Treatment 4 - full rate		
Starter	15- 15-150	
38 WTA, credited at 100%	124-164- 14	
Added 24# 46-0-0	11- 0 - 0	150-179-164
Treatment 5 - full rate		
Starter	15- 15-150	
38 WTA, credited at 50%	62- 82- 7	
Added 158# /a 46-0-0, 178# /a 0-46-0, 12# 0-0-60	73- 82- 7	150-179-164
Total available nutrients at 100% credit		(212-261-183)
Treatment 6 - 150% rate		
Starter	15- 15-150	
57 WTA, credited at 100%	186-246- 21	
Added 0 supplemental fertilizer		201-261-171

May 27 – Paper mill residual material was applied to the plots and incorporated with disc and field cultivator.
June 5 – Snowden potatoes were planted.
June 17 – Applied Dual 2E at 1.6 pints per acre and Linex DF at 1.6# per acre
June 30 – First fungicide application; Bravo Ultrex and Quadris
July 8 – Added supplemental fertilizer to treatments 1, 2, 3, and 5; hilled
October 6 – Harvested plots
October 17 – Graded trials at Hancock
Irrigated – July 22, .5"; July 30, .6"; Aug 15, .7"; Aug 20, .7".

Trial weights were recorded for total yield, culls, undersize and US#1's. The US#1's were size graded and weights were recorded for all potatoes less than 4 ounces, 4-6 ounces, 6-10 ounces, 10-13 ounces, 13-16 ounces and over 16 ounces. Scab ratings, internal defects and trial yields were rated and statistically analyzed by Vaughan James, UW Plant Pathology.

Scab symptom rating and yield.

Trt no.	Scab Rating		Yield						
	Lesion Area Index [1]	Lesion Type Index [2]	TOTAL cwt/A	US#1		Undersize [3]		Culls	
				cwt/A	%	cwt/A	%	cwt/A	%
1	2.1	3.3	346.8	255.9	73.8	13.3	3.8	77.5	22.4
2	2.9	5.6	329.4	274.5	83.5	13.7	4.1	41.2	12.4
3	2.3	4.5	379.6	299.5	79.0	15.5	4.1	64.5	16.9
4	2.5	4.4	332.7	272.3	81.6	11.7	3.5	48.7	14.9
5	3.6	4.6	348.2	280.2	80.6	12.3	3.5	55.7	15.9
6	4.4	6.4	322.2	256.6	79.5	10.1	3.2	55.5	17.3
Pr>F[4]	0.55	0.84	0.41	0.59	0.09	0.56	0.81	0.05	0.10
LSD	NS	NS	NS	NS	6.5*	NS	NS	22.3	6.7*

Specific gravity, and size grades of US#1 size Snowden potatoes

. Trt no	Specific Gravity	Size Grades of US # 1 Potatoes - %						
		< 4 oz.	4-6 oz.	6-10 oz.	10-13 oz.	6-13 oz.	13-16 oz.	> 16 oz.
1	1.098	22.3	26.7	36.4	11.0	47.4	3.6	0.0
2	1.096	26.0	26.6	35.6	8.2	43.8	3.6	0.0
3	1.096	26.3	28.4	34.0	6.7	40.7	4.3	0.3
4	1.096	21.2	28.0	39.3	8.4	47.6	3.1	0.0
5	1.093	23.7	24.2	38.5	8.2	46.7	4.5	0.9
6	1.090	17.6	23.5	38.8	11.4	50.2	8.0	0.7
Pr>F[4]	< 0.01	< 0.01	0.15	0.12	0.29	0.09	0.10	0.65
LSD	0.003	NS	NS	NS	NS	6.5*	3.5*	NS

1 Lesion area index. Lesions were rated on a 5-point scale with: 0 = no lesions; 1 = 1-10% of the surface area of the tuber affected; 2 = 10-25% affected; 3 = 25-50% affected; 4 = 50-75% affected; 5 = > 75% affected. The lesion area index = the sum for all classes of [(the number of tubers in that class x the class number) x 100]/(5 x total number of tubers rated). The maximum value for this index (if all tubers were rated 5) is 100.

2 Lesion type index. Lesions were rated on a 5-point scale as described in the text. The type lesion index was calculated by summing the number in each class x the class number x 100 /(5 x the total number of tubers rated). The maximum value for this index (if all tubers were rated 5) is 100.

3 Undersize indicates potatoes < 1 7/8 inch diam.

4 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at *P* = 0.10 (* indicates differences between pairs of treatments were significant at *P* = 0.10, but not at *P* = 0.05).

Tuber internal quality

Trt	% with no internal defects	% with any kind of internal defect	Com-bined Defect Rating	Hollow Heart				Internal Browning				Black Spot/Bruising				
				% with any HH	% with slight HH	% moder-ate HH	% severe HH	% with any IB	% with SLIGHT IB	% MODER-ATE IB	% SEVERE IB	% Bruise Free	% with 1 spot (<1cm)	% with 1 spot (> 1cm)	% with 2-3 spots	% with > 3 spots
1	55.0	45.0	0.8	0.0	0	0	0.0	0.0	0	0.0	0.0	55.0	30.0	2.5	7.5	5.0
2	62.5	37.5	0.7	0.0	0	0	0.0	0.0	0	0.0	0.0	62.5	20.0	2.5	12.5	2.5
3	70.0	30.0	0.4	0.0	0	0	0.0	0.0	0	0.0	0.0	70.0	27.5	0.0	2.5	0.0
4	60.0	40.0	0.6	0.0	0	0	0.0	0.0	0	0.0	0.0	60.0	30.0	0.0	10.0	0.0
5	47.5	52.5	1.0	2.5	0	0	2.5	2.5	0	0.0	2.5	50.0	30.0	5.0	15.0	0.0
6	53.6	46.4	0.8	0.0	0	0	0.0	2.3	0	2.3	0.0	55.9	29.3	2.5	12.3	0.0
Pr>F[2]	0.37	0.37	0.21	0.45	---	---	0.45	0.60	---	0.45	0.45	0.50	0.86	0.65	0.61	0.57
LSD	NS	NS	NS	NS	---	---	NS	NS	---	NS	NS	NS	NS	NS	NS	NS

1 The worst possible rating would be 10. Hollow heart and internal browning categories given values of 1(slight), 2 (moderate), 3 (severe); bruising categories given values of 1 (1 spot<1cm) to 4 (> 3 spots). Combined defect rating = sum of Hollow heart, int. browning and bruising values/10 (the worst defect value a tuber could have if hh=3, ib=3 and bruise=4.

Soil Test Result

pH 2004 Trial

Trtmnt	1	2	3	4	5	6
04-0501	5.25	5.43	5.30	5.30	5.25	5.25
04-1104	5.83	6.38	6.38	7.15	7.25	7.43

2003 Trial

Trtmnt	1	2	3	4	5	6
06/03	4.85	5.08	5.15	5.00	5.05	5.10
11/03	4.83	5.50	5.35	6.05	5.95	6.18
03-0704	5.03	5.38	5.40	5.70	5.70	5.54

OM

Trtmnt	1	2	3	4	5	6
04-0504	2.50	2.60	2.58	2.50	2.48	2.63
04-1104	2.40	2.38	2.48	2.48	2.45	2.70

Trtmnt	1	2	3	4	5	6
06/03	2.15	2.18	2.20	2.18	2.13	2.23
11/03	2.18	2.25	2.30	2.38	2.33	2.40
03-0704	2.20	2.15	2.43	2.30	2.38	2.31

K

Trtmnt	1	2	3	4	5	6
04-0501	172	181	193	166	162	188
04-1104	168	168	172	170	170	196

Trtmnt	1	2	3	4	5	6
06/03	171	165	176	197	196	212
11/03	140	135	119	126	148	153
03-0704	162	163	158	151	175	162

P

Trtmnt	1	2	3	4	5	6
04-0501	118	123	127	123	125	134
04-1104	162	162	170	164	169	169

Trtmnt	1	2	3	4	5	6
06/03	133	145	153	144	150	154
11/03	163	162	163	165	160	162
03-0704	159	151	159	159	160	157

Ca

Trtmnt	1	2	3	4	5	6
04-0501	540	590	560	540	525	570
04-1104	687	765	760	810	855	880

Trtmnt	1	2	3	4	5	6
06/03	505	540	505	515	515	500
11/03	495	550	535	645	545	555
03-0704	550	550	525	595	575	561

Mg

Trtmnt	1	2	3	4	5	6
04-0501	260	120	112	110	110	112
04-1104	103	320	327	510	557	667

(39,000 ppm)

Trtmnt	1	2	3	4	5	6
06/03	83	90	90	90	90	93
11/03	105	248	220	328	315	375
03-0704	115	205	200	282	297	246

Est CEC

Trtmnt	1	2	3	4	5	6
04-0501	5.50	4.25	4.25	4.00	4.00	4.25
04-1104	4.67	7.00	6.75	8.50	9.25	10.25

Trtmnt	1	2	3	4	5	6
06/03	3.75	3.75	3.75	3.75	3.75	3.75
11/03	3.75	5.00	4.50	6.00	5.75	6.50
03-0704	4.25	5.00	5.00	5.50	5.50	5.25

B

Trtmnt	1	2	3	4	5	6
04-0501	0.35	0.3	0.4	0.48	0.43	0.4
04-1104	0.8	0.43	0.43	0.2	0.33	0.33

Trtmnt	1	2	3	4	5	6
06/03	0.23	0.30	0.25	0.28	0.28	0.23
11/03	0.43	0.50	0.58	0.28	0.35	0.38
03-0704	0.18	0.2	0.25	0.25	0.3	0.25

Mn

Trtmnt	1	2	3	4	5	6
04 0504	22.5	22.7	24	21.5	22.7	23.2
04 1104	30	17	18	16	16.5	15.5

Trtmnt	1	2	3	4	5	6
06/03	35.3	33.3	34.8	38.8	35.8	36.0
11/03	35.8	18.8	21.5	17.3	18.0	17.8
03-0704	45.5	30.5	33.5	29.75	31.2	31.25

Zn

Trtmnt	1	2	3	4	5	6
04 0504	2.5	3	2.88	2.7	2.5	2.8
04 1104	2.63	2.9	3.13	3.5	3.8	4.4

Trtmnt	1	2	3	4	5	6
06/03	2.9	3.0	3.0	3.2	3.3	3.3
11/03	3.3	3.3	3.2	3.5	3.5	3.7
11-0704	3.23	3.23	3.1	3.23	3.45	3.25

S(SO4)

Trtmnt	1	2	3	4	5	6
04 0504	5.63	5.15	5.95	5.38	5.85	5.13
04 1104	30.6	31.7	31.5	29.2	19.1	38.2

Trtmnt	1	2	3	4	5	6
06/03	8.0	8.6	7.5	8.2	8.6	8.6
11/03	21.7	29.7	30.3	28.3	31.4	28.3
03-0704	11.8	11.9	12.6	12.33	17.0	13.47

Soil Density

Trtmnt	1	2	3	4	5	6
04-0501	1.02	1.01	1.01	1.03	0.99	1.01
04-1104	1.08	1.08	1.07	1.07	1.06	1.04

Trtmnt	1	2	3	4	5	6
06/03	1.16	1.15	1.15	1.16	1.16	1.15
11/03	1.13	1.12	1.12	1.11	1.12	1.10
03-0704	1.15	1.14	1.15	1.13	1.13	1.14

Results and Summary

There was no noticeable difference in time of emergence or in development of vine growth over the course of the summer. Scab ratings on the harvested potatoes showed no significant difference between treatments in either lesion area index or in the lesion type index. Numerically, treatment 4 showed higher amounts of both lesion area index and lesion type index. In 2002 there was a numerically higher, although not significant scab reading for treatment 3. Yield results also showed no significant difference in total yield, US#1's, undersize or culls between the plots with or without PMR. Undersize potatoes for all treatments ranged from 13.0 cwt to 20.9 cwt and the culls ranged from 15.7 cwt to 20.3 cwt. Specific gravity showed a directly related range from 1.098 for the untreated plot down to 1.090 for treatment #6. This result was nearly identical in both years 2003 and 2004. Analysis of variance showed a difference between pairs of treatment results at P=0.10 but not at P=0.05. In 2002 the readings were also lower for treatment #6 but there was no direct correlation between the higher amounts of PMR and lower readings. In the 2003 trial an analysis of size breakdown of the US #1 potatoes showed no significant difference for all sizes with the exception of the 6-10 oz. size where there was a difference that was significant at the 10% level but not at the 5% level of probability. In the 2004 trial there was a difference in yields of 6-13 ounce and 13-16 ounce potatoes. Checks for tuber internal quality showed no significant difference in amount of hollow heart, internal browning, or for black spot/bruising. Soil sample analysis showed a slight increase in pH and OM for treatments with added PMR. Phosphorous levels showed a sight increase for all treatments including the control. Calcium levels showed a slight decrease to all treatments including the control. The magnesium content of the material applied over the past three years has been relatively high. This has resulted in a temporary sharp increase in soil levels of magnesium which has moderated in later soil samples. This was evident in the results as the magnesium levels in the soil moved from around 90 ppm at planting to a high for treatment 6 of 375 ppm at harvest in 2003. The estimated CEC showed a definite increase as higher rates of PMR were applied. The levels of boron and zinc showed no change. The levels of manganese showed a steady decrease with added amounts of PMR.

Potato Trial Conclusion

The results of this trial were fairly similar to the trial conducted in 2002 and 2003. There were no real significant differences in yield or disease but there were some numerical differences that were similar each year. Yield and internal defect data showed no significant difference for treatments with or without added PMR. The nutrient analysis of the material used in this trial showed nutrient availability for the first year after application for each wet ton to be 3.26# of N, 4.33# of P and .36# of K. With an application of 38 wet ton per acre this material would contain around $60 in available nutrients per acre. Valuing this material as a liming agent, with a neutralizing index of around 20%, an application of 38 tons per acre could possibly replace 5 tons of aglime per acre for an additional value of around $125 /acre. With no significant differences in yields it appears that the nutrients in this material are able to be utilized by potatoes. The pH levels showed a significant increase for samples taken six months after application. Samples taken 18 months after application showed that the large amount of increase was temporary as pH levels then were shown to have declined back closer to original levels. Samples taken 30 months after application show that pH levels had leveled off at a point for the full application rates of around 5.7 with a pH of 5.2 at time of application. Trial results indicate that with accurate analysis and accurate application rates, the use of this material for potato production should be an acceptable practice.

Soybean Production and Long-Term Soil Effects

In 2003 soybeans were planted on the area used for the PMR trial in 2002. Treatments applied in 2002 followed the same sequence as was used in 2003.

- Treatment 1 – Control
- Treatment 2 - 50% rate, (10.7 WTA), plus 0 added N
- Treatment 3 - 50% rate plus 62# supplemental N
- Treatment 4 - full rate of 21.4 WTA plus 0 added N
- Treatment 5 - full rate of 21.4 WTA plus 62# added N
- Treatment 6 - 150% rate, (32.1 WTA), plus 0 added N

2003 was extremely dry in Langlade County for the majority of the summer and the soybeans received no supplemental water. Treatment number 3 and treatment number 5 received 62# of supplemental N in 2002. They were planted with a grain drill on May 24 with Pioneer 90B74, Round-Up Ready, soybeans. Soybeans were cut on October 21 with a John Deere sickle mower. The cut beans were bagged and taken to Arlington where they were threshed out using a small plot combine. Vine height was measured on August 20, 2003. Soil samples were taken again on November 3, 2003 to check for long-term changes in soil nutrient levels.

Paper Mill Residual Effect on Soybean yield and Grain Composition

	Paper mill	Nitrogen	Grain			Total plant	Test	Seed composition		
Trt#	residue	lb/a (2002)	Yield	Moist.	Height	weight	weight	Protein	Oil	Fiber
	tons/a		bu/a	%	in	lb/140 sq ft	lb/bu		%	
1	0	0	18.4	12.0	20.8	9.2	57.8	35.7	19.1	5.1
2	10.7	0	19.2	11.6	23.1	9.9	57.9	35.6	18.7	5.1
3	10.7	62	19.2	13.2	22.9	9.5	57.9	35.9	18.8	5.1
4	21.4	0	19.7	11.8	22.8	10.1	58.4	37.3	17.9	5.0
5	21.4	62	20.9	12.4	23.0	10.5	56.0	37.9	17.2	4.9
6	32.1	0	23.5	11.9	24.4	11.3	56.8	38.3	16.9	4.9
Means			20.1	12.1	22.8	10.1	57.5	36.8	18.1	5.0
Probability %			>50	19.4	46.3	>50	38.0	4.4	1.2	15.7
LSD 10%			NS	NS	NS	NS	NS	0.7	0.4	NS

Soybean Results and Summary

Yield results showed higher yields, greater plant height and greater amounts of dry matter with the higher amounts of PMR. There was also a significant increase in the protein and oil content in the soybeans harvested from the plots with the added PMR. Soil test results showed no real long-term change in soil nutrient levels with the exception of magnesium, which showed an increase in 11/02, and a slightly lower reading in 11/03. The added organic matter may have helped to retain soil moisture or there may be other factors similar to those seen when applying dairy manure that affect yield but are hard to pinpoint. This trial indicates that soybeans planted in 2003 on these plots benefited favorably from the addition of PMR in 2002.

Corn Trial Using PMR

In 2003, a trial was conducted using the same treatment protocol consisting of six treatments replicated four times that has been used for the potato trials.

Treatments for PMR Corn 2003
6 row(18') plots 20' long

	Starter (100# 19-19-19)			PMR			At planting N	P2O5	K2O	Total N	P2O5	K2O
treatment 1 Control	19	19	19	0	0	0	121	0	46	140	19	65
Treatment 2, 13.25 tn PMR 50% rate, 100% credit	19	19	19	62	82	7	61	0	45	142	101	71
pounds PMR/plot				219								
treatment 3, 13.25 tn PMR 50% rate, 50% credit	19	19	19	30	64	0	91	0	46	140	83	65
pounds PMR/plot				219								
treatment 4, 26.5 tn PMR 100% rate 100% credit	19	19	19	120	249	2	0	0	44	139	268	65
pounds PMR/plot				438								
treatment 5, 26.5 tn PMR 100% rate, 50% credit	19	19	19	60	124	1	61	0	45	140	143	65

pounds PMR/plot				438								
treatment 6, 39.75 tn PMR	19	19	19	180	249	4	0	0	42	199	268	65
150% rate, 100% credit												
pounds PMR/plot				657								

Shell corn yield results harvest 11-13-03

Sample #	wt(gms)	wt (lbs)	% moist	Test wt	#DM	Wt # @ 15.5% moist	wt/a @ 15.50%	bu/a @56#/b
1	4544.3	10.02	37.33	41.25	6.28	7.43	5395	96.3
2	4202.7	9.27	34.48	40.53	6.05	7.16	5200	92.9
3	4273.4	9.42	33.78	40.25	6.24	7.39	5364	95.8
4	4180.8	9.22	34.13	40.85	6.08	7.19	5221	93.2
5	4828.3	10.64	37.15	40.50	6.73	7.97	5784	103.3
6	4540.1	10.01	35.23	41.65	6.49	7.68	5577	99.6

Corn Silage Data

Sample No						Forage Analysis					
1	Net t/a	wet sample	dry sample	%DM*	DM tn/a	% DM**	%Moist	Cd Prot	ADF	NDF	NFC
2	16.72	298.39	95.70	32.07	5.36	32.23	67.77	8.86	23.52	42.71	42.24
3	16.48	276.42	89.84	32.50	5.36	32.74	67.22	8.69	24.37	45.06	40.47
4	17.61	247.20	79.33	32.09	5.65	32.91	67.10	9.20	23.65	42.94	41.86
5	16.34	290.40	94.72	32.62	5.33	31.04	68.97	9.14	24.61	44.86	40.10
6	17.33	251.56	81.22	32.29	5.60	31.56	68.44	9.09	24.38	44.44	40.26
	17.57	294.03	95.47	32.47	5.70	31.60	68.40	8.96	23.40	43.83	41.46

Sample No	Starch	Non-stch NFC	Fat	TDN	milk /tn DM	Mlk/acre	P	Ca	K	Mg	Ash
1	31.29	10.95	3.20	74.34	3795	20347	0.22	0.29	1.04	0.20	4.30
2	30.13	10.33	3.20	73.84	3764	20161	0.21	0.29	1.04	0.20	3.89
3	30.45	11.42	3.20	75.06	3866	21842	0.22	0.31	1.08	0.21	4.12
4	28.13	11.98	3.20	74.49	3820	20353	0.22	0.32	1.06	0.22	4.00
5	29.53	10.73	3.20	74.40	3816	21356	0.22	0.31	1.14	0.21	4.32
6	31.15	10.30	3.20	74.95	3852	21973	0.22	0.30	1.03	0.20	3.85

Corn Trial Summary

Shell corn samples showed a slightly lower yield for treatments 2 and 3 when compared to the control treatment 1. In the silage analysis there was no difference between silage yields when comparing treatments 1, 2, and 4. In the shell corn analysis there was an increase in yield for treatment 3 over treatment 2 and for treatment 5 over treatment 4 as well as an increase in yield for treatment 6 over the control. This may suggest that the fertilizer level of 140-20-65 should have been higher. Corn silage yields show no difference between treatments 1, 2, and 4. Here again we see an increase in yield for treatments 3, 5, and also 6. Milk per acre also shows no difference for treatments 1, 2, and 4 but again we see an increase for treatments 3, 5, and also 6. The use of PMR especially in a corn-hay rotation would appear to be a positive step toward utilizing a by-product and appears to have no negative effects on corn or soybean production.

Metals Content Information

The following information has been furnished by STS Consultants, LTD. Green Bay, WI.
Steve Shimek, Associate Scientist, 1-920-468-1978; e-mail: shimek@stsconsultants.com

Metals Content Comparison Item	Concentration in Parts per Million							
	Cadmium	Lead	Arsenic	Chromium	Mercury	Nickel	Copper	Zinc
Wausau-Mosinee, Brokaw Mill [1]	0.45	No Detect	0.45	8.29	No Detect	4.98	17.8	45.7
Local Topsoil [2]	0.1	5.6	2.4	11.9	0.02	6	4.7	24
Average U.S. Topsoil [3]	0.27	12	No Detect	No Detect	No Detect	24	30	57
Commercial Fertilizer (N-P-K) [4]	5.3	1.6	<0.1	70	<0.1	11	4.6	60
Fresh and Rotted Manure [5]	No Detect	125	No Detect	12	No Detect	No Detect	6.7	75
Wood Ash [6]	<1.5	125	48	34	0.4	23	116	424
Ace Hardware Vegetable Food [7]	1.8	5.3	2.9	No Detect	0.5	11	No Detect	368
Nu Life Trace Elements [8]	86.8	2491	29.2	No Detect	2491	515	No Detect	68,150

Source for item 1 - STS Consultants

1) STS Consultants, Table 5 Sludge Analytical Summary Wausau -Mosinee Paper Mill Corp, December 2000.

2) STS Consultants, Topsoil sample from the Town of Kronenwetter, Marathon County.

Data from the following sources referenced in U.S.-EPA Publication EPA 747-R-98-003, 1999

3) Holmgren, 1993
4) International Mineral Corp., 1997
5) Arora, et al., 1975
6) Washington Dept. of Ecology,1997
7) Seattle Times, 1998

Wisconsin Metal and Dioxin Loading Limits and Site Life Estimates [1]

Parameter	Cumulative Limit (Pounds/Acre)	Wausau-Mosinee Paper Corp Brokaw WI	
		(Pounds/Dry Ton)	Years of Site Life
Cadmium	4.5	0.0009	500
Copper	110	0.036	305
Lead	445	<0.0044	>1011
Nickel	45	0.010	450
Zinc	225	0.091	247
TDE [2]	1.20 (ppt)		>706

Note: **1)** Limits based on NR 214 and WDNR guidance. Table values assume minimum cation exchange capacity, and a crop nitrogen requirement met with 10 dry tons per acre. The ppt = parts per trillion

2) TDE is total dioxin equivalency, which is the sum of 2,3,7,8-TCDD + (0.1x 2,3,7,8-TCDF)

Prepared by STS Consultants, Ltd. January 2003.

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EFFECT OF SOIL pH ON SOYBEAN YIELD

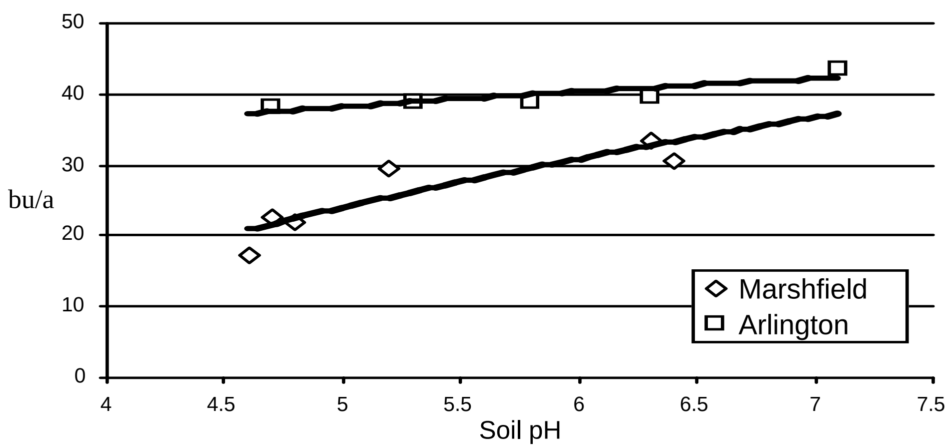
J.B. Peters, P.E. Speth, K.A. Kelling and R. Borges [1]

Soybean production has increased very rapidly in recent years. In 1939, Wisconsin grew only about 20,000 acres of soybeans for grain. This figure had increased to around 450,000 acres twenty years ago and is now at approximately 1.7 million acres. The average yield of soybeans in Wisconsin varies a great deal from year to year depending on growing conditions. The average yield in 1972 was about 28 bu/acre, which was the same as the average yield for 2003. Clearly, this average yield is far below yields of 70 to 90+ bu/acre commonly being reported in highly managed test plots.

Nutrient availability can be strongly influenced by soil pH and many of Wisconsin's soils are natively acid, often requiring lime to raise the soil pH. Since many of Wisconsin's soybeans are grown on soils with some degree of acidity, more information on the effect of soil pH on nutrient uptake and yield is needed. Earlier studies conducted at various Agricultural Research Stations in Wisconsin showed that a soil pH of at least 6.3 was required for optimum yields of soybeans. At the Marshfield location in 1984, a soil pH below 5.2 was very detrimental to soybean plant performance and top performance seen when the soil was limed to a pH of 6.3 (Fig. 1). A similar study conducted that same year in southern Wisconsin at the Arlington Research Station, showed that soybean yields may require a soil pH somewhat above 6.3 for optimum production.

This series of studies was designed to evaluate the effect varying soil pH has on soybean production on several soil types across the state.

Figure 1. Effect of soil pH on soybean yield. 1984



[1] Director, UW Soil Testing Laboratories, Senior Research Specialist, Emeritus Professor, Department of Soil Science, and Assistant Professor, Department of Agronomy, Univ. of Wisconsin-Madison. Support for this project from the Wisconsin Liming Materials Council is gratefully acknowledged.

Materials and Methods

This study was conducted in 2004 at the long-term pH plots located at four sites located on or near three UW Agricultural Research Stations. These plots at Spooner, Hancock, and the two locations at Marshfield, have pH levels ranging from about 4.8 to 7.0 in five levels at Spooner and six at all other sites. In addition, Hancock also has two pH levels (6.0 and 7.0) limed with either calcitic or dolomitic lime. In 2003, soybeans were planted on the two sites at Marshfield. Earlier studies were conducted in 1984 at both the Marshfield location as well as an additional site at the Arlington Research Station in southern Wisconsin. Soil pH was the only fertility variable in this study, however, several varieties were evaluated in the 1984 studies, with results reported averaged across all varieties (Fig. 1).

The soil at the Marshfield plot locations was a Withee silt loam. Pioneer 90B73 was the variety planted at both the airport and research station sites in 2004, with 200,000 seeds/a seeded with a grain drill on May 5 and May 19, respectively. On May 23, 2003, NK S08-R4 was drilled at a rate of 225,000 seeds/acre at the airport location and the same variety was seeded at a rate of 190,000 seeds/acre at the research station. In all cases, Roundup herbicide was used for post-emergence weed control. In 2004, both Marshfield locations were harvested on October 12 using a 5-foot wide Massey Ferguson plot combine with samples collected for quality analysis. An Almaco combine with a 5-foot head was used in 2003 with harvests made on October 10 at both Marshfield locations.

The Spooner location was planted on a Pence sandy loam in 30-inch rows at a seeding rate of 180,000 plants/acre on May 19, 2004. Roundup herbicide was used for weed control with this glyphosate resistant variety, NK S08-R4. Yields were measured and samples collected for quality analysis on October 6, 2004.

The long-term soil pH plots at the Hancock Research Station were planted to NK S24-K4, a glyphosate resistant variety, on May 26, 2004. This location, which consists of a Plainfield loamy sand soil, was treated with Roundup herbicide for weed control and harvested on November 21, 2004 using a plot combine.

Soil samples to measure soil pH were taken at all locations at the time of harvest. In addition, bulk grain samples were collected for quality analysis. All soil analyses were performed by the UWEX Soil and Plant Analysis Laboratories at Madison and Marshfield using methods described by Peters et al. (2004).

Results and Discussion

Results of the two studies conducted at Marshfield in 2003 appeared to support the recommendation of a target pH of 6.3 for soybeans in Wisconsin. At the airport location, soybean yields were optimized at a pH of around 6.2, with no further improvement in grain yield as soil pH was increased above that level (Table 1). At the site located at the research station, the data were a bit variable. The field where these plots are located is a much wetter site and is subject to being saturated following high rainfall events. At this site in 2003, it appears that liming to a soil pH of between 5.5 and 6.0 resulted in optimum yields, although there were no statistically significantly differences in yield (Table 2).

Table 1. Effect of soil pH on soybean yield, Marshfield airport site 2003.

Target pH	Actual pH	Soybean yield bu/acre
4.8	4.5	19.3
5.3	5.3	28.3
5.8	6.2	30.8
6.3	6.4	28.9
6.8	6.6	30.1
7.3	6.7	29.1
Statistical significance Pr>F.		0.27
LSD $_{0.05}$.		<0.01

Table 2. Effect of soil pH on soybean yield, Marshfield station site 2003.

Target pH	Actual pH	Soybean yield bu/acre
4.8	4.5	22.5
5.3	4.9	23.3
5.8	5.4	28.4
6.3	6.0	25.0
6.8	6.7	27.5
7.3	6.9	27.5
Statistical significance Pr>F.		0.25
LSD $_{0.05}$.		NS[*]

[*] Not significant

The studies conducted in 2004 at these same two Marshfield pH plot locations showed that there was a significant depression in soybean yield at the lowest soil pH levels found in the study (<5.0). At the airport location, no statistically significant yield response was found as the soil pH was increased above 5.0, but liming to a pH above 6.0 was required to maximize yields (Table 3). As was seen in the previous year, yields at the more poorly drained station location were lower than those found at the airport. At this location, optimum yields were seen as soil pH was increased to at least 6.3 (Table 4).

At the Spooner location, soybean yields responded quite dramatically to liming. Yields increased approximately 400%, from 7.5 bu/acre at a soil pH of 4.5 to around 30 bu/acre as soil pH was increased to between 6.1 and 6.6 (Table 5).

Table 3. Effect of soil pH on soybean yield, Marshfield airport site 2004.

Target pH	Actual pH	Soybean yield bu/acre
4.8	4.3	28.8
5.3	5.0	42.5
5.8	6.1	44.3
6.3	6.6	44.7
6.8	6.7	45.2
7.3	6.9	46.5
Statistical significance Pr>F.		<0.01
LSD $_{0.05}$.		6.85

Table 4. Effect of soil pH on soybean yield, Marshfield station site 2004.

Target pH	Actual pH	Soybean yield bu/acre
4.8	4.6	24.0
5.3	4.9	25.8
5.8	5.4	27.9
6.3	6.3	31.6
6.8	6.9	32.2
7.3	7.1	33.4
Statistical significance Pr>F.		<0.01
LSD $_{0.05}$.		3.27

At the Hancock location, there was very little soybean grain yield response to liming above a soil pH of 5.5 (Table 6). On this irrigated sandy textured soil, liming did not appear to have a significant impact on improving grain production of soybeans. Yield was optimized by liming to a soil pH of about 5.5 or greater.

Taken together, it appears that the yield response of soybeans lies somewhere between that for alfalfa and corn. Figure 2 presents a second-order polynomial fit of all 2004 soybean data from this report where there was a significant effect of soil pH on yield. Also included in this same figure are second-order polynomial fits of alfalfa and corn grain yield from previous studies at these same research study locations.

Table 5. Effect of soil pH on soybean yield, Spooner station site 2004.

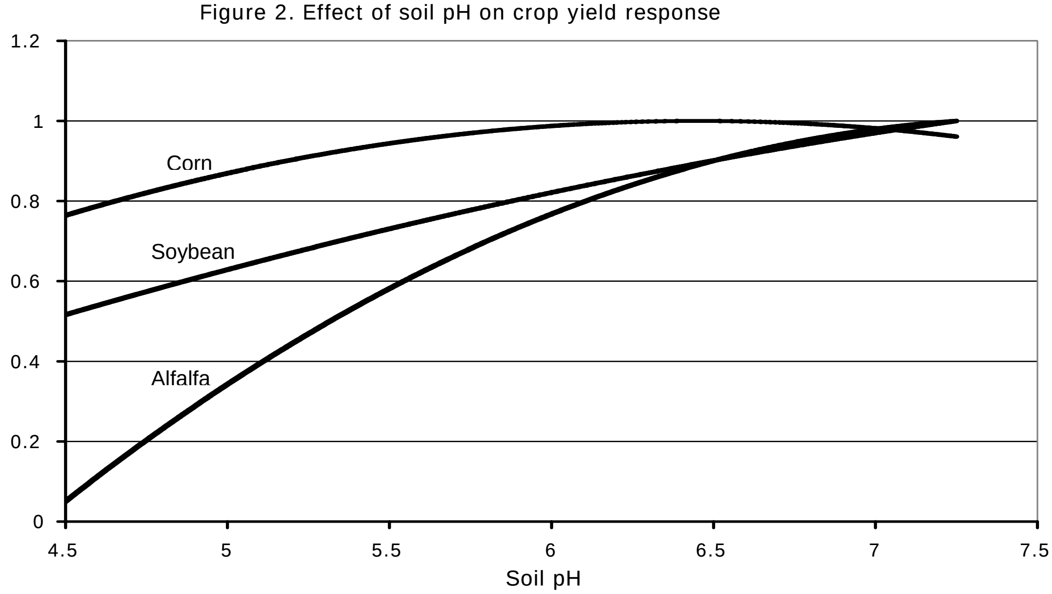
Target pH	Actual pH	Soybean yield bu/acre
4.7	4.5	7.5
5.2	4.9	12.6
5.7	5.4	21.4
6.2	6.1	27.5
6.7	6.6	31.4
Statistical significance Pr>F.		<0.01
LSD $_{0.05}$.		4.95

Table 6. Effect of soil pH on soybean yield, Hancock station site 2004.

Target pH	Actual pH	Soybean yield bu/acre
4.5	4.9	45.7
5.0	5.3	48.9
5.5	5.6	50.0
6.0	6.0	51.3
6.5	6.3	50.3
7.0	6.5	49.3
6.0 §	5.9	50.5
7.0 §	6.6	49.1
Statistical significance Pr>F.		0.72
LSD $_{0.05}$.		NS*

§ Calcitic lime used
* Not significant

Figure 2. Effect of soil pH on crop yield response



Summary

Significant soybean yield responses were seen on the heavy textured silt loams in the Marshfield area and the sandy loam soil at Spooner. Little response was seen in 2004 on the irrigated sands at Hancock. This is comparable to alfalfa, which shows a yield response to liming on virtually all acidic soils in the state, and corn, where yields are often increased by liming on many soils especially those in the central and north central areas of the state. Of the major agronomic crops in Wisconsin, the yield response of soybeans to liming is somewhere in between what is seen with corn and alfalfa. Overall, these results support the current recommendation of liming to a pH of at least 6.3 for soybean production in Wisconsin.

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SOYBEAN GRAIN COMPOSITION AS AFFECTED BY SOIL pH

Roger Borges [1/]

Increasingly sophisticated market demand may provide price premium opportunities for specific soybean grain composition such as high protein and/or high oil content. Management recommendations to foster those specific grain composition outputs are scarce at best. Neither growers nor the processing industry have a good understanding of how soil pH might affect soybean's protein and oil output per acre. These studies objectives are to evaluate the impact of acidic soil pH on soybean protein and oil output per acre.

A total of six randomized complete block pH trials with four replications each were evaluated in 2003 and 2004. Two trials conducted in 2003 (Marshfield 1 and Marshfield 2) and two in 2004 (Hancock and Spooner) were planted following corn. The two Marshfield trials conducted in 2004 were planted into soybean residue. Soil pH treatments ranged from 4.5 to 7.0. Soybean varieties varied with year and location. Grain yield was determined for each plot and grain samples were collected for composition analysis. Grain protein, oil, and fiber content were determined for each plot using near infrared transmittance technology.

As expected, grain yields were higher as pH approached neutrality (See companion Slides). As soil pH increased from 4.5 to 7.0, grain yields increased up to 40%, overall protein content of soybeans grain increased up to 6% points, oil content decreased up to 3% points, and fiber content decreased over 1% point.

Previous literature and over nine thousand samples from 72 trials of our own (data not shown) indicate a trend of decreased protein content when grain yield is increased. Consequently, the positive correlation between yield and protein content in this study is surprising and encouraging. It suggests that management factors such as liming when soil pH is low can potentially be used to enhance grain composition without compromising grain yield.

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EFFECT OF TILLAGE AND POTASSIUM FERTILIZATION ON SOYBEAN YIELD[1/]

Richard P. Wolkowski [2/]

There continues to be considerable interest in P and K fertilizer placement among cash grain producers for numerous reasons. Growers have faced low commodity prices for several years and are interested in placement methods that improve the efficiency of nutrient use and potentially reduce input costs. This issue seems be more important in high residue management systems where broadcast, incorporated applications are not possible because of the need to maintain surface crop residue for conservation purposes. Wisconsin research has shown response to banded P and K for corn in conservation tillage systems, but little research has been conducted regarding fertilizer placement for soybean. It is not known what effect tillage will have on the uptake of K by soybean, and if this crop will respond like corn to localized K placement in no-till and other low-disturbance tillage systems.

Soybean has become an important crop to Wisconsin grain producers. The Wisconsin Agricultural Statistics (WDATCP, 2003) shows that over 1.5 million acres of soybean were grown in the state in the past three seasons, representing a 0.5-million acre increase over the acreage in 1998. Recent observations by many agronomists have shown situations where K deficiency has developed, especially in no-till systems. This may be an issue for soybean because the majority of the crop as is planted as "Roundup Ready" seed with minimal disturbance or no-till. Furthermore, many grain crops are grown on rented land that is typically not manured and commonly has relatively low soil test K levels.

Research is currently being conducted at the Arlington Agricultural Research Station that addresses some of the issues mentioned above. A long-term rotation x tillage x fertilizer placement study was established in 1997. This work is expected to identify sustainable K fertilization practices for Wisconsin cash grain producers. The objectives of this research are to examine the response of corn and soybean to the application of a fertilizer containing both P and K. This report summarizes the accomplishments related to the tillage/fertilizer placement study for soybean for 2002–2004.

Methods and Materials

A tillage/rotation study was established in 1997 on a Plano silt loam soil at the Arlington Agricultural Research Station. The initial soil test values were pH 6.8, and P and K of 41 and 105 ppm, respectively. The main plot treatment is rotation (continuous corn, soybean/corn, and corn/soybean). These treatments are subdivided into tillage subplot treatments (fall chisel/spring field cultivator, strip-till, and no-till). These treatments were maintained from 1997–2000 and the plots did not receive additional P and K fertilizer until the fall of 2000 when the current fertilizer treatments were installed.

[1/] Support from Monsanto, the United Soybean Board, the Foundation for Agronomic Research, and Remlinger Mfg. is gratefully acknowledged.
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The sub-subplot treatment is fertilizer placement. A rate of 200 lb/acre of a 9-23-30 material was applied as a fall broadcast prior to primary tillage, in the row on a 2x2 placement at planting, and 6 to 8 inches deep in the strip-till treatment only. Similar fertilizer treatments were made in both corn and soybean. An untreated control was included. All treatments were replicated four times in a split-split plot treatment arrangement.

The chisel system employed a fall twisted shank coulter chisel plow, followed by a single pass with a combination field cultivator in the spring. Strip-tillage was conducted in the fall with a tool that features finger coulters, a ripple coulter, a mole knife that runs 7 to 8 inches deep, followed by closing disks that form a ridge about 4 inches high. This tool is manufactured by Remlinger Mfg. of Kalida, OH, who has loaned the tool to the University to use in tillage research and Extension programs. Strips were alternated between rows each year. The succeeding crop was planted on the ridge the next spring. A Gandy air-delivery fertilizer system was mounted on the tool to permit deep fertilizer placement. The no-till treatments receive no tillage other than the pass with a four-row Kinze corn planter equipped with a dry row fertilizer attachment and a double-disk opener for the seed unit. The same planter was used in all tillage treatments and was adjusted for changes in soil condition between treatments.

Soybean (Asgrow AG2107, zone 2.1) were planted in 21, 21, and 7 May 2002–2004, respectively in 30-inch rows to establish a population of approximately 150,000 to 175,000 plants per acre. The soybean variety has the "Round-up Ready" trait so that weed control could be performed on the plots that would be adjacent to Round-up Ready corn.

Measurements made included: (1) population; (2) surface crop residue; (3) bi-weekly dry matter accumulation; (4) soybean whole-plant K concentration for each dry matter sampling; (5) soil samples collected incrementally by depth in 2002 and from the 0- to 6-inch depth in 2004; and, (6) yield and seed K concentration. Population counts were made by counting the number of plants along a measured length of row at about 45 days after planting. Three crop residue measurements were taken shortly after planting using the line-transect method in each tillage subplot. Early-season plant samples were taken beginning at about 45 days after planting (third trifoliate) by collecting 10 plants per plot. Plants were dried, weighed, and ground for analysis. Yield was measured by harvesting the middle two rows of the four row plots with a small plot combine.

Data were analyzed with an analysis of variance for a split-split plot treatment arrangement using SAS (Statistical Analysis System, Cary, NC). Where significance was found at the p=0.05 level, a Fisher's LSD was calculated. Means for the data collected for the deep-placement treatment within the strip-till plots are shown for comparison purposes, but these were not included in the statistical analysis shown in this paper.

Results and Discussion

Table 1 shows the surface crop residue in the soybean following corn for each year of the study. Measurements were made shortly after planting. As expected the chisel treatment had significantly lower residue although at an average of 34% significant conservation benefits could be expected. The strip-till and no-till treatments were similar at about 70% surface cover. It should be indicated that the strip-till tool is not designed to work in corn residue and therefore did not move enough residue that would result in a relatively residue-free zone.

Table 1. Surface crop residue in soybean following corn as affected by tillage, Arlington, WI, 2003.

Tillage	2002	2003	2004	Average
	-------------------------------- % --------------------------------			
Chisel	29	40	33	34
Strip-till	62	69	69	67
No-till	74	68	72	71
LSD	8	16	19	
Pr>F	<0.01	<0.01	<0.01	

Although the residue levels were similar between no-till and strip-till plant stand tended to be affected by tillage and fertilization (Table 2). Stands were somewhat variable between seasons. In general the highest stands were in the chisel treatment, but there was a much greater difference between strip-till and no-till compared to strip-till and chisel. Tillage only significantly affected stand in 2004. Fertilizer placement also tended to affect stand. The lowest stand each year was found where row placement was made. Even the broadcast treatment, which was made the previous fall, resulted in lower stands compared to the untreated plots. It would be hard to imagine that this was due to high salt concentrations. Fertilizer placement only significantly affected stand in 2003.

Table 2. Main effect of tillage and fertilizer treatment on the population of soybean, Arlington, WI, 2003–2004.

	Tillage*				Fertilizer			
Year	CH	ST	NT	Pr>F	None	Bdct.	2x2	Pr>F
	------ plt./acre (x 1000) -----				------- plt./acre (x 1000) ------			
2002	115	123	112	0.47	119	116	115	0.57
2003	144	139	123	0.12	144	132	125	0.01
2004	166	161	145	0.05	164	160	150	0.16

* CH=Chisel, ST=Strip-till, NT=No-till

Soil samples were collected in 2002 from the unfertilized and broadcast treatments in all tillage systems in 2-inch increment to a depth of 8 inches. The broadcast treatment was selected to avoid sampling banded situations. Samples were collected from the same fertilizer placement treatments in 2004 and were taken to a 6-inch depth as a single core across all tillage plots. Soil samples were not collected in 2003. Table 3 shows the incremental soil test results for K in 2002 and the routine analysis (pH, organic matter, P and K) in 2004. A mathematical average of the 0- to 6-inch depth (average of 0- to 2-, 2- to 4-, 4- to 6-inch increments) for the soil test K from the 2002 sampling is shown for comparison purposes. Soil test P is in the excessively high range for this soil and pH is well above the level considered optimum for soybean production in Wisconsin (6.3). These data show that overall the soil test K for the 2004 sampling is higher than that for the 2002 sampling. The reason for this observation is not readily apparent, since samples were collected in the early summer in both years. The addition of 200 lb 9-23-30/acre appears to exceed crop removal and has resulted in an increase in both soil test P and K. While tillage did not significantly affect soil test K in the 2004 sampling, there appears to be a trend for lower values in the high residue systems.

Table 3. Effect of tillage and fertilization on the soil test at, Arlington, WI, 2002 and 2004.*

	No fertilizer				Bdct. fertilizer		
	CH	ST	NT		CH	ST	NT
2002 Incremental sampling							
Depth (inch)	------------------------------ Soil test K (ppm) --------------------------------						
0 - 2	114	101	104		161	160	142
2 - 4	80	68	70		106	93	68
4 - 6	65	59	64		77	72	62
6 - 8	59	54	60		75	68	59
Avg. (0-6 in.)	86	76	79		115	108	91
Pr>F	0 – 2	2 – 4	4 – 6	6 – 8			
Tillage	0.20	<0.01	0.07	0.27			
Fertilizer	<0.01	<0.01	0.03	0.03			
T x F	0.64	0.07	0.14	0.20			
2004 Sampling (0–6 inch)							
P (ppm)	54	50	39		68	73	50
K (ppm)	113	92	93		134	133	116
pH	6.7	6.7	6.6		6.8	6.6	6.6
OM (%)	3.8	3.9	3.8		3.5	4.0	3.8
Pr>F	P	K	pH	Organic matter			
Tillage	0.17	0.27	0.69	0.17			
Fertilizer	<0.01	<0.01	0.74	0.21			
T x F	0.49	0.31	0.16	0.20			

* Fertilizer rate = 18+46+60 lb $N+P_2O_5+K_2O$/acre. CH=Chisel, ST=Strip-till, NT=No-till.

Table 4 shows the main effects of tillage and fertilization on the dry matter accumulation of soybean on 23 June, 7 July, 24 July, 21 August, and 10 September 2003. These sampling dates represent sampling on 33, 47, 64, 92, and 112 days after planting. A sampling was conducted on 6 August; however the samples were mistakenly ground for analyses prior weighing. The last sampling was conducted just as the crop was senescing, and therefore some dry matter may have been lost by leaf drop. Soybean growth in 2003 got off to a good start, but was substantially reduced by droughty conditions in August. Soybean yields throughout most of Wisconsin were lower because the drought caused many pods to abort or fill with fewer small seeds. These data show consistently significant differences related to tillage throughout the season until senescence. The dry matter produced in the chisel treatment remained higher than both the strip-till and no-till treatments until this time when the soybean growth in these treatments caught up to that of the chisel. There was also a response to fertilization such that the row fertilizer treated plots tended to have the higher dry matter content early in the growing season. As the season continued the broad cast treatment had greater dry matter accumulation. This difference was only significant at the p=0.05 level at the final sampling.

Table 4. Main effect of tillage and fertilizer placement on the dry matter content of soybean, Arlington, WI, 2003.*

Treatment	6/23/03	7/7/03	7/24/03	8/21/03	9/10/03
	------------------------------		lb/acre		------------------------------
Tillage					
Chisel	495	1112	3271	6249	7412
Strip-till	301	678	2544	5433	7530
No-till	307	711	2628	5154	7396
LSD	55	72	563	856	NS%
Fertilizer					
None	346	820	2711	5148	6709
Bdct.	368	798	2818	5982	8201
Row	389	883	2914	5706	7428
Deep **	390	890	2395	4990	6602
LSD	30	NS	NS	NS	1081
Pr>F					
Tillage	<0.01	<0.01	0.04	0.05	0.96
Fertilizer	0.02	0.26	0.46	0.06	0.03
T*F	0.11	0.22	0.71	0.43	0.56

* Fertilizer rate=18+46+60 lb $N+P_2O_5+K_2O$/acre.

** Deep-placement data not included in the ANOVA.

% NS, not significant.

Table 5. Main effect of tillage and fertilizer placement on the K concentration of soybean, Arlington, WI, 2003. *

Treatment	6/23/03	7/7/03	7/24/03	8/21/03	9/10/03	Seed
	------------------------------------- % ---					
Tillage						
Chisel	2.07	1.95	1.78	1.49	1.22	1.72
Strip-till	1.87	1.78	1.62	1.39	1.11	1.65
No-till	1.81	1.95	1.61	1.45	1.23	1.66
LSD	NS%	NS	NS	NS	NS	NS
Fertilizer						
None	1.52	1.42	1.28	1.12	0.85	1.61
Bdct.	2.12	2.11	1.92	1.60	1.37	1.72
Row	2.11	2.15	1.84	1.61	1.34	1.70
Deep **	2.36	2.09	1.81	1.48	1.23	1.68
LSD	0.20	0.23	0.37	0.23	0.20	0.05
Pr>F						
Tillage	0.12	0.39	0.56	0.86	0.47	0.12
Fertilizer	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
T*F	0.44	0.09	0.42	0.61	0.46	0.91

* Fertilizer rate=18+46+60 lb N+P_2O_5+K_2O/acre.
** Deep-placement data not included in the ANOVA.
% NS, not significant.

Table 5 shows the grain and whole-plant K concentration for the sampling dates in 2003. Tillage did not significantly affect either the grain or whole-plant K concentration at any sampling time. Where the Pr>F level was relatively small (first whole-plant sampling and grain), the K concentration tended to be higher in the chisel. Fertilization significantly affected the K concentration in the grain and at all sampling times. In all cases there was no difference between broadcast and the 2x2 placement. The unfertilized treatment was lower than either placement. The whole-plant samples for the unfertilized treatments had K concentrations that were about 30% lower than the fertilized treatments, yet the difference in the grain was less than 10%. In general, the interaction between tillage and fertilization was not significant for either dry matter or tissue K concentration.

Figure 1 shows the K uptake for the whole-plant samples separated by tillage treatment. The K uptake value is the product of the dry matter yield and tissue K concentration. The K uptake was greater in 2004 compared to 2003 due to greater dry matter production. In general, the uptake curves were similar for the broadcast and 2x2 treatments. Where there were differences, usually the 2x2 was lower than the broad cast treatment.

Table 6 shows the effect of tillage and fertilization on soybean yield. Overall yield was substantially reduced in 2003 because of the dry conditions that occurred late in the growing season. Historically yield levels in this experiment have been in the 50–60 bu/acre range. Tillage significantly affected yield in 2004 such that the chisel system produced a higher yield than the no-till treatment. A 2-bu/acre difference in favor of the chisel system was noted when averaged for the 3 years of the study. Possible explanations for this difference include the somewhat lower population, lower soil test K, and slower growth found in no-till. Fertilization did not significantly affect yield in any year, however there was a trend for higher yield with the broadcast treatment in 2003, and either the broadcast or 2x2 placements in 2004. A 2-bu/acre response to fertilization was measured when averaged over the 3 years of the study. Either method of application appeared to be appropriate. A significant interaction between tillage and fertiliza-tion was observed in 2004 that showed a greater responsiveness to the 2x2 placement in both the strip-till and no-till relative to the chisel treatment.

Table 6. Main effect of tillage and fertilizer placement on the yield of soybean, Arlington, WI, 2002–2004.*

Placement	2002	2003	2004	Average
	-------------------------------- bu/acre	--------------------------------		
Tillage				
Chisel	51	32	57	47
Strip-till	50	31	54	45
No-till	49	32	53	45
LSD	NS%	NS	3	
Fertilizer placement				
None	49	31	53	44
Bdct.				
Row	51	31	56	46
Deep**	53	31	50	45
LSD	NS	NS	NS	
Pr>F				
Tillage	0.88	0.90	0.04	
Fertilizer	0.49	0.07	0.06	
T x F	0.46	0.12	0.02	

* Fertilizer rate = 18+46+60 lb $N+P_2O_5+K_2O$/acre.

** Deep-placement data not included in the ANOVA.

% NS, not significant.

Summary

A 3-year study evaluating the response of soybean following corn to tillage and fertilization was conducted at the Arlington Agricultural Research Station from 2002–2004. Crop residue levels were adequate for conservation purposes in all tillage systems. Population and early season dry matter accumulation were greater in the chisel system. Dry matter production appeared to “catch-up” in the strip-till and no-till treatments. Fertilization tended to reduce stand and showed a trend of increasing dry matter early in the growing season. Fertilization substantially increased whole-plant K concentration during the season; however, the difference between the unfertilized and fertilized treatments was relatively small in the grain. Grain yield was significantly affected by tillage and fertilizer treatment in one year. When averaged over three seasons, grain yields were two bu/a higher in the chisel system compared to strip-till and no-till, and were 2 bu/acre higher compared to the unfertilized treatment, where fertilization was made either as broadcast or 2x2.

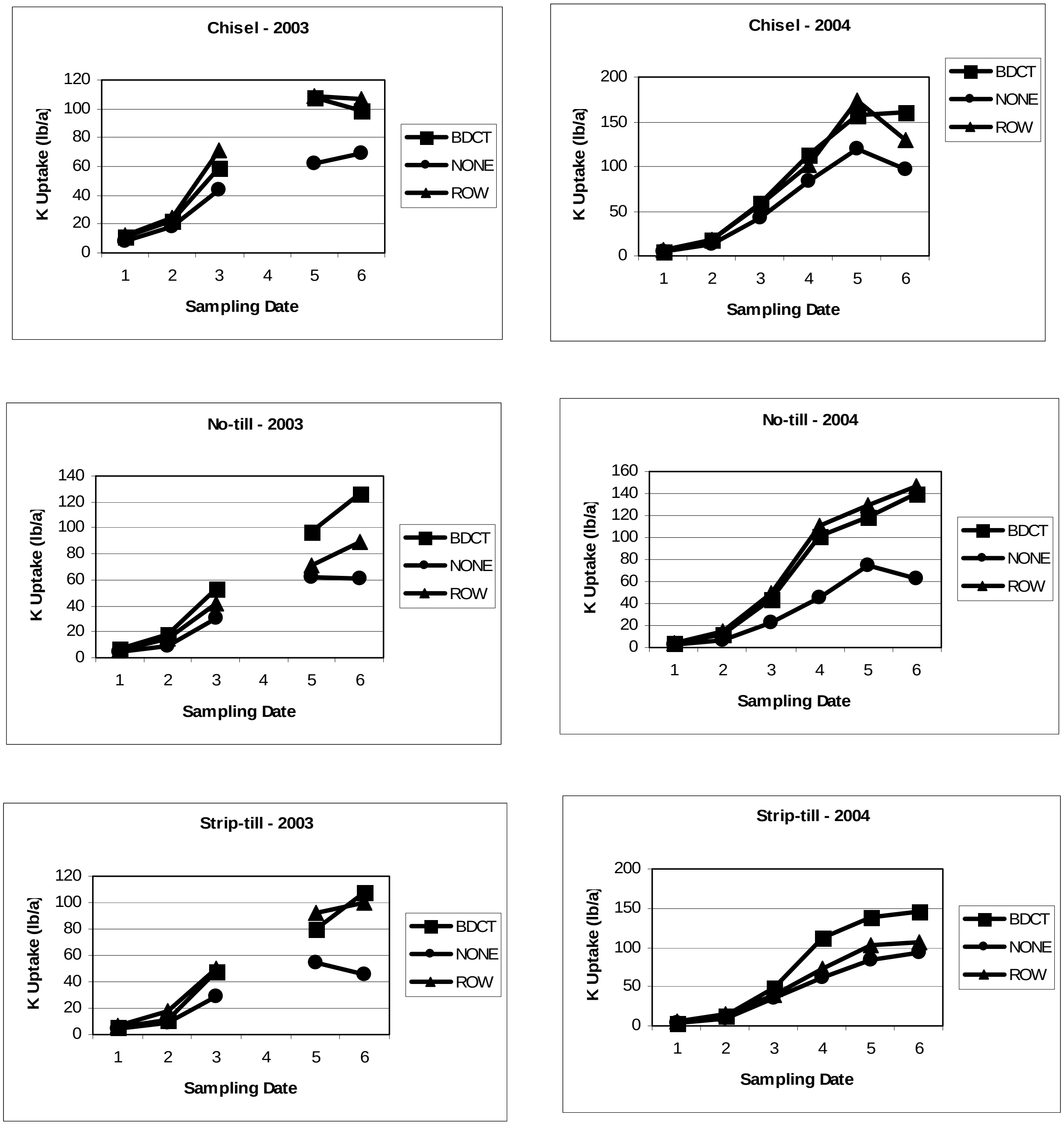


Figure 1. Whole-plant K uptake by soybean for three tillage systems, Arlington, WI, 2003 and 2004.

Wisconsin Administrative Code ATCP 40 Fertilizer & Soil or Plant Additive Programs

Lorett Jellings and Lori Bowman

Wisconsin Department of Agriculture, Trade and Consumer Protection

Mission and Goal

Mission:
To protect consumers from fraud and deception and to prevent the distribution of mislabeled products in Wisconsin.

Goal:
To further improve industry compliance with laws regulating the manufacture, labeling and distribution of fertilizers and soil or plant additives in the state.

Summary of Changes

- **Clarifies standards & procedures for licensing, permitting & labeling**
- **Exempts unpackaged, manipulated manure applied to land under a Nutrient Management Plan**
- **Exempts federally listed organic products labeled solely for organic production from permits**
- **Prohibits excessive concentrations of Heavy Metals**

License Requirements

- **Annual license required for any person who manufactures and/or distributes fertilizer and/or soil or plant additives in Wisconsin**
  - **Distribute means to sell or give away**
- **Rule clarifies current licensing requirements and procedures**

Manure

- **Defines manipulated and unmanipulated manure**
- **Manipulated Manure is Fertilizer**
- **Exempts unpackaged bulk manipulated manure used on land under a Nutrient Management Plan from requirements (License & Tonnage Fee not required)**

Manipulated Manure

- **Manure that is ground, pelletized, mechanically dried, packaged, supplemented with plant nutrients or other substances, or treated to facilitate sale or distribution as a fertilizer or soil or plant additive.**
  - **Needs Fertilizer and/or Soil or Plant Additive License**
  - **Exempt from licensing and tonnage fee if distributed to land under Nutrient Mgmt Plan**

Unmanipulated Manure

- **On-farm practices of animal husbandry, livestock facility cleaning, manure handling, manure storage or odor control on the farm where the manure is produced:**
  - **adding bedding, sand or water.**
  - **Shredding, grinding or agitating for purposes of manure handling or removal from a manure storage system.**
  - **Drying incidental to mechanical ventilation of animal confinement areas.**

License Required for Manure - Examples

- **Mixed with another ingredient**
  - **Compost, Sand, Nutrient, etc**
  - **Distributed as packaged or bulk**
- **Distributed to Land Not Under a Nutrient Management Plan**
  - **Sold or Given Away**
- **Separating Solids From Liquids is Manipulated; Tonnage On Each**

Product Specific Permits

- **Soil or Plant Additive**
- **Low-nutrient mixed fertilizers**
  - **Product specific permit to distribute fertilizers with *less than* 24 total units of N, P and K**
  - **Nonagricultural or agricultural special-use fertilizer**
  - **Exempts federally listed "organic" product labeled solely for organic crop production**

Permit Review Timeframe

- **30 days to determine and notify applicant if application is incomplete**
- **Applicant must respond in 30 days if incomplete or DATCP may deny**
- **Complete application reviewed & decision made within 60 working days**
- **Supplementary review, if needed, to be completed within 120 days and grant or deny permit**

Organic Fertilizer Requirements

- **Exempts federally listed organic products from permit requirements and some labeling requirements if the following occur:**
  - **Product is federally listed for organic crop production or is approved by an accredited agency**
  - **Product label states "This product is intended for use according to an approved organic system plan."**
  - **No performance claims**
  - **Includes use instructions**
  - **All other labeling requirements apply**

Substantiation Requirements

- **Before DATCP issues a permit, the applicant must be able to submit credible and reputable field research to verify that the proposed directions and application rates, as well as all product claims, are scientifically valid.**

Fertilizer Labeling Requirements

- **All fertilizers must be labeled with the following:**
  - **Name and address of licensed manufacturer**
  - **Brand or product name**
  - **N-P-K grade**
  - **Guaranteed analysis**
  - **Net weight**
  - **Any statements/disclaimers required by rule**

Soil or Plant Additive Labeling Requirements

- **Similar to fertilizer labeling except:**
  - **Specific purpose for which product is claimed to be effective.**
  - **Complete and acceptable directions and application rates.**
- **This rule clarifies current labeling requirements.**

Special Provisions

- **Foliar fertilizers**
- **Phosphite or phosphorous acid**
- **Soil or Plant Additive’s containing humic substances**

Content Deficiencies

- **An “official test” fertilizer is mislabeled if:**
  - **Contains less than 90% of guarantee or 2 percentage points (whichever is less)**
  - **The economic value of NPK is less than 98% of the amounts guaranteed**
  - **Non NPK are specified in the rule**
  - **Soil or Plant Additive mislabeled if it contains less than 98% of labeled active ingredient**

Toxic Substances

- **No Product may contain:**
  - **Toxic concentrations of *metals* as specified in rule**
  - **A substance that is toxic or injurious to plants, animals or humans when the fertilizer or soil or plant additive is handled or applied under reasonably foreseeable use conditions, unless the substance and its hazards are identified on the product label.**

Enforcement Actions

- **Warning Letters/Notices**
- **Stop Sales/Holding Orders**
- **Special Orders**
- **Injunctions**
- **Forfeitures/Fines**
- **License Suspension/License Revocation**

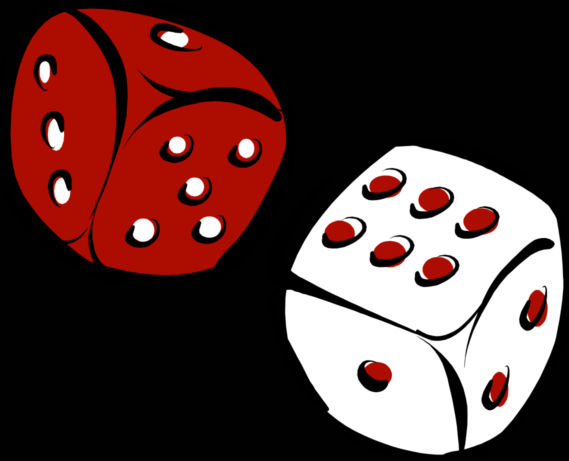
Welcome
to the

WeedSOFT CASINO

Chris Boerboom
Extension Weed Scientist
University of Wisconsin

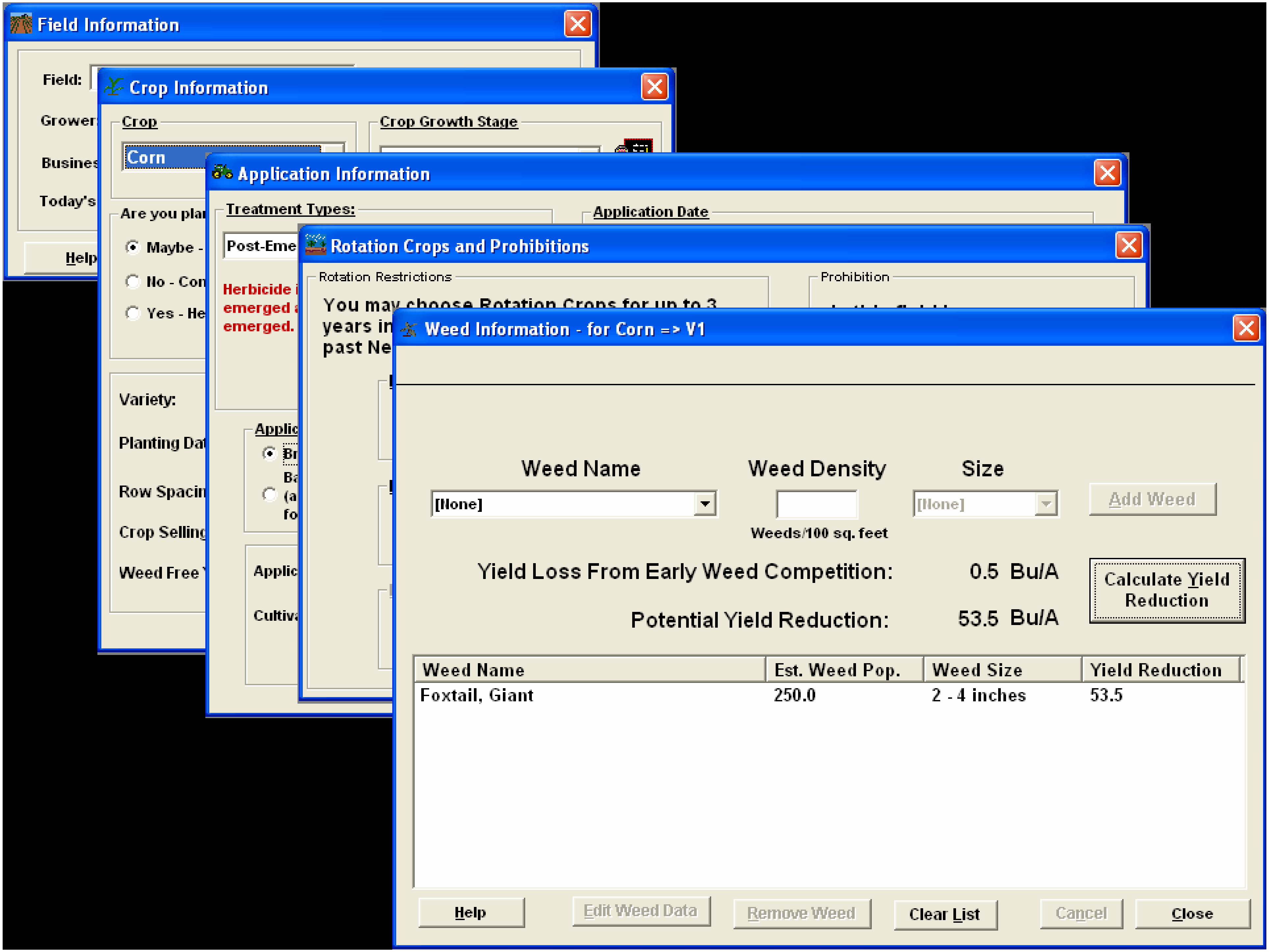
WeedSOFT

Remove the “Gamble” from weed management



WeedSOFT Casino

- Weed competition
  - Weed densities, size, species – yield loss
  - Early season yield loss
  - Treatment thresholds
- Product filters
  - Rotational restrictions, atrazine restrictions, ground water restrictions, crop growth stages
- Economic returns
  - Herbicide efficacy and costs
  - Net VALUE


Field Information
Field:
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Corn
Crop Growth Stage
Are you plan
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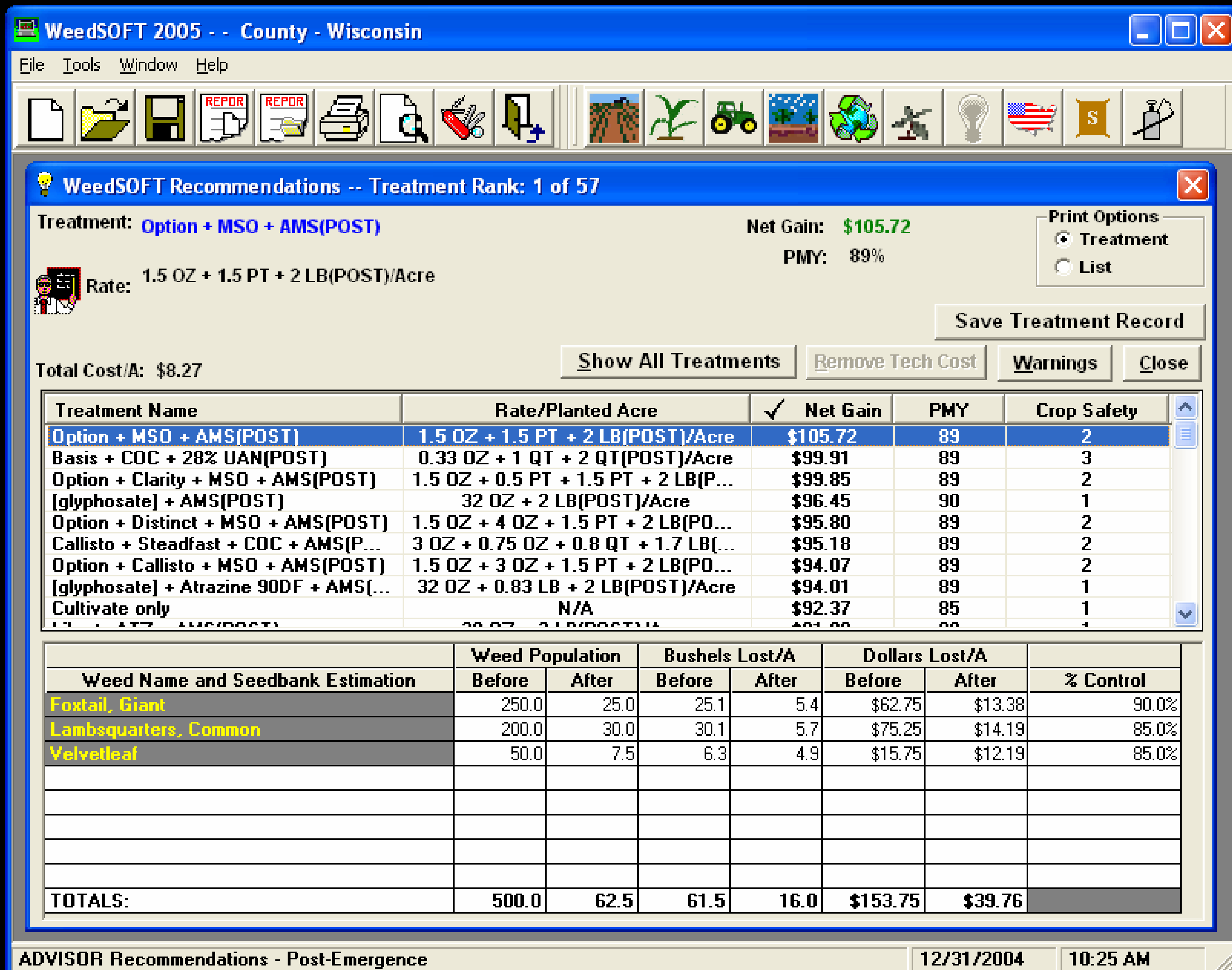
Planting Dat
Row Spacin
Crop Selling
Weed Free
Application Information
Treatment Types:
Post-Eme
Application Date
Herbicide
emerged
emerged.
Applic
Applic
Cultiva
Rotation Crops and Prohibitions
Rotation Restrictions
Prohibition
You may choose Rotation Crops for up to 3
years in
past Ne
Weed Information - for Corn => V1
Weed Name
Weed Density
Size
[None]
[None]
Add Weed
Weeds/100 sq. feet
Yield Loss From Early Weed Competition:
0.5 Bu/A
Calculate Yield Reduction
Potential Yield Reduction:
53.5 Bu/A
Weed Name
Est. Weed Pop.
Weed Size
Yield Reduction
Foxtail, Giant
250.0
2 - 4 inches
53.5
Help
Edit Weed Data
Remove Weed
Clear List
Cancel
Close



Treatment Name	Rate/Planted Acre	✓ Net Gain	PMY	Crop Safety
Option + MSO + AMS(POST)	1.5 OZ + 1.5 PT + 2 LB(POST)/Acre	$105.72	89	2
Basis + COC + 28% UAN(POST)	0.33 OZ + 1 QT + 2 QT(POST)/Acre	$99.91	89	3
Option + Clarity + MSO + AMS(POST)	1.5 OZ + 0.5 PT + 1.5 PT + 2 LB(P...	$99.85	89	2
[glyphosate] + AMS(POST)	32 OZ + 2 LB(POST)/Acre	$96.45	90	1
Option + Distinct + MSO + AMS(POST)	1.5 OZ + 4 OZ + 1.5 PT + 2 LB(PO...	$95.80	89	2
Callisto + Steadfast + COC + AMS(P...	3 OZ + 0.75 OZ + 0.8 QT + 1.7 LB(...	$95.18	89	2
Option + Callisto + MSO + AMS(POST)	1.5 OZ + 3 OZ + 1.5 PT + 2 LB(PO...	$94.07	89	2
[glyphosate] + Atrazine 90DF + AMS(...	32 OZ + 0.83 LB + 2 LB(POST)/Acre	$94.01	89	1
Cultivate only	N/A	$92.37	85	1

Weed Name and Seedbank Estimation	Weed Population		Bushels Lost/A		Dollars Lost/A		% Control
	Before	After	Before	After	Before	After	
Foxtail, Giant	250.0	25.0	25.1	5.4	$62.75	$13.38	90.0%
Lambsquarters, Common	200.0	30.0	30.1	5.7	$75.25	$14.19	85.0%
Velvetleaf	50.0	7.5	6.3	4.9	$15.75	$12.19	85.0%
TOTALS:	500.0	62.5	61.5	16.0	$153.75	$39.76	

WeedSOFT Casino

Starting Bankroll: $1,000

• Ponies	$200	$________
• Black Jack	$400	$________
• Roulette	$600	$________
• Craps	$800	$________
• Slots	$1,000	$________
• Texas Hold'em	$2,000	$________

• Final Bankroll $________

Play the Ponies

Which weed has the greatest competitive ability against 12 inch corn?

	#/100 ft^2	Bu/a lost
1. Giant ragweed – 12”	5	?
2. Giant foxtail – 8”	50	
3. Crabgrass – 2”	300	
4. Lambsquarters – 4”	100	
5. Woolly cupgrass – 8”	50	

Play the Ponies

Which weed has the greatest competitive ability against 12 inch corn?

	#/100 ft^2	Bu/a lost
1. Giant ragweed – 12”	5	11
2. Giant foxtail – 8”	50	20
3. Crabgrass – 2”	300	16
4. Lambsquarters – 4”	100	31
5. Woolly cupgrass – 8”	50	12

Black Jack - Double Down

2 grasses vs 1 broadleaf – Who's Worse?

	#/100 ft^2	Bu/a lost
1. Giant foxtail – 8"	50	
+	+	
Crabgrass – 2"	300	?
2. Lambsquarters – 4"	100	?

Black Jack - Double Down

2 grasses vs 1 broadleaf – Who's Worse?

	$\#/100\ ft^2$	Bu/a lost
1. Giant foxtail – 8"	50	
+	+	
Crabgrass – 2"	300	30
2. Lambsquarters – 4"	100	31

Herbicide Roulette

Best return for postemergence lambsquarters control in corn – Pick the winner!

	Cost/a	Gain/a
1. Liberty 28 oz/a	$24	?
2. Atrazine 0.8 lb/a	$8	
3. Accent 0.67 oz/a	$29	
4. Cultivate	$5	
5. Callisto 3 oz/a	$20	

Herbicide Roulette

Best return for postemergence lambsquarters control in corn – Pick the winner!

	Cost/a	Gain/a
1. Liberty 28 oz/a	$24	$51
2. Atrazine 0.8 lb/a	$8	$70
3. Accent 0.67 oz/a	$29	$-7
4. Cultivate	$5	$63
5. Callisto 3 oz/a	$20	$58

CRAPS   Pick the winner!

Lambsquarters and foxtail control; coarse soil, 1% OM, 10 ft to groundwater,

7.5 pH, alfalfa next year

	Cost/a	Gain/a
1. Lumax	$33	?
2. Bicep Lite II Mag	$20	
3. Harness + Hornet	$35	
4. Prowl	$10	
5. Prowl + Atrazine	$13	

CRAPS Pick the winner!

Lambsquarters and foxtail control; coarse soil, 1% OM, 10 ft to groundwater,

7.5 pH, alfalfa next year

	Cost/a	Gain/a
1. Lumax	$33	
2. Bicep Lite II Mag	$20	
3. Harness + Hornet	$35	
4. Prowl	$10	$98
5. Prowl + Atrazine	$13	

Slots

4” Lambsquarters in 12” corn; $20/a Callisto

Lowest density that exceeds the economic threshold?

	#/100 ft^2	Gain/a
1.	100	?
2.	50	
3.	20	
4.	10	
5.	5	

Slots

4” Lambsquarters in 12” corn; $20/a Callisto

Lowest density that exceeds the economic threshold?

	#/100 ft^2	Gain/a
1.	100	$58
2.	50	$27
3.	20	$2
4.	10	$-9
5.	5	$-14

Texas Hold'em

- How long can you bluff before you lose your shirt to early season weed competition; yield that cannot be regained?

Texas Hold'em

- Which case has the max loss from early season lambsquarters if sprayed now and controlled for the rest of the season?
  - 50 bu/a soybean at $5/bu; 200 bu/a corn at $2.50

	LQ	#/100 ft^2	$/a loss
1. V2 soybean	3"	300	?
2. R1 soybean	8"	100	
3. V2 corn	3"	600	
4. V4 corn	6"	300	
5. V6 corn	8"	50	

Texas Hold'em

- Which case has the max loss from early season lambsquarters if sprayed now and controlled for the rest of the season?
  - 50 bu/a soybean at $5/bu; 200 bu/a corn at $2.50

	LQ	#/100 ft^2	$/a loss
1. V2 soybean	3"	300	$2
2. R1 soybean	8"	100	$13
3. V2 corn	3"	600	$6
4. V4 corn	6"	300	$15
5. V6 corn	8"	50	$8

Final Jeopardy – Speed Round

Tank mix calculator –

80 acres to be sprayed

400 gallon sprayer

calibrated at 20 gal/a

Clarity applied at 0.5 pt/a

How many pints to add to each spray tank?

Final Jeopardy – Speed Round

Tank mix calculator –

80 acres to be sprayed

400 gallon sprayer

calibrated at 20 gal/a

Clarity applied at 0.5 pt/a

How many pints to add to each spray tank? 10 pints

WeedSOFT Casino

Starting Bankroll: $1,000

• Ponies	$200	$ 1,200
• Black Jack	$400	$ 1,600
• Roulette	$600	$ 2,200
• Craps	$800	$ 3,000
• Slots	$1,000	$ 4,000
• Texas Hold'em	$2,000	$ 6,000
• Final Bankroll		$ 6,000

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GIANT RAGWEED RESPONSE TO TILLAGE AND MANAGEMENT

Mark R. Jeschke and David E. Stoltenberg[1]

Introduction

Giant ragweed is a challenging weed species to manage in many cropping systems due to its extended period of emergence, rapid growth rate, and high degree of competitiveness with crop species. Giant ragweed has become increasingly prevalent in glyphosate-resistant cropping systems, possibly due to later-emerging plants which avoid exposure to glyphosate. A study conducted in the late 1960's found that nearly all giant ragweed emerged before May 1 in central Illinois (Stoller and Wax 1973). This early emergence suggested that giant ragweed populations could be effectively managed by preplant tillage or other preplant weed management practices. However, recent research has found relatively late emergence of giant ragweed, with emergence of some biotypes occurring throughout June (Hartzler et al., 2002), potentially later than the timing of post-emergence herbicide applications.

Research has been underway at the University of Wisconsin since 1998 to determine the long-term effects of crop rotation, primary tillage system, and glyphosate use intensity on weed population dynamics in glyphosate-resistant corn and soybean cropping systems (Stoltenberg 2002). Assessment of weed community composition after 6 yr indicated that giant ragweed had become the dominant weed species in several treatments and had increased in abundance in several other treatments (Jeschke and Stoltenberg 2003). The objective of this analysis was to characterize long-term giant ragweed population dynamics in glyphosate-resistant corn and soybean as affected by crop rotation, tillage system, and glyphosate-use intensity.

Methods

Research was conducted at the University of Wisconsin Arlington Agricultural Research Station from 1998 through 2004. Six weed management treatments were compared in continuous corn and a corn-soybean annual rotation, and in three primary tillage systems, moldboard plow, chisel plow, and no-tillage:

GLY:	Glyphosate applied post-emergence (POST) at 0.75 lb ae/A
GLY + GLY:	Glyphosate applied POST at 0.75 lb ae/A and late post-emergence (LPOST) at 0.75 lb ae/A
GLY + CULT:	Glyphosate applied POST at 0.75 lb ae/A plus inter-row cultivation (CULT) in corn only
GLY // NON-GLY:	Glyphosate applied POST at 0.75 lb ae/A rotated annually with a non-glyphosate herbicide program
NON-GLY:	Non-glyphosate herbicide program
NON-GLY PRE + GLY:	Non-glyphosate grass herbicide applied pre-emergence (PRE) plus glyphosate applied POST at 0.75 lb ae/A

[1] Graduate Research Assistant and Professor, Department of Agronomy, University of Wisconsin, Madison, WI 53706.

The experimental design was a randomized complete block in a split-split-block arrangement with three replications. The main plots were factorial combinations of tillage and crop rotation treatments, and the subplot factors were weed management treatments.

Soil type was Plano silt loam with pH 5.8 and 4.1% organic matter. Primary tillage was conducted during the Fall of each year. The seedbed was prepared shortly before planting with a field cultivator/straight-tooth harrow in moldboard plow and chisel plow systems. Corn and soybean were planted in 1998, 2000, 2002 and 2004, whereas corn only was planted in 1999, 2001, and 2003. Glyphosate-resistant soybean was drilled in early May at 250,000 seeds/A in rows spaced 7.5-inches apart. Glyphosate-resistant corn was planted in late April or early May at 32,000 seeds/A in rows spaced 30-inches apart. For corn, 150 lb/A N were applied pre-plant and 150 lb/A 6-24-24 was applied as starter fertilizer at planting. Corn and soybean were harvested by machine for grain yield.

Plots were maintained in the same location and received consistent treatments over the duration of the experiment. Plot size was 20-ft wide by 40-ft long. The soil weed seedbank was sampled each spring. Giant ragweed seeds were quantified from 30 soil cores taken from the upper 4 inches of the soil profile in each plot. Sixteen micro-plots (each 10 inches by 10 inches) were established within each plot for measuring weed plant density. Giant ragweed plant density was measured immediately before POST herbicide application, after LPOST herbicide applications, after crop pollination, and before crop harvest.

Results

Giant ragweed occurrence was rare in sampled areas when this experiment was established in 1998 (Figures 1 and 2). However, by 2001, giant ragweed was abundant in several treatments, with the highest plant densities measured in non-glyphosate based treatments in the chisel plow system, more so in continuous corn than corn-soybean rotation. In subsequent years, giant ragweed density increased in some glyphosate-based treatments as well, but was limited mostly to the chisel plow system. Systems with high giant ragweed plant densities showed corresponding increases in giant ragweed seedbank density (Figures 3 and 4). By 2004, average giant ragweed seedbank density in the continuous corn, chisel plow system was nearly 1000 seeds/m^2 (93 seeds/ft^2), whereas seedbank densities in all other systems were less than 250 seeds/m^2 (23 seeds/ft^2), including some weed management treatments in which giant ragweed seedbank density was near zero.

Giant ragweed plant densities were low for all weed management treatments in the corn-soybean rotation in both moldboard plow and no-tillage systems (Figure 2). Across crop rotation and tillage systems, giant ragweed densities were lowest for glyphosate applied POST/LPOST among weed management treatments. This was attributed to the high degree of efficacy of the glyphosate POST/LPOST treatment on late-emerging giant ragweed, including both plants in and between crop rows, relative to other treatments. In the chisel plow, continuous corn system, giant ragweed densities increased over the last 3 yr of the experiment in weed management treatments with a single POST application of glyphosate (Figure 1). Reduced efficacy of glyphosate on giant ragweed was not apparent (data not shown), therefore, it is likely that plants that survived in these treatments emerged following the POST application. The contrast in giant ragweed densities between the glyphosate POST treatment and glyphosate POST/LPOST treatment illustrates the importance of an extended period of effective management of this species. The rapid increase in giant ragweed densities between 1998 and 2001 in non-glyphosate based treatments was attributed to lower efficacy of herbicides included in this treatment compared to the efficacy of glyphosate in other treatments. Beginning in 2002, the non-glyphosate treatment included herbicides with greater efficacy on giant ragweed. By 2004, late-season giant ragweed density was relatively low for this treatment.

Summary

Giant ragweed established relatively rapidly, and become the dominant weed species in some crop-weed communities. Lower densities of giant ragweed in the corn-soybean rotation relative to the continuous corn system were likely due to greater early-season competition in narrow-row soybean (Burnside and Colville, 1964) than in corn. The greater apparent affinity of giant ragweed for the chisel plow system relative to moldboard plow and no-tillage systems was attributed to a greater proportion of giant ragweed seeds at optimal soil depths for germination, emergence, and early growth (Cousens and Moss, 1990). Giant ragweed emergence rates have been found to be greatest at a seed burial depth of about 1 inch, although emergence can occur from as deep as 6 inches (Abul-Fatih and Bazzaz, 1979). Emergence rates are typically very low within the upper 0.5-inch of the soil profile (Abul-Fatih and Bazzaz, 1979), where a large proportion of the weed seedbank is found in no-tillage systems (Mulugeta and Stoltenberg, 1997). In contrast, the weed seedbank tends to be concentrated near the bottom of the plow layer in moldboard plow systems, below the depth for optimal emergence. Consequently, weed management risks for giant ragweed were lowest for the moldboard plow and no-tillage systems in corn-soybean rotation.

Giant ragweed emergence over extended periods of time was likely a critical factor affecting its population dynamics and management in the chisel plow system. Late emerging plants have the potential to be competitive with crops due to their rapid growth and high photosynthetic rate (Harrison et al. 2001). The lowest giant ragweed densities over time in the chisel plow system were associated with weed management treatments that provided effective management of late-emerging plants.

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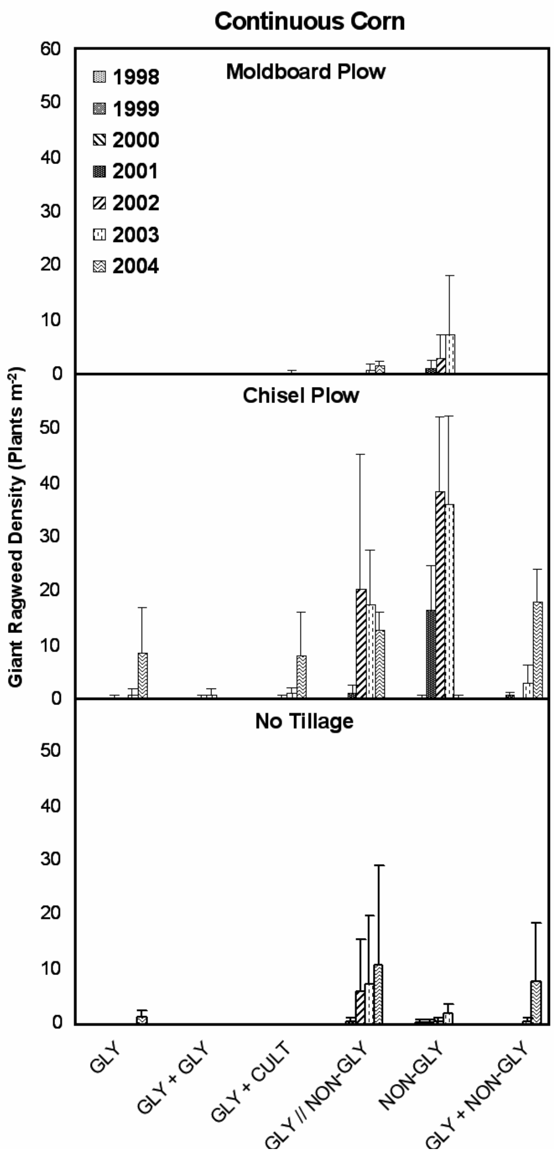

Figure 1. Late-season giant ragweed plant density in continuous corn.

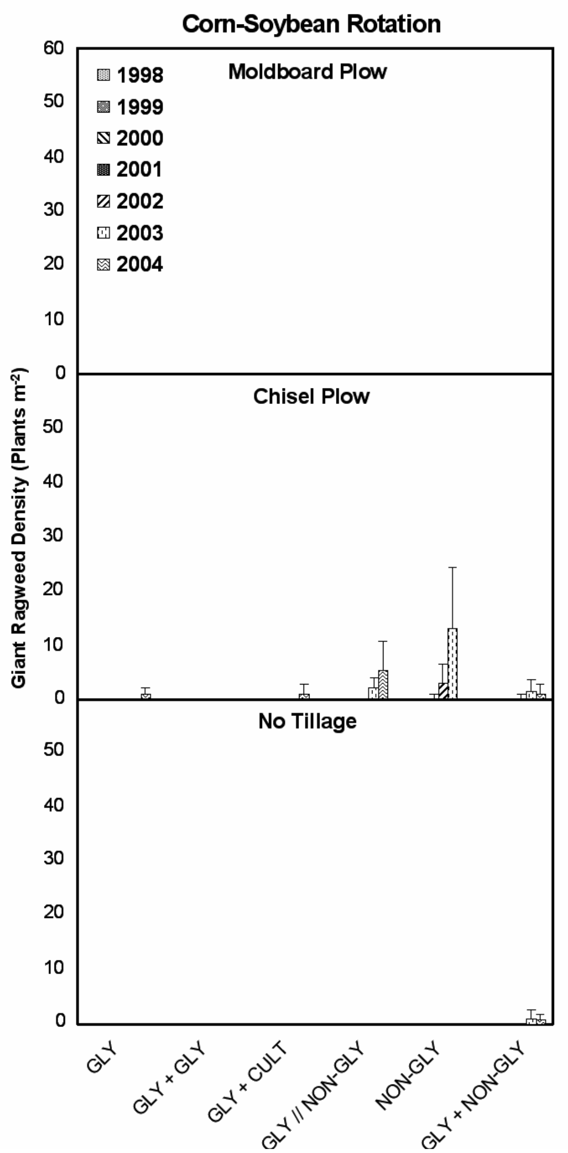

Figure 2. Late-season giant ragweed plant density in corn-soybean rotation.

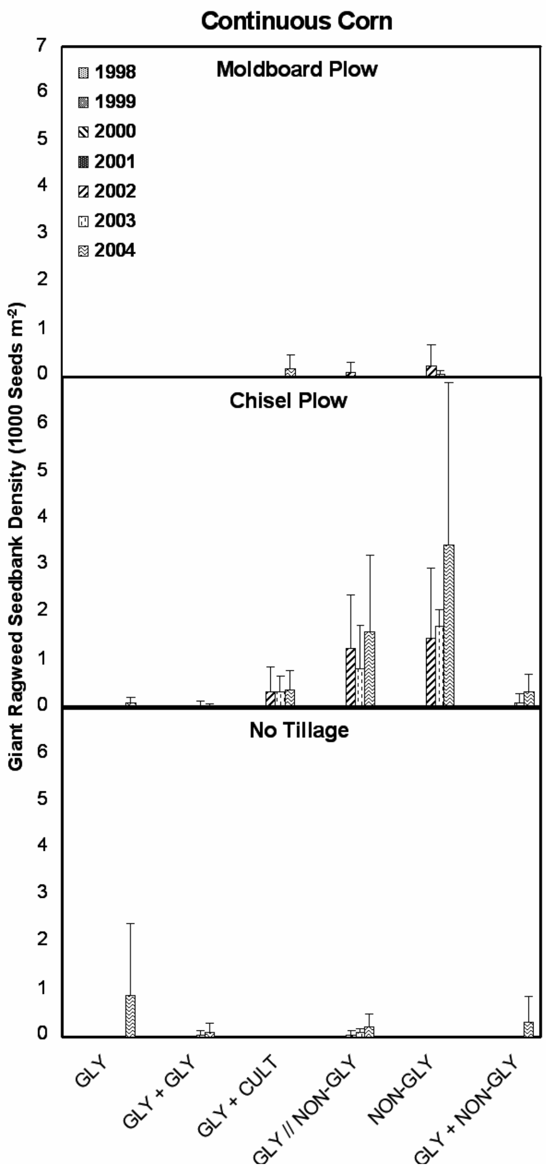

Figure 3. Giant ragweed seedbank density in continuous corn.

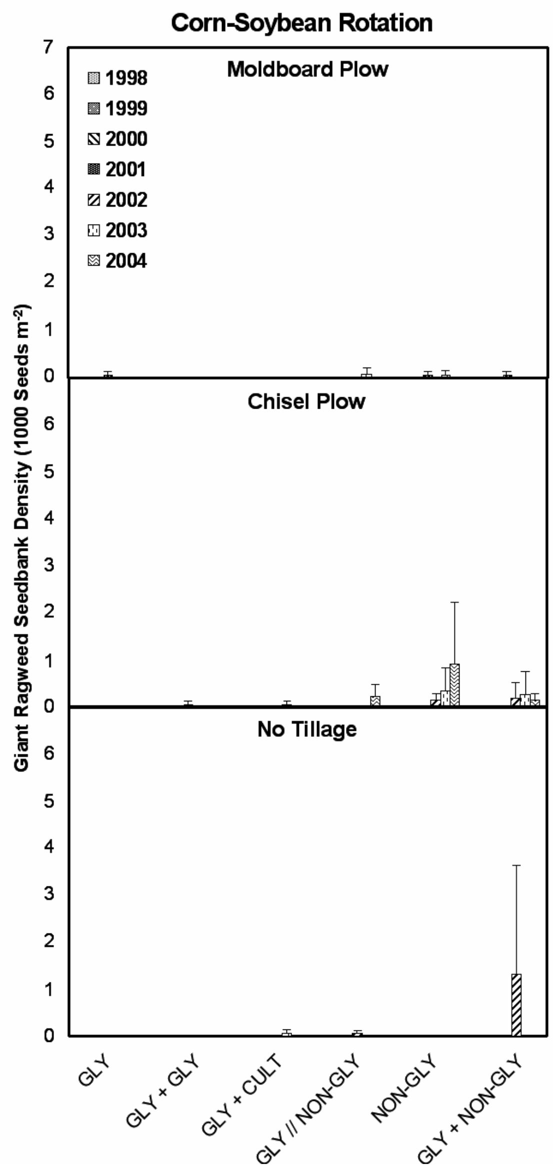

Figure 4. Giant ragweed seedbank density in corn-soybean rotation.

NEW SPRAY TECHNOLOGIES

Robert E. Wolf [1]

Several technological advancements in spray systems have occurred in recent years as the application industry searches for ways to apply crop protection products more efficiently and safely in the environment. Many of these technologies have been present for several years but adoption has been slow for different reasons. Much of the design emphasis in recent years has been to minimize drift potential. This paper will give a brief review of several of these technologies.

Drift Reducing Spray Nozzles

Several application equipment technologies for boom sprayers have been developed to assist in the minimization of spray drift. The most popular and least costly to the industry has been in the design of spray nozzles. Most all manufactures have designed new nozzles with the emphasis on improved droplet size control to enhance efficacy and minimize drift potential. Chamber- and venturi-style tips have been the most successful with this effort.

Air-Assisted Boom Sprayers

Air-assisted boom sprayers, uses a high-velocity air stream channeled along the boom to assist or shield the spray into the target. Research data will support improved deposition, but unless used in a canopied target the excess air velocity has potential to increase spray drift.

Electrostatic Sprayers

The second involves the use of system that will create and distribute electrically charged spray droplets into the target. The spray droplets are charged with an opposite polarity of the plant material and theoretically are attracted into the canopy. This is similar to the process used to spray paint new automobiles. Electrostatic spray systems are available for both ground and aerial sprayers. Electrostatic sprayers have moderate acceptance for increasing coverage in certain parts of the canopy, mostly in the upper portions. Electrostatic applications have also shown potential to increase droplet coverage on the underside of leaves. This feature is more critical when applying fungicides and insecticides rather than when applying herbicides. However, because of the need to develop fine spray droplets for the system to work effectively to achieve improved coverage potential, reducing the incidence of spray drift has not been as easily demonstrated.

Pulse Width Modulation

A third technology is available that is designed to alleviate drift problems associated with sprayers equipped with rate-controllers and capable of large spray speed fluctuations during the application process. The technology utilizing pulse width modulation (PWM) for controlling droplet size while varying application volume, speed, and pressure is available. By maintaining a constant application volume while adjusting spray pressure, operators are able to manipulate droplet size to meet changing wind and weather conditions or protect sensitive downwind areas. It is also possible to adjust application volumes without changing nozzles or adjusting pressure. This technology can also help maintain pattern uniformity when slowing in turns, for corners, and

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on hills preventing over-application at lower speeds and reducing under-application during acceleration. See additional abstract - Pulse Width Modulation to Control Spray Droplet Size for Increased Efficacy and Spray Drift Mitigation

Hoods and Shields

Spray hoods and shields have proven successful for reducing spray drift. Proper design is very critical for hoods to be beneficial. Hoods are typically designed to completely cover the boom while shields are usually placed in front or behind the boom and act strictly to shield the boom from wind. Other systems are designed to individually shield rows of sensitive crops from specific herbicides applied between the rows. Caution must still be used when highly active pesticides are used upwind of sensitive crops or around trees and gardens. Field conditions, size and added weight to modern agricultural spray systems has limited the adoption of this technology. The use of hoods or shields does not allow applicators to ignore label statements about drift. If the label states a wind speed limit, that limit must be followed.

Sensors

The use of optical sensors to actuate spray tips in combination with individual row hoods can be an effective tool in reducing spray drift. By design, the system only sprays a detected weed, and since it is not spraying all the time it is most effective for drift control because it is reducing the amount of pesticide being applied. However, in combination with improper tip selection and high pressures this technology would not be very effective.

Site-Specific Applications

Additional technologies are forthcoming that will utilize many of the above systems in combination with on-the-go site-specific application practices to help reduce drift. Sprayers utilizing prescription application maps for variable rate applications and others with sensors to identify targeted pests to apply crop protection products when and where needed are in development.

Each of the above technologies has seen limited adoption because of the additional cost added to the spray equipment. As future application guidelines regarding increased efficacy and spray drift minimization are established, more technologies will be developed and adopted. These developments will require sound research to support adoption. Additional information on each system discussed above is available by doing a basic web search. Use a key word describing the system of interest, i.e., hooded sprayers, electrostatic sprayers.

PERENNIAL WEEDS – MY OLD FRIENDS

Jerry Doll [1/]

Introduction

Perennial weeds in grain and forage crops used to be a major challenge faced by many of our producers. We know this is true because the older literature and extension bulletins highlighted the difficulty of controlling weeds like Canada thistle, quackgrass and field bindweed and many of us do not need publications to tell us this: we have lived in the era when perennial weeds were a real management challenge. Life has changed dramatically in the past 28 years and in this presentation I will cover the changes I've seen in perennial weed management. For each species presented, I will mention unique biological features, the research we have done and give the principal findings and the most effective management system. The species covered include:

Field horsetail	Yellow nutsedge
Quackgrass	Wirestem muhly
Common dandelion	Canada thistle
Hemp dogbane	Common milkweed
Wild four o'clock	Leafy spurge
Multiflora rose	Comfrey

Field Horsetail

This non-seed bearing plant is one of our oldest plants in an evolutionary sense. It is most common in poorly drained sites but is surprisingly common along roadsides and in railroad beds. Plants produce spores on the reproductive stems but in agricultural crops, the vegetative form (plants appear like a horsetail or small pine trees) predominates. Horsetail is a poor competitor except in no-till systems. With tillage to prepare a seedbed and a single row cultivation or vigorous competition from narrow row crops, horsetail seldom reduces crop yields. Where tillage is not practical, we found that a combination of primisulfuron (Beacon) at 0.75 oz/a and 2,4-D amine at 0.5 pt/a that resulted in the highest foliar burn on horsetail (75% one month after application) of all treatments tested. Beacon alone only gave 33% control and 2,4-D alone had little effect (13% control) one month later. Thus, it appears that 2,4-D has a synergistic effect with Beacon on horsetail. The level of control with Beacon plus dicamba was 50%, which was also better than that of Beacon alone (33%). Thus, it appears to take more than just Beacon to achieve a significant level of horsetail suppression. Glyphosate has essentially no effect horsetail so even in Roundup Ready crops, this is not an option. The literature indicates that MCPA is better than 2,4-D so if horsetail appears in small grains, this may be a consideration. The bottom line: horsetail is still a challenge, especially in no-till systems.

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Yellow Nutsedge

This is one of my really old friends. In fact, I worked with his very close cousin, purple nutsedge south of the border (Colombia, South America) before coming to Wisconsin. We have reigned in yellow nutsedge while purple nutsedge still wears a crown that reads, "the world's worst weed." My first long term research projects and those of my early graduate students related to yellow nutsedge. We documented that it is allelopathic and that high densities of uncontrolled nutsedge can reduce corn and soybean yields by more than 50%. The name of the game for nutsedge suppression is tuber prevention. When not controlled, we found up to 30,000,000 tubers per acre! Thankfully tubers have a relatively short half life (unlike true seeds, most tubers either sprout or die the year after they are produced) and with only two seasons of excellent control we achieved a great reduction in tuber populations.

We found no advantage to crop or herbicide rotation to reduce the tuber population; generally the best results occurred when a single row cultivation followed the use of an effective preplant incorporated or postemergence herbicide. The most active herbicide for yellow nutsedge control is halosulfuron (Permit). As with horsetail, glyphosate is relatively weak on this nutsedge. Basagran (bentazon), Classic (chlorimuron), acetochlor, metolachlor, difenamid and alachlor are also effective yellow nutsedge herbicides.

Quackgrass

This plant is much less common in cropped land today as well it should be. After 40 years of atrazine and 30 years of glyphosate use, it is surprising that we have any quackgrass left! The reason we do is primarily because quackgrass is very well adapted to forage crops and it is still found on many livestock farms. Its seriousness as a weed in these systems depends on the species of livestock, harvest system (mechanical or grazing), and the perception of the producer.

Quackgrass is vulnerable to tillage. A single year of summer fallow with repeated soil disturbance (this is how the term "quack digger" can to be used) can be as effective as glyphosate. Quackgrass is also controlled by other weeds. In a long-term study that included a non-weeded treatment for both quackgrass and annual weeds, heavy annual weed pressure for three or more years eliminated quackgrass! It's not a profitable farming system but points out the adaptability of quackgrass to survive when we give it a chance by removing competition from other weeds or tillage, as is the case in forages and pastures.

As mentioned, effective quackgrass herbicides have been available for many years. The discovery of the accase herbicides (sethoxydim, quizalofop, etc.) gave us a great in-crop management tool for soybean and alfalfa. The "fops" are more effective than the "dims) on quackgrass and in general, neither is as effective as glyphosate. And with the advent of glyphosate resistant crops, the use of other herbicides for quackgrass control on grain farms is nil. Clethodim and sethoxydim are still our best alternatives for quackgrass suppression in forage legumes.

Wirestem Muhly

Wirestem muhly is another weed native to our region. In fact, the driftless area of Illinois, Iowa and Wisconsin is where it first appeared as a weed. Its rhizomes are considerably shorter than those of quackgrass but it is a prolific seed producer. We studied the growth of wirestem alone, in soybean and in corn when the weed started either from rhizomes or from seed at both Arlington and Lancaster for two years. Competition from corn and soybeans significantly reduced wirestem muhly stem numbers and plant biomass. Soybeans reduced stem numbers 82 to 99% and corn reduced them 71 to 96% compared to the crop-free environment. Wirestem muhly biomass was reduced 78 to 97% in soybeans and 72 to 95% in corn compared to the crop-free treatment. Interestingly, in the absence of crop competition, the biomass of wirestem plants originating from seed exceeded those starting from rhizomes! Thus, we must pay attention to wirestem seedlings to ensure reinfestation does not occur following the destruction of the rhizomes.

Previously producers assumed high rates of atrazine would control wirestem because quackgrass was controlled with 3 to 4 lb ai atrazine (legal rates years ago). Wirestem is essentially immune to atrazine at almost any rate. Our first effective herbicides for wirestem muhly control in growing crops came with the arrival of the accase inhibitors (the dims and the fops) for postemergence use in soybeans. All are equally effective and are nearly equivalent to using glyphosate in Roundup Ready soybeans. In corn, foramsulfuron (Option) and nicosulfuron (Accent) alone or tank mixed with primisulfuron (Beacon) or premixed with rimsulfuron (Steadfast) suppresses wirestem muhly effectively if applied when the tallest wirestem plants are no taller than 8 inches. This is tricky because most perennials emerge over many days so plant height is variable. Wirestem is also controlled in corn by glyphosate or glufosinate (Liberty) in their respective biotech hybrids (RR or Liberty Link). A single row cultivation 10 to 14 days after herbicide application improves wirestem control with most herbicides.

Common Dandelion

I have spent many hours working on dandelions. It is probably my favorite weed, so much so that I often do not see it as a weed but rather as an old friend. Here are the primary take home messages I've learned.

In forages, common dandelion:

- has little impact on forage digestibility
- is 4 to 5% lower in protein than alfalfa at the first cutting
- is equal to alfalfa in protein content in subsequent harvest
- can add a day of drying time if the forage is handled as dry hay
- seeds germinate anytime the soil is warm and moist and they receive light
- seedlings survive winter once they have produced only 3 or 4 leaves
- is expensive to control but pre-greenup applications of hexazinone (Velpar) or metribuzin (Sencor) are effective
- will be economically controlled with fall applications of glyphosate once Roundup Ready alfalfa is available

In no-till grain production systems, common dandelion:

- is increasing in abundance in long-term no-till systems
- can cause far greater yield losses than you would expect
- is effectively controlled with fall herbicide applications based on sulfonylurea herbicide combinations that include tribenuron (Express)
- can be adequately suppressed in the spring by 2,4-D if applied when air temperatures are 60F or greater and dandelions are in the early to mid bloom stage
- control is synergized by diflufenzopyr applied with dicamba and other herbicides
- is surprisingly sensitive to glufosinate (Liberty), a contact herbicide

Dandelions are becoming more abundant in no-till systems on grain farms. The fall burndown system offers new and effective control alternatives. More assessment of the weed changes in long-term no-till systems and further fall burndown research is needed.

Hemp Dogbane

This perennial is native to North America and the fibers extracted from soaked stems were used by native Americans for clothing and rope, thus the name “hemp” dogbane. Interestingly, plants often flower in cropped land but rarely form seeds while plants in fence rows and roadsides often produce seed.

It is surprising that hemp dogbane became problematic in grain fields because it is very sensitive to 2,4-D which could have reduced its abundance when corn or wheat was in the rotation. Many producers do not like the risk of crop injury associated with 2,4-D in corn and for those who used this herbicide in fields with dogbane, my suspicion is that the application was too early to be effective. An even more active and safer herbicide choice in conventional corn is the relatively new alternative of fluroxypyr (Starane) which can also be used in winter wheat. We have no herbicides to control dogbane in conventional soybeans.

Hemp dogbane is the weed that started me down the road to the “three-step system for perennial broadleaf control in glyphosate resistant crops.” The steps are as follows:

1. Use a no-till system; this allows the weed to develop quickly and keeps the root system in tact
2. Consider applying a half rate of a soil residual herbicide with the burndown herbicide; this will control most annual weeds for 20 to 30 days and removes the risk that these would reduce crop yield while waiting to treat the perennial weed
3. Apply 0.75 lb ae/acre of glyphosate when hemp dogbane is starting to flower or is 24 inches tall, whichever occurs first. This is later than we normally apply glyphosate in glyphosate resistant crops but earlier applications are often less effective.

We have tested higher rates of glyphosate and repeated applications: neither is necessary if the above steps are followed. My observation is that in the BG days (before glyphosate), most producers targeted their perennial broadleaf weed problems in the corn phase of the rotation. Now the soybean crop is the point of perennial weed attack and I am in full agreement with this strategy because soybeans offer an earlier and more complete canopy cover which is the critical "next step" to ensure maximum kill and little if any root regeneration of the weed.

Common Milkweed

This native milky-sapped perennial has very deep roots and can also generate new plants via seed germination. It is rarely a weed of concern in cropped land where it actually serves as food for the monarch butterfly. We have had questions on controlling milkweed in pastures because the sap is potentially harmful to livestock if consumed. We used the system described for hemp dogbane in two years of research in RR soybeans and achieved excellent milkweed control. The same would be expected in RR corn. In conventional corn hybrids, halosulfuron (Permit and Yukon) and dicamba plus diflufenzopyr (Distinct) offer the best milkweed suppression.

Wild Four O'clock

This plant is also native to North America and is found mostly in sites with shallow, loose soils including roadsides. In no-till fields, the taproots of four o'clock may be 3 inches or more in diameter. Plants produce abundant seeds and these germinate readily. I used to associate this weed with no-till systems but it certainly survives a chisel plowing. Repeated mowing of alfalfa does not eliminate established wild four o'clock plants but should prevent seed production.

There are no control options for this weed in conventional soybeans but in non-biotech corn hybrids, dicamba suppresses wild four o'clock for several weeks. If the field is cultivated after the herbicide is applied (10 to 14 days later), control is improved and little if any yield loss is expected. The best solution for wild four o'clock infestations is to use the glyphosate system described for hemp dogbane.

Leafy Spurge

Leafy spurge is a long-standing legally declared noxious weed in Wisconsin. It was of little concern to most people until about 15 years ago when it began appearing in new locations. It's spread in non-disturbed sites continues, with prairies, roadsides and other right-of-way sites being the most common habitat for leafy spurge.

Control options in Wisconsin are few. The most active herbicide is picloram (Tordon) which is not widely used here due to its persistence, leachability and cost. My research at Ft. McCoy on leafy spurge has focused on how often imazapic (Plateau) is needed over a long time interval. We find that a single early fall application suppresses leafy spurge for 2 to 4 years. Control is often lost if the site is burned as is done in prairies. Several insects aid in suppressing leafy spurge and my current on this weed involves the use of insects, Plateau and mowing as single strategies and in all combinations. More time is needed to determine how these tools can best be integrated into a management program.

Multiflora Rose

I grew up with this weed in Southern Illinois as my Dad, like many other conservation-minded farmers, did what was recommended: plant multiflora rose for wildlife benefits. Now we seek ways to fix our mistake! And the task is feasible biologically but a challenge physically given the terrain where the wildlife we wanted to foster has move multiflora rose seeds which are now large plants that often form impenetrable thickets.

Several foliarly applied herbicides control multiflora rose, including metsulfuron (Ally, Escort and Cimarron), 2,4-D plus triclopyr (Crossbow) and glyphosate. All are reasonably priced and land owners are gaining back terrain from this invader. We find great interest in learning how to control this plant. Attendance at field days far exceeds expectations. Part of this if driven by the approval in several counties in southwest Wisconsin to use EQIP funds from the NRCS to control multiflora rose. Approved plans must have a long-term view and a monitoring method so will yield valuable information for others to learn from.

Mother Nature is also entering the picture regarding multiflora rose. The rose rosette disease was confirmed in Wisconsin several years ago but did not become abundant until 2004. The level and scope of infection in Richland and Crawford counties were indeed impressive. Time will tell if this “free agent” will result in dead plants but it can only help.

Canada Thistle

This is also a favorite plant of mine as we’ve spent a lot of time together! In the late 1970s, we found that the white-flowered biotype (less than 1% of the Canada thistles in the state) are more sensitive to bentazon (Basagran) than the much more common purple-flowered biotypes. Both biotypes were similar in sensitivity to dicamba and glyphosate. Clopyralid (Stinger and Transline) arrived and we had a new and very effective tool to tackle Canada thistle in crops, pastures and roadsides. We learned that the plant responds to this molecule differently as habitats differ. In cropped land, a single application can result if suppression for 3 or more years. In roadsides, a higher rate is needed and the length of suppression is perhaps 2 to 3 years. In pastures, lower rates are needed to reach economical realms and this meant we needed to apply clopyralid (or this product followed by dicamba) for consecutive years to reach low infestation levels.

I and others had observed for years that Canada thistle is often “sick” with a natural disease, *Pseudomonas syringae* pv. *tagetis* (PST) that turns many leaves on some stems creamy white. This only happens when Canada thistle is on non-disturbed sites such as roadsides, pastures and CRP fields. In the mid 1980s, we tested a freeze-dried version of PST as a possible biocontrol agent. It failed to infect in Wisconsin and several other states where it was tested and the commercial effort to have a biocontrol for Canada thistle ended.

But Mother nature kept showing us the disease and this lead to a research project my last graduate student explored: trying to use infected Canada thistle plants as the source of PST to biologically control (or at least infect) healthy Canada thistles. We were able to achieve or increase the level of infection but could not reach the levels needed to expect a reduction in thistle severity.

We learned that rainfall is a key factor is inducing the infection and that was driven home in 2004 when the levels of infection reached impressive levels with no input from anyone. If similar levels of infection occur in subsequent years, Canada thistle densities may decline. Several locations that had infected thistles in previous years were found to be nearly thistle free in 2004. So perhaps nature will do what the Noxious Weed Law has not.

Comfrey

I have saved the most interesting perennial weed for the last. It is interesting because we planted it in our gardens (for medicinal uses) and fields (as a forage), because it has little ability to spread on its own, because it is not affected by most herbicides, and because I said I might not retire until I found a way to control it! Initially it appeared that I would not retire for a while, if ever. But the "3-step" method proved effective even with comfrey. Here's some of what you need to know about comfrey:

- it flowers abundantly but rarely produces seed
- the root is:
  - the source of reinfestation and spread (if we move them)
  - a deep, branched taproot, usually with a brownish surface but may also be black
  - able to produce new plants from segments as small as 0.25 inch in length

- new plants emerge early and continue appearing throughout the summer
- plowing, especially mold board plowing, ensures prolonged emergence
- plants are very shade tolerant

Comfrey is not controlled by 2,4-D, paraquat, dicamba alone, clopyralid (Stinger), sulfonylureas and imidazolinones used in corn. Dicamba plus diflufenzopyr (Distinct) applied in split applications in corn and some of the sulfonylureas used in soybeans suppress comfrey but without a doubt, glyphosate is the most active herbicide for this plant. Plant a RR crop in a no-till system and apply 0.75 lb ae/acre when comfrey begins to flower or when it is 24 inches tall; this will reduce the infestation significantly in a single year. Consecutive-year use of this system will approach eradication.

The seldom used practice of preharvest applications of glyphosate approached eradication with a single treatment in both corn and soybeans. This would be the best approach in fields with comfrey that have been tilled as the preharvest application would kill plants that emerged after the in-crop herbicide application.

Summary

There you have it. Twenty-eight years of Wisconsin experiences with perennial weeds boiled down to seven pages of "take home messages!" The rest of the story on these friends has been told over the years at this event. Check past proceedings for more information on almost all of these weeds.

Are there challenges left? Of course. Weeds that need further attention on cropped land include curly dock, white cockle and giant chickweed. In pastures, edges of wood lots and other areas, woody species like buckthorn, prickly ash and autumn and Russian olive. And we need to see what else Mother nature brings our way for this will certainly happen. With giant hogweed encroaching from the north, Turkish warty cabbage from the south and devil's claw from the west, weed scientists will not have to look far or hard to find plants that need their attention. So while I may soon be moving on, "my old friends" will remain and new ones may join them. Hope you enjoy being with them as much as I have.

MAPPING THE CORN ROOTWORM VARIANT

The Southeast Wisconsin Variant Trapping Network[1]

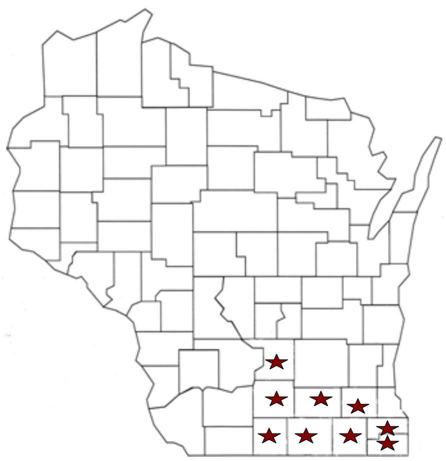

Figure 1 Area of Wisconsin currently monitored by the SE Wisconsin Variant WCR Trapping Network

The 'eastern variant' of the western corn rootworm (WCR), *Diabrotica virgifera virgifera*, has developed a behavioral adaptation to the corn-soybean rotation in some areas of the Midwest. The variant western corn rootworm (VWCR), first documented in east-central Illinois, is known to circumvent the corn-soybean crop rotation by laying eggs in soybean. Like normal corn rootworm beetle populations, the VWCR moves readily between corn and other crops between late July and early September. Unlike normal corn rootworm beetle populations however, the VWCR can lay heavy populations of eggs in soybean fields, resulting in economic injury to corn planted in the same field the following year.

Beginning in 2003, efforts of UWEX County Agricultural Agents, Extension Specialists, and corn-soybean producers from Racine, Kenosha, Rock, Walworth, Green, Waukesha, Jefferson, Dane and Columbia counties, coalesced to form the *Southeast Wisconsin Variant Western Corn Rootworm Trapping Network.*

<u>Project Goals</u>

- Monitor and delimit range expansion of the VWCR in southeast and southern Wisconsin and communicate findings to Wisconsin corn and soybean producers.

- Inspect root condition in first-year corn fields for western corn rootworm (WCR) larval feeding (or lack thereof) to confirm that beetle activity in the previous years soybean is the behavioral adaptation (that it is the variant).

- Assess WCR beetle activity in soybeans during August to determine whether threshold levels are met which indicate egg-laying is taking place in soybean that will cause economic injury to first year corn the following year.

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[1] Eileen Cullen, UW-Entomology and UWEX Field Crops Entomologist; David Fischer, Dane County UWEX; Matt Hanson, Dodge County UWEX; Bryan Jensen, UW IPM Program; Peg Reedy, Walworth County UWEX; Kevin Shelley, UW NPM Program; Jim Stute, Rock County UWEX and Karen Talarczyk, UW NPM Program.

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Background

In addition to our recent confirmation of VWCR activity in extreme southeast Wisconsin, the adapted WCR behavior (sometimes referred to as 'rotation-resistant') has previously been documented in eastern Illinois, northwestern Indiana, southern Michigan, and western Ohio. The scouting method that we have been using to monitor emergence of this variant WCR behavior in Wisconsin was developed by field crop research and extension entomologists at the University of Illinois at Urbana-Champaign. This is near where the problem was first observed in the 90s, thus the reference to 'eastern variant' of the western corn rootworm. An excellent website summarizing U of I scouting protocol and management recommendations for the VWCR can be accessed at: http://www.ipm.uiuc.edu/fieldcrops/insects/western_corn_rootworm/index.html.

Currently, we are monitoring nine counties (Figure 1) in southeastern-southern Wisconsin. The problem, presenting as economic larval root pruning injury in first year corn fields, has to date not been reported from counties outside of the southeastern portion of the state. Crop rotation continues to be a highly effective cultural control for managing corn rootworm in the majority of Wisconsin. Furthermore, all nine counties in the trapping network are not affected. Results from 2004 are presented below.

Scouting Methods

Pherocon AM yellow sticky traps, available from Gempler's [www.gemplers.com or 1-800-382-8473] and Great Lakes IPM [www.greatlakesipm.com or 1-989-268-5693], are used to monitor beetle abundance in soybean. Much like the corn rootworm scouting protocol in continuous corn, adult beetle numbers are assessed each year during August after rootworm beetles have emerged from the soil, and are in the process of feeding, mating and ovipositing the eggs which will overwinter in the soil. Trapping WCR beetles (Figure 3) in August will tell you if they are present in a soybean field and if so at what level. Next year's corn rootworm treatment decision will be based on this year's beetle count.

In the SE Wisconsin network, we employed the U of I scouting protocol. The traps (Figure 2), mounted on stakes just above the soybean canopy level, capture and hold beetles with a sticky glue coating. Twelve traps are placed in each field during the last week of July in a grid pattern, evenly spaced throughout the field and avoiding field edges. Beginning the first week in August, western corn rootworm beetles are counted, data recorded, and traps replaced every 7 to 10 days. This process is repeated into the first week of September.

For each field scouted, the following equation is used to calculate average WCR densities in the soybean field for the trapping period:

Total WCR beetles (male and female) caught / # traps / # days the field was monitored

Example:

- 1680 western corn rootworm beetles trapped
- Trapping Period was Aug. 8 to Sept. 6 (28 days)
- 12 traps/field

[1680 (number of beetles)/12 (traps)] /28 (days) = ***5 beetles/trap/day***

Figure 2. Pherocon AM yellow sticky trap used to monitor Variant WCR in soybean.

Figure 3. Western corn rootworm
Photo by Kathryn Thomas, UW Madison

Based on the U of I research referenced above, beetle numbers within the range of 0 to 4 Beetles/Trap/Day (B/T/D) over the entire 4-week trapping interval in soybean, resulted in no visible corn rootworm larval feeding, minor root scarring, to some root feeding, but not pruned to within 1.5 inches of the plant in first-year corn the following year. A B/T/D for the entire soybean trapping interval of 5 B/T/D did result in several roots pruned to within 1.5 inches of the plant the following year, but never an entire node. The latter represents a root damage score of economic significance and certainly higher than you'd expect in a first-year corn field under normal conditions. Trap numbers above the 5 B/T/D reference threshold sustained even greater root damage (more than one entire node pruned).

The Affected Area in Wisconsin

The map in Figure 4 illustrates results of our 39 soybean fields monitored in the 2004 network. Fields were located over nine counties, with greater sample sizes (more fields) in extreme southeast WI. In 2003, soybean field scouting indicated that VWCR was limited to Kenosha, Racine and southern Walworth counties. By 2004, VWCR detection shifted westward into eastern Rock County, as well as northward within Walworth County. This shift is depicted in Figure 5.

Table 1 presents corn root node-injury ratings in first-year corn from the network counties in 2004 using the Iowa State University 0 to 3 scale. Node-Injury root rating values on the 0 to 3 scale have been explained in previous conference proceedings (Jensen, 2003). Node-injury mean scores were highest in Rock, Kenosha and Walworth counties in 2004. Our sample size is admittedly small (e.g. 3 fields in Kenosha County) in some counties. However, 2004 network soybean fields which reached or exceeded 5 B/T/D occurred in eastern Rock and Walworth counties as well. As in 2003, we did not detect first year corn damage or threshold B/T/D in soybeans in Dane, Columbia, Green, Jefferson, or Waukesha counties.

Is the Variant WCR a Concern for You?

At this time, based on our network results the VWCR has been positively documented in Walworth and Eastern Rock counties. It is important to note that in 2003, soybean fields in Racine and Kenosha met or exceeded the 5 B/T/D threshold. However, 2004 soybean trapping results in our small Racine/Kenosha sample size were below threshold. Based on these variable trapping results, and our 2004 root evaluations in Kenosha County, we still consider Racine and Kenosha to be within the affected area.

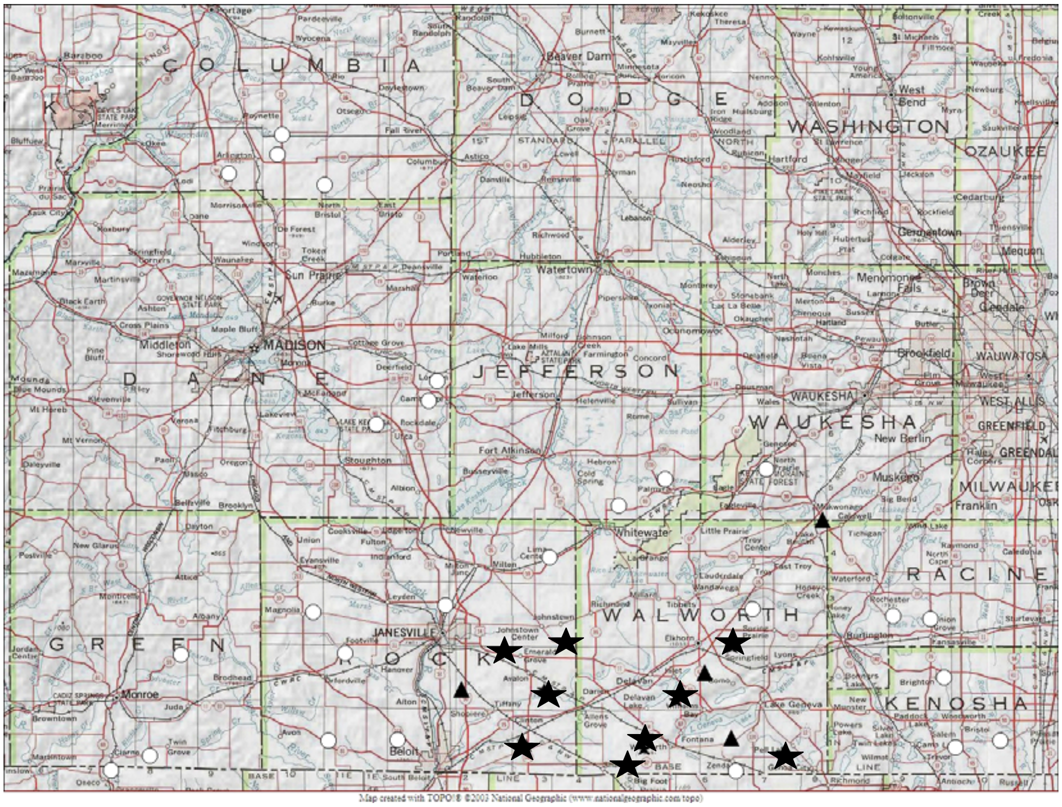

Figure 4. Western corn rootworm beetle abundance in 39 fields trapped for 4-5 weeks during August-September, 2004. Open white circles below threshold [0.00 to 3.50 B/T/D]; Solid triangles sub-threshold [3.51 to 4.99 B/T/D]; Solid stars above threshold [5.00 or more B/T/D].

Table 1. Node-injury results in first year corn fields, 2004.

County	No. of Fields	Node-injury County Average (1)	% of Roots Rating 0.50 to 0.75	Node-Injury Range
Dane	5	0.00	0	0.00 - 0.10
Columbia	7	0.01	0	0.00 - 0.20
Green	6	0.03	0	0.00 - 0.30
Jefferson	3	0.03	0	0.00 - 0.20
Racine	2	0.04	0	0.00 - 0.40
Waukesha	1	0.00	0	0.00 - 0.00
Kenosha	3	0.15	13	0.00 - 1.25
Rock	10	0.12	8	0.00 - 1.30
Walworth	11	0.52	20	0.00 - 3.00

(1) Uses Iowa State University 0 to 3 rating scale.

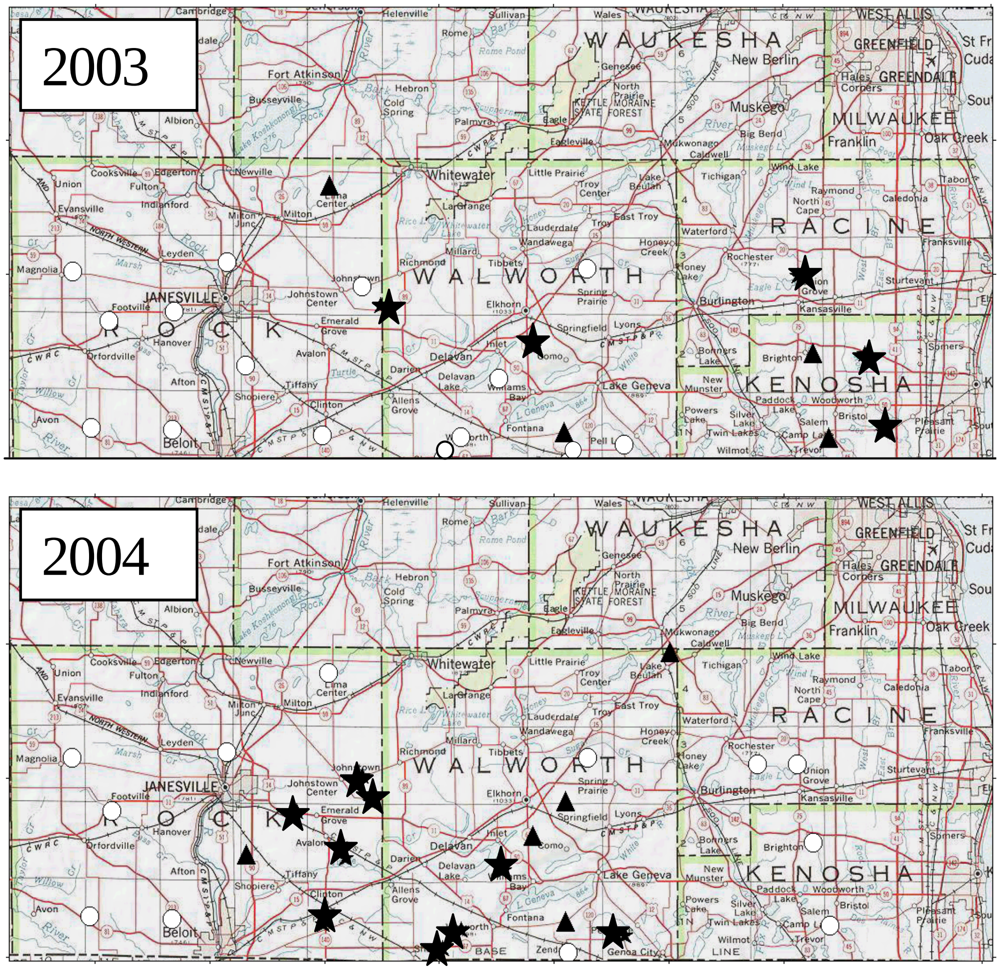

Figure 5. Change in western corn rootworm beetle abundance between 2003 and 2004 in the affected area. <u>Open white circles</u> below threshold [0.00 to 3.50 B/T/D]; <u>Solid triangles</u> sub-threshold [3.51 to 4.99 B/T/D]; <u>Solid stars</u> above threshold [5.00 or more B/T/D].

In affected areas (Table 1 and Figure 4), producers and consultants can take steps to minimize the risk of first-year corn damage by western corn rootworm. It is important to scout for WCR beetles in soybean fields to determine whether beetles are present in sufficient (threshold) numbers to cause economic damage to corn roots the following year (indicating beetles are VWCR). Treating first-year corn fields without first establishing the need is both economically and environmentally unsound. Just as important as knowing where the VWCR has been documented in Wisconsin, is knowledge of where we have <u>not</u> yet detected it's presence (Figure 4). We will continue to monitor the situation in 2005, and respond to suspect affected areas with new field locations in the network.

Data collected thus far indicate variability of both beetle populations in soybean fields and resulting damage to first-year corn roots the following year, as indicated by the range of root injury displayed in Table 1. Monitoring WCR populations in individual fields with Pherocon AM yellow sticky traps is currently the only way to determine the potential for economic damage in first-year corn. While the map in Figure 4 provides a general idea of the affected area, it should not be used to solely base treatment decision on for an entire county. On a regional scale we are still working with a relatively small sample size (n=39 fields) of one or two fields per township. The map should, however, give you an indication of whether field scouting is something to consider going into 2005.

The cost of monitoring beetles is relatively low compared to routine treatment of first-year corn with any of the available control options. Table 2 shows the per-acre monitoring cost over a range of field sizes and compares them to routine treatment with soil-applied insecticides. The return to management (the decision to scout) is substantial and increases rapidly with field size if monitoring indicates that treatment is unwarranted. The return to management column represents the return for each hour spent monitoring soybean fields in August, whether an individual does their own monitoring or has it done by someone else. Conversely, the investment in monitoring is small should treatment be required, and could be viewed as insurance that the correct management decision is made, and inputs are not used unwisely.

Table 2. Cost and return of monitoring VWCR populations versus routine treatment.

Field Size (acres)	Monitoring Costs: Total Labor (hours)	Monitoring Costs: Labor ($/acre)	Monitoring Costs: Traps and Materials ($/acre)	Monitoring Costs: Total ($/acre)	Difference Between Routine Treatment and Scouting ($/acre)	Difference Between Routine Treatment and Scouting ($/field)	Return to Mgt. if Tmt Unnecessary ($/hour)
50	4.00	1.20	0.92	2.12	14.88	744.10	186.03
100	4.68	0.70	0.46	1.16	15.84	1583.90	338.44
150	5.36	0.54	0.31	0.84	16.16	2423.70	452.18
200	6.04	0.45	0.23	0.68	16.32	3263.40	540.30
250	6.72	0.40	0.18	0.59	16.41	4103.25	610.60
300	7.40	0.37	0.15	0.52	16.48	4943.10	667.99

Assumes: Labor, $15.00/hour; Pherocon AM sticky traps and materials (stakes and shipping), $45.89/field and routine treatment, $17.00 /acre for soil-applied insecticide

Plans for 2005

In July we will revisit the 2004 soybean fields you see on the map in Figure 4 when these fields are expected to be in corn. Some will be treated based on 2004 trapping data, others will not require treatment based on our results. In treated fields, where cooperators allow, we'll evaluate roots in an untreated strip area. In evaluating these fields for corn rootworm larval feeding injury in 2005, we will continue to validate the 5 B/T/D threshold correlation between WCR beetle abundance in soybean and subsequent first-year corn root damage in Wisconsin. We will also expand beetle trapping sites and monitored area to continue delineation of the affected area.

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Bt Corn Rootworm Corn Hybrid Damage in Illinois, 2004

Eileen Cullen[1]

Bt CRW Performance Article Highlights:

Transgenic Corn Rootworm Hybrid Stumbles in Urbana Experiment; Some Producers Also Report Severe Lodging with YieldGard Rootworm Hybrids in Commercial Fields

University of Illinois, Urbana-Champaign
Pest Management & Crop Development Bulletin
No. 22/ Sept. 2, 2004

http://www.ipm.uiuc.edu/bulletin/pastissues.php

[1] *Assistant Professor and Extension Entomologist,* University of Wisconsin, Madison, Entomology Department, 1630 Linden Drive, Madison, WI 53706.

Transgenic Corn Rootworm Hybrids
“Bt CRW Corn”

YieldGard Rootworm (YGRW) Corn [MON 863] received EPA registration February 2003.

YGRW is not a high-dose transgenic event as are Bt Corn Borer hybrids.

YGRW is a non-high dose event, thus expect corn rootworm survivorship (adult emergence) in YGRW fields.

Transgenic Corn Rootworm Hybrids
“Bt CRW Corn”

Although a non-high dose event, root protection in University trials overall has been excellent.

Adult corn rootworm beetles in YGRW fields are present due to:

1. Immigrants from other corn fields
2. Survivors from YieldGard Rootworm corn

2001 Adult Emergence Numbers from YGRW corn
(Univ. of Illinois study)

(comparable reports from other universities)

Emergence cages were placed over transgenic Bt rootworm corn and non-transgenic isoline.
(n=96 cages total in replicated, split plot design).

Adult emergence projection from MON 863-corn:
2,450 male western CRW adults per acre
25,320 female western CRW adults per acre
Overall projection: **27,770** adult western CRW emergence from 1 Acre of transgenic corn
(MON 863, Cry3Bb1).

I. 2004 CRW product efficacy trials (Univ. Illinois)

Three sites (DeKalb, Monmouth, Urbana)

Planted: (4/28, 4/27, 4/19)
Roots Rated: (7/21, 7/15, 7/10)

Heavy CRW pressure, trap-cropped fields.

Golden Harvest (H-8588 RW) YieldGard Rootworm
Golden Harvest (H-8799) Non-transgenic Isoline

Untreated Check Damage Severe:
2.0 to 3.0 nodes destroyed.

YGRW Damage: pruning observed, considerably less than 1 node destroyed.

II. Calls from Illinois Producers
Lodging observed at U of Illinois, Urbana site

Following a mid-July storm with high winds, U of I Extension received calls on severely lodged corn. Including fields with YieldGard Rootworm hybrids.

Severe lodging of the YieldGard Rootworm hybrid (Golden Harvest H-8588RW) observed at U of I, Urbana trial site.

Monsanto personnel had checked plants from U of Ill. DeKalb, Monmouth, and Urbana trial sites for expression of Cry3Bb1 protein, **Results Positive.**

III. 2004 CRW product efficacy trials (Univ. Illinois) – Revisited in August

During 1st Week of August: 40 roots (10/replicate) were taken from YieldGard Rootworm plots in the Urbana experiment.

Root ratings on Golden Harvest H-8588RW in August, 3+ weeks after original (7/10) rating average of considerably less than 1 node destroyed:

Rep A 1.43 (nearly 1-1/2 nodes destroyed)
Rep B 1.08 (1 node destroyed)
Rep C 1.64 (slightly more than 1-1/2 nodes destroyed)
Rep D 1.24 (slightly more than 1 node destroyed)

Damage significantly greater in August than in July at the U of Illinois Urbana site.

Possible Explanations

Resistance unlikely, YGRW hybrids released commercially for the first time in 2003.

1. Early planting of Urbana Experiment (4/19)
2. Development and emergence of surviving CRW from YGRW corn is known to be delayed as compared to non-transgenic corn hybrids.
3. Intense larval pressure in Urbana trial 2004

Perhaps combined factors above compromised YGRW efficacy in the Illinois example.

Further Questions

Does expression of the Cry3Bb1 protein diminish as the season progresses?

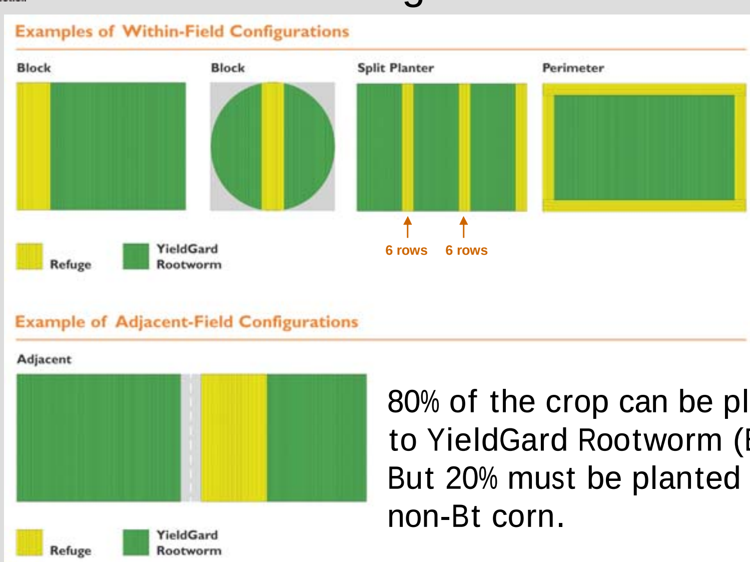
Are there differences in expression across hybrids?

Do hybrid root characteristics influence YGRW technology performance?

Steps to take if unexpected YGRW damage or suspected resistance should occur:

1. Check planting records
2. Rule out damage from nontarget insects, weather, or other environmental factors.
3. Conduct tests to verify MON 863 was planted and that the correct % of plants are expressing. (e.g. Monsanto personnel verification)
4. If expression is +, and root damage is near 0.5 (node-injury scale) on any expressing plant, Evaluate roots from **the corresponding refuge**.

YieldGard® Rootworm Refuge Configurations



80% of the crop can be planted to YieldGard Rootworm (Bt-corn) But 20% must be planted to non-Bt corn.

For complete IRM information please refer to the IRM Grower Guide for YieldGard Rootworm or you may also call 1-800-951-9511.

THE ECONOMICS OF Bt CORN IN WISCONSIN

Paul D. Mitchell [1/]

The Wisconsin DATCP has conducted annual surveys of European corn borer (ECB) populations in Wisconsin corn fields since the 1940's. Using these annual ECB population data and published research (Mitchell et al. 2002, Hurley, Mitchell and Rice 2004), the long-run average percentage yield loss due to ECB in nine Wisconsin regions (crop reporting districts) is estimated (Table 1). However, because ECB populations are uncertain, the random distribution of these yield losses is also estimated to capture the uncertainty in yield losses due to ECB. These yield losses are then combined with USDA-NASS five-year (1999-2003) average corn yields to estimate the long-run average net benefit of Bt corn in each Wisconsin region, assuming a corn price of $2.00/bu and a technology fee of $18/bag ($7.43/ac) (Table 1).

Table 1. European corn borer (ECB) population pressure, yield loss from ECB, average corn yield, average net benefit of Bt corn, and probability that this net benefit is negative for the nine Wisconsin regions and the state as a whole.

Region	Average ECB/plant	Coefficient of Variation ECB/plant	Yield Loss from ECB	5-year Average Yield (bu/ac)	Average Bt Corn Net Benefit ($/ac)*	Probability Negative Net Benefit
NW	0.31	1.20	4.04%	123.8	2.06	57.6%
NC	0.17	1.05	3.46%	119.2	0.66	64.1%
NE	0.25	1.14	3.83%	125.6	1.76	59.1%
WC	0.60	1.48	4.75%	132.8	4.15	50.0%
CN	0.58	1.52	4.69%	125.0	3.44	52.4%
EC	0.29	0.97	4.09%	135.4	2.92	54.0%
SW	0.79	1.30	5.21%	141.8	5.86	44.2%
SC	0.70	1.31	5.04%	139.2	5.27	45.9%
SE	0.68	1.82	4.75%	123.4	3.44	52.7%
State	0.49	0.87	4.80%	133.2	4.28	48.4%

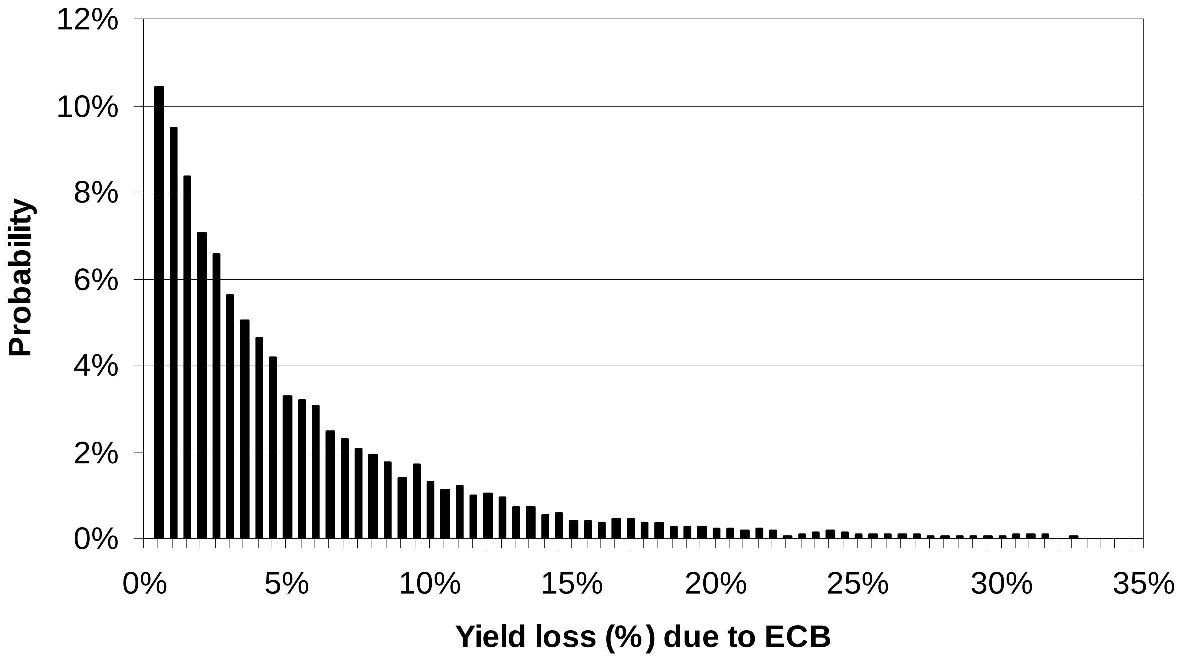
* Assuming $7.43/ac Bt corn technology fee, 20% conventional corn planted as refuge, and a corn price of $2.00/bu.

[1/] Agricultural and Applied Economics, University of Wisconsin-Madison.

Results indicate that Bt corn on average yields a positive net benefit (value of the yield gain exceeds the cost of Bt corn) for Wisconsin farmers. However, the distribution of yield losses is highly skewed towards low losses (Figure 1). As a result, farmers in most years should expect Bt corn to generate a net loss (cost exceeding the yield benefit), but in years that it does generate a net benefit, the benefits can be quite large, so that on average Bt corn generates a positive net benefit.

The presentation will focus on providing an intuitive understanding of what the results imply for the performance of Bt corn in Wisconsin, as well as explain what the analysis does not include (e.g., yield loss due to lodging).

Figure 1. Distribution of yield loss due to European corn borer in South Central Wisconsin.



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Mitchell, P.D., T.M. Hurley, B.A. Babcock, and R.L. Hellmich. 2002. Ensuring the stewardship of Bt corn: The carrot versus the stick. J. Agric. Resour. Econ. 27:390-405.

DATCP'S 2004 INSECT SURVEY RESULTS AND OUTLOOK FOR 2005

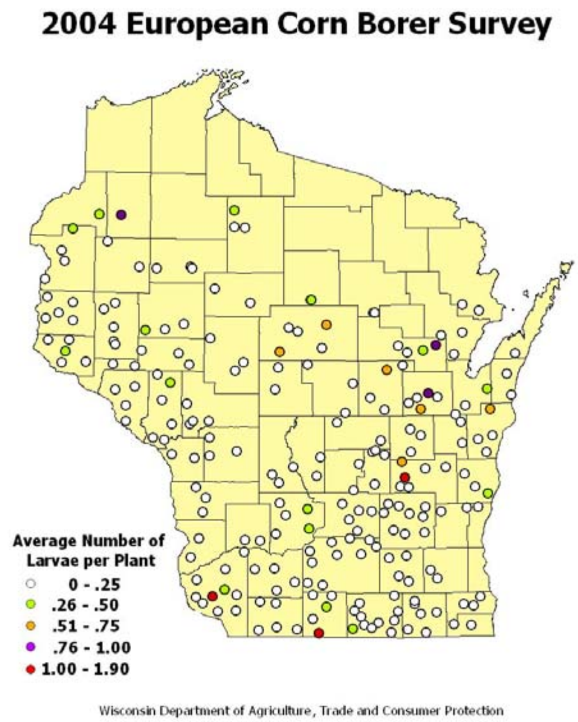
Krista L. Lambrecht[1/]

A few key variables merged to make 2004 an exceptionally quiet year for many of Wisconsin's leading field crop pests. Chilly spring temperatures and an unprecedented statewide average rainfall of 7.64 inches in May made it difficult for potential insect populations to fully develop. Migratory species, like the black cutworm and potato leafhopper, arrived to find the wettest spring in more than 100 years. Below-normal temperatures continued to slow crop development while the surplus of precipitation left fields saturated through June. Together these factors drastically reduced insect populations. As a result, European corn borers were practically nonexistent this fall and soybean aphid densities were at their lowest levels since being detected in Wisconsin in 2000. Following are the results of DATCP's insect surveys from 2004, a summary of last summer's pest insect trends, and an outlook for pest conditions in 2005.

EUROPEAN CORN BORER

2004 Survey Results

Wisconsin's 2004 fall European corn borer survey documented the lowest overwintering population of corn borers since 1998, and the third lowest in 50 years. Survey results continue to show a pattern of very low overwintering densities of this insect pest. In 2004, the statewide average percentage of plants infested by corn borers was 12%, while the statewide average number of corn borers was 0.10 per plant. The 2004 statewide average is substantially lower than both the 10-year average of 0.49 borer per plant and the 50-year average of 0.48 borer per plant. Population declines were found in all but the north central district, where only a very minor increase from 0.14 borer per plant in 2003 to 0.20 in 2004 was recorded. The biggest declines occurred in the south central (0.52 to 0.05 borer/plant), southwest (0.35 to 0.10 borer/plant) and central districts (0.44 to 0.06 borer/plant). The 2004 fall survey included 222 grain corn fields throughout the state.



Why was the 2004 fall population of corn borers so low? First, the overwintered population of larvae from 2003-2004 was very low. The 2003 survey documented a statewide average of 0.30 borer per plant, suggesting that the first flight of moths in 2004 would be light. Next, when moths of the first flight began to appear in black light traps around June 4, intense and persistent periods of rainfall combined with overall cool temperatures suppressed flight activity and increased mortality rates of tiny, newly-emerged larvae. In addition, when moths of the second flight were active in late July and August, evening temperatures were unseasonably cool; little corn borer activity occurs when temperatures dip below 60ºF. Below-normal temperatures severely limited mating and egg laying activity of the first and second flights of corn borer moths.

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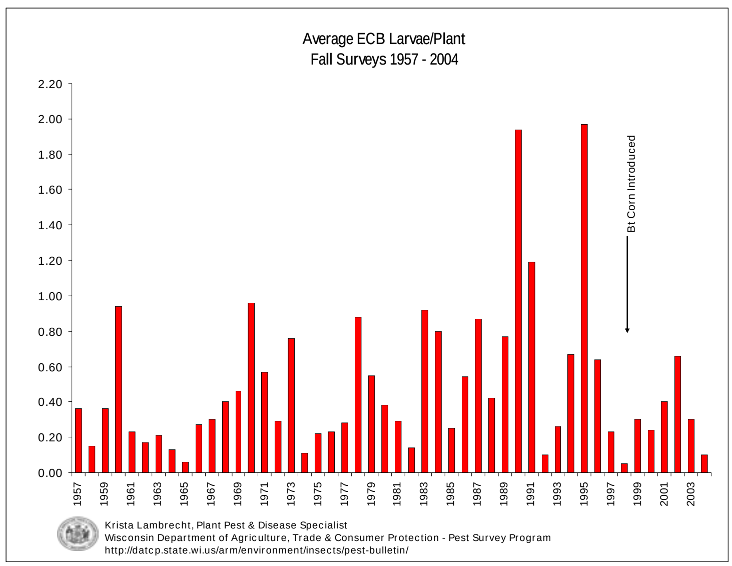
In summary, harsh weather conditions impacted corn borers during critical stages of development, and were the principal cause of the decline in corn borer abundance in 2004. The 2004 statewide average of 0.10 corn borer per plant represents a very low fall population, as well as a very low infestation of corn borers that Wisconsin producers had to manage last season.

District	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	10 Yr Ave
NW	0.10	0.32	0.03	0.02	0.15	0.24	0.33	0.44	0.20	0.13	0.20
NC	0.17	0.41	0.26	0.01	0.03	0.04	0.05	0.26	0.14	0.20	0.16
NE	0.53	0.47	0.18	0.01	0.18	0.03	0.07	0.75	0.23	0.22	0.27
WC	1.21	0.80	0.15	0.02	0.30	0.31	0.67	0.71	0.16	0.05	0.44
C	1.23	1.02	0.09	0.02	0.30	0.41	0.48	1.21	0.44	0.06	0.53
EC	2.49	0.65	0.26	0.03	0.25	0.19	0.33	0.44	0.22	0.22	0.51
SW	6.31	0.51	0.39	0.17	0.57	0.39	0.87	0.65	0.35	0.10	1.03
SC	2.65	0.83	0.35	0.10	0.61	0.33	0.48	0.86	0.52	0.05	0.68
SE	3.08	0.79	0.35	0.10	0.31	0.16	0.36	0.61	0.17	0.02	0.60
State Ave	**1.97**	**0.64**	**0.23**	**0.05**	**0.30**	**0.24**	**0.40**	**0.66**	**0.30**	**0.10**	**0.49**

Figure 2. European corn borer fall survey summary 1995-2004 (by district).
Average number of borers per plant.

Outlook for 2005

Fall survey results suggest growers can expect a very light first flight of moths in May and June of 2005. With a fall population as low as 0.10 borer per plant it is unlikely that corn borer densities will recover enough to cause significant problems for growers in 2005, though favorable weather during the 2005 growing season could result in a considerable increase of borers near the hotspots where counts exceeded 0.75 borer/plant (see map on page 1). As always, growers are encouraged to pay particularly close attention to the first flight of moths and growing degree day accumulations, and to scout for injury caused by first generation larvae next spring. Black light trap counts are available at: **http://datcp.state.wi.us/arm/environment/insects/pest-bulletin/**



CORN ROOTWORM

This year's corn rootworm larvae were apparently not hindered by June's dismal weather and flooded fields, as corn rootworm beetles appeared right on schedule by July 8. July brought warmer weather and many replanted fields that provided fresh silks and an ideal setting for egg laying for an extended period of time. The first western corn rootworms of the season were detected in Green Co., and by the following week, northern corn rootworm beetles were observed in Dane Co. While beetle populations grew in the south, larval hatch continued northward as light lodging and larval activity were observed in Trempealeau Co. during the week of July 16.

Scouting efforts in the southeast around July 30 revealed beetle populations were generally less than the threshold of 0.75 beetle per plant. During the first week of August, light amounts of silk feeding and an average of fewer than 0.82 beetles per plant were noted in southern fields. And despite a chilly August, which further hindered corn development, beetles fared well in fall, with populations ranging from 0.3-2.1 beetles per plant in the central sands region.

In contrast, September was unusually warm, and corn rootworms had four more weeks of nearly perfect conditions for mating and egg laying. Although no official count was made, it appeared that numerous fields across the state had populations that far exceeded the threshold of 0.75 beetle per plant or 38 per 50 plants. In the south central district observations of 4-7 beetles per plant were not uncommon. Beetles persisted into October as far north as Polk Co., indicating they had plenty of time to lay an abundance of eggs. If winter weather conditions are not cold enough to kill at least a fraction of overwintering rootworm eggs, growers replanting to corn can expect heavy larval populations and instances of severe lodging next spring.

WESTERN BEAN CUTWORM

The western bean cutworm is a late-season pest of field corn and dry beans that was seldom found in Wisconsin prior to the late 1990s. Western bean cutworm typically had a very limited range in the western cornbelt states, including in Nebraska, Wyoming, Kansas and Colorado, but on occasion significant outbreaks were known to occur in surrounding states. In recent years, the areas of significant activity have expanded eastward. In Wisconsin, the western bean cutworm has been making a regular appearance in western and southern black light traps for several years now (as far east as Mazomanie in Dane Co. last summer). The increasing frequency of sightings suggests it's time for growers to be on the lookout for this pest, particularly if we have another mild winter that favors survival of the larvae. Western bean cutworm feeds mostly on corn ears, damaging kernels and leaving the ear susceptible to secondary fungal infections and molds. This pest has the potential to cause large yield losses in corn and is often present in successive years.

Researchers believe there are a few key reasons why the range of western bean cutworm has been expanding. First, climatic factors have been particularly influential. Milder winters have made overwintering possible in areas where western bean cutworm was unable to survive in the past. Further, western bean cutworm prefer sandier soils for overwintering, and increased winter survival has meant increased potential to expand to areas with preferred soil types. Next, it appears that Roundup Ready® soybeans may be having an indirect impact. In fields planted with Roundup Ready® crops, soils are generally disturbed less; this translates into less disturbance of overwintering prepupae. Last, Bt transgenics may also be a factor in the recent expansion of western bean cutworm. Because of Bt transgenics fewer pesticides are being used, and the elimination of other species of larvae may be lowering the overall incidence of insects and reducing direct competition within the ear. (*Information from Gary Hein [NE Extension Entomologist Panhandle REC]*)

Another interesting feature of the western bean cutworm is that while corn appears to be its primary host, its host preference changes from corn to dry beans around mid-summer; corn is most attractive for egg laying. In the west central plains states there is one generation per year.

Adults begin to emerge late June/early July and damage becomes visible mid-August to early September. Scouting for western bean cutworm should begin as soon as the first moth is noticed.

The best method for monitoring western bean cutworm is with the use of black light traps. Peak trap catches directly indicate when the peak flight/ peak egg laying period is in progress; flight typically peaks just prior to corn tasseling. Treatments to control western bean cutworm are most effective from tassel formation through late August. Consider applying an insecticide if eight percent of the plants have an egg mass or young larvae in the tassel. Look for updates on the Western bean cutworm situation in summer issues of the Wisconsin Pest Bulletin at: h**ttp://datcp.state.wi.us/arm/environment/insects/pest-bulletin/**

Western Bean Cutworm Growing Degree Day Model (base 50°F)

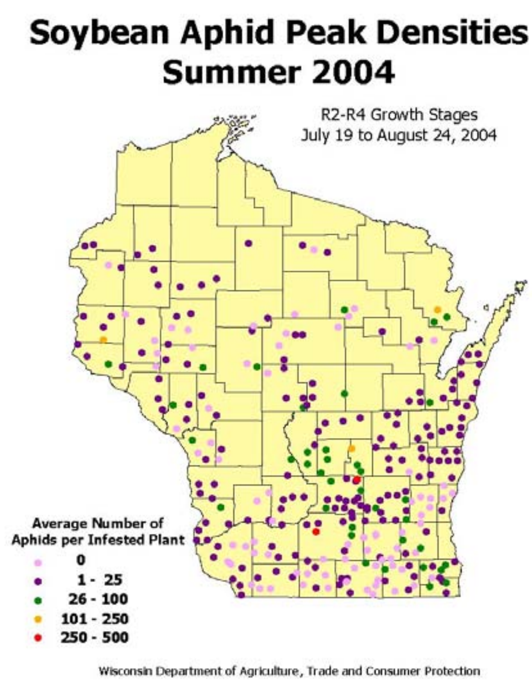
25% emergence	1319 GDD
50% emergence	1422 GDD
75% emergence	1536 GDD

SOYBEAN APHID

With each passing season, the soybean aphid continues to surprise and elude entomologists, DATCP's pest survey staff and farmers alike. Following record levels of aphids in 2003, densities dropped to the lowest levels since soybean aphids were first detected in Wisconsin just five summers ago. While it appears that soybean aphid populations have been very cyclic in Wisconsin and throughout the Midwest in general, forecasting the extreme fluctuations in the aphid populations from year to year has proven difficult. Aphid experts had predicted the possibility of lower aphid densities in 2004, but no one expected just how much lower they might be. For the first time since 2000, soybean aphids did not colonize an estimated 27% of the state's soybean fields; in previous years staff were pressed to find any fields without aphids.

2004 Survey Results

The 2004 summer soybean aphid survey took place between July 19 and August 24 and included 293 sites. Aphid densities were assessed during the R2-R4 stages of growth, when populations were forecast to peak. The 2004 survey found that soybean aphid population densities declined dramatically in all districts compared to 2003. The highest density of 53 aphids per infested plant, detected in the central district, compared to an average of 680 aphids per infested plant in that same district in 2003. The statewide average number of aphids per infested plant declined from 770 in 2003 to 15 in 2004. Further, soybean aphids were not detected in 27% (80/293) of the soybean fields surveyed last season. In 2003, soybean aphids were not detected in only 1 of the 289 fields included in the survey.



Outlook for 2005

If soybean aphid populations are indeed cyclic, then 2005 may turn out to be the next big year for the soybean aphid. Much to our dismay, there's evidence to support this theory. University of

Illinois-Extension entomologists monitored the fall migration of soybean aphids from soybeans to buckthorn (the primary host) to estimate the potential for soybean aphids in 2005; fall populations of flying soybean aphids may be indicative of relative densities from one year to the next. Soybean aphid migration was tracked via nine suction traps that were in place throughout the state of Illinois. Based upon a limited amount of suction trap data from this fall and from previous years, David Voegtlin, entomologist at the Illinois Natural History Survey, warns that the potential exists for significant infestations of soybean aphids to develop in 2005. Fall suction trap catches of soybean aphids were high enough to suggest that populations may build to economically important levels in 2005.

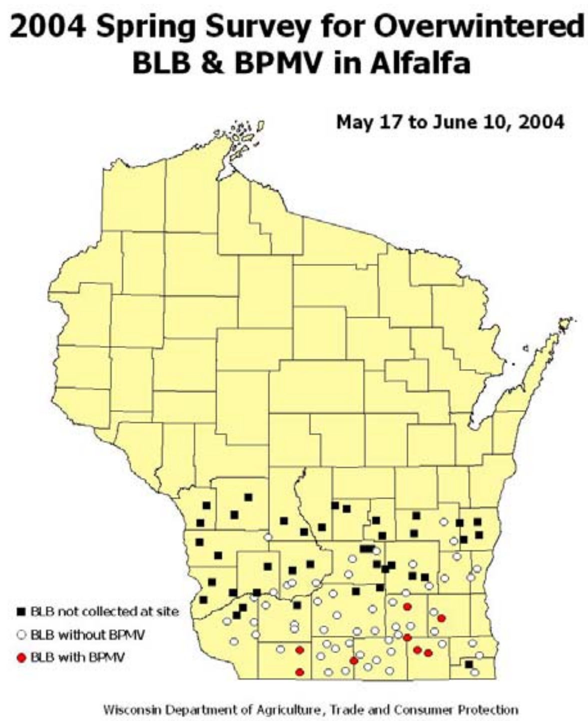
While 2004 was a light soybean aphid year, this pest has on more than one occasion demonstrated a remarkable capacity to rebound. Growers would be wise to err on the side of caution and expect the soybean aphid situation in 2005 to more closely resemble events of 2003 instead of 2004. As is always the case with fluctuating insect populations, early and regular scouting will be the key to detecting infestations of soybean aphids in 2005. Current University of Wisconsin-Extension recommendations are based on an action threshold of 250 aphids per plant from the late vegetative through R3 growth stages, when populations are actively increasing.

BEAN LEAF BEETLE

In 2004, DATCP's pest survey staff conducted two separate surveys for bean leaf beetle and bean pod mottle virus (BPMV). The first took place in spring, between May 17 and June 10, and targeted overwintered beetles. The second survey, carried out between July 19 and August 24, targeted second generation beetles. In addition to assessing beetle distribution, beetles were collected and later processed using ELISA test kits to screen for the presence of BPMV.

2004 Spring BLB Survey Results

The first overwintered adults were swept from alfalfa fields in Rock and Walworth Cos. on May 17, marking the beginning of the survey. The survey was completed on June 10, as soybean seedlings began emerging and overwintered bean leaf beetles started to migrate to soybean fields. The objective of the spring survey for overwintered bean leaf beetles was to determine where beetles had survived the winter in Wisconsin. Although bean leaf beetle is a soybean pest, the spring survey was conducted in alfalfa fields, where overwintered bean leaf beetles feed in the springtime before soybeans emerge. At each alfalfa field the surveyors took 200 sweeps (50 sweeps in 4 separate areas) and saved any bean leaf beetles obtained in the sweeps.



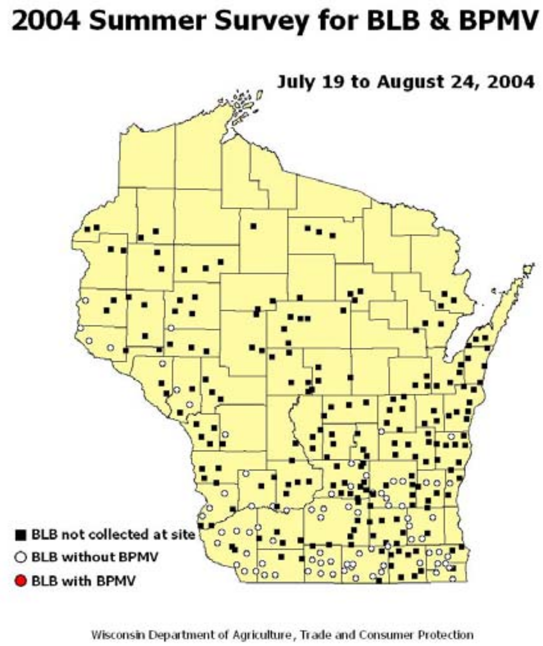
The spring survey found overwintered bean leaf beetles at 64 of 101 survey sites located mostly in the southern three tiers of Wisconsin counties. When the overwintered beetles collected during the survey were later tested for the BPMV, beetles from 8 of the 64 sites tested positive. The BPMV-positive beetles were collected from sites in Jefferson, Lafayette, Walworth and Waukesha Cos. Spring survey results demonstrated that bean leaf beetles were able to survive winter months in the southern one-third of the state, and that a very small percentage of that overwintered population were in fact carriers of BPMV. In turn, this indicated that BPMV transmission might be a problem for some southern Wisconsin soybean growers in 2004.

2004 Summer BLB Survey Results

The summer bean leaf beetle survey targeting second generation beetles got underway on July 19 and continued through August 24. As part of the survey protocol, staff collected beetles from 82 of the 293 soybean fields and measured bean leaf beetle defoliation levels. The 82 individual beetles were tested for BPMV using the same ELISA method used to test beetles from the spring survey; all tested negative for BPMV. In addition to the beetles, soybean leaf samples were collected from each of the 293 fields and tested for BPMV. No BPMV was found in any of the 293 soybean fields surveyed in 2004.

Outlook for BLB in 2005

Contrary to the above forecast, the bean leaf beetle did not develop into a significant pest in 2004. The same variables that suppressed in populations in general, cool temperatures and surplus amounts of rainfall, also helped to limit bean leaf beetle population growth. Results from the summer bean leaf beetle/BPMV survey suggest that early season growers should continue to closely monitor beetle activity both early and throughout the season, but that potential for early-season BPMV transmission need not factor into management strategies at this time. This, however, may not be lasting, especially if the general trend toward milder Wisconsin winters persists. In 2005 growers are strongly encouraged to regularly scout emerging soybean fields for bean leaf beetles and defoliation, especially early planted fields.



ALFALFA WEEVIL

2004 Survey Results

Alfalfa weevil, an insect that has been a relatively inconsequential alfalfa pest in recent years, made a surprising comeback during the spring of 2004. Adult activity resumed in late April, and spring-laid eggs began hatching near Madison by May 9. Larvae from overwintered eggs grew increasingly abundant throughout May, and by mid-month, 50%-60% tip injury larvae had become evident in hay fields throughout the southwest and south central districts. Compounding the larval pressure was the fact that alfalfa growth was delayed by temperatures that lagged 4-8 degrees below normal in late May/early June, and the record amounts of rainfall that fell in May prevented many farmers from getting into their fields to harvest first crop hay at the same time larval feeding was most concentrated. By early June, outbreak conditions had developed in a number of southern Wisconsin fields and tip feeding in many uncut fields far exceeded the threshold of 40%. A slight reprieve from the wet weather came around June 7, when farmers finally managed to cut first crop hay between the rain showers; however, by that time numerous fields were beyond harvest stage and most had been exposed to high populations of larvae for approximately two to three weeks longer than normal. Together these factors dramatically lessened the quality of first crop hay. When pupation began about June 16 near Madison, high rates of tip feeding and heavy populations of larvae existed in some fields. Numbers of larvae in second crop regrowth began to decline due to pupation by June 25 and by mid-July larval numbers had decreased to less than 4/10 sweeps. In most districts the potential for damage had passed. Numbers were low during the balance of the summer and through October, and subsequent hay crops fared far better than the first. One reminder that might be derived from last spring's survey findings is that growers should not discount the alfalfa weevil simply because it hasn't been a major player in recent years. While heavy losses of the first cutting have become less and less common, under the right conditions populations do build rapidly, and chemical intervention may still be necessary on rare occasions.

POTATO LEAFHOPPER

2004 Survey Results

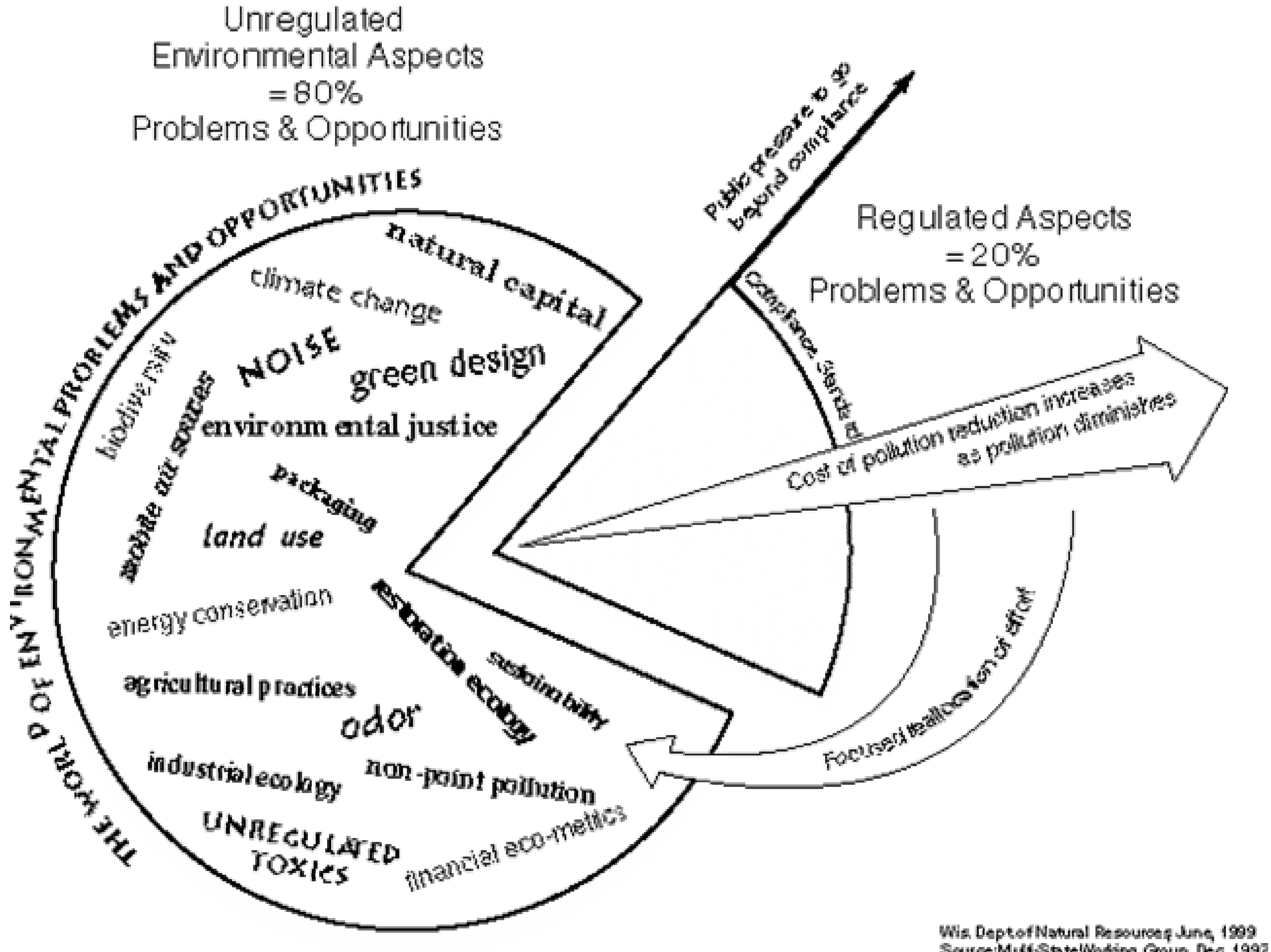
While some scattered hotspots were reported in the southern and northeastern parts of the state, on the whole, 2004 was not a noteworthy year for the potato leafhopper. Migrants began arriving around May 21, but because of unfavorable weather conditions, leafhoppers got off to a slow start. Consistent and heavy rainfall throughout May suppressed reproduction early on, keeping counts below 0.5 per sweep in the southern tier of counties throughout May and into early June. The first sighting of nymphs was reported on June 5 in Dane Co., but it wasn't until June 14-18 that nymph production in regrowth alfalfa really took off. In the south central district, counts of 0.8-3.2 adults/nymphs per sweep in 8"-12" fields were commonplace by mid-June. Although populations appeared to be rapidly and steadily increasing, wet conditions prevailed again around mid-month, effectively slowing a potentially damaging population of leafhoppers. Strong southerly winds over the July 4th weekend blew in more migrants, and by July 9, moderate to high populations could be found in many second and third crop alfalfa fields. Populations continued to build throughout July, and between July 16-30, conditions were the most ideal of the 2004 season for development and reproduction of potato leafhoppers. Despite escalating leafhopper populations, by early August most alfalfa acreage seemed to be faring well. Shortly thereafter evening temperatures began to decline, significantly slowing potato leafhopper reproduction by mid-August. Nymph production decreased considerably between August 13-20, and only light populations persisted through fall. Although some heavy populations developed in isolated southern and northeastern alfalfa fields, very little economic injury was attributed to this pest in 2004. Because potato leafhopper is a migratory insect, it's not possible to forecast its damage potential from one year to the next. In 2004 growers were fortunate to experience mostly low leafhopper densities, but that may not be the case in 2005. Growers with susceptible crops are encouraged to pay attention to low level jet stream activity that delivers potato leafhoppers into the state around mid-May, and to monitor the subsequent population build-up.

Environmental Management Systems (EMS)

Wisconsin Fertilizer, Aglime and Pest Management Conference

Alliant Energy Center - Madison

Proactive Business Operations



Unregulated
Environmental Aspects
=80%
Problems & Opportunities
THE WORLD OF ENVIRONMENTAL PROBLEMS AND OPPORTUNITIES
natural capital
climate change
NOISE
green design
biodiversity
mobile air sources
environmental justice
packaging
land use
energy conservation
restoration ecology
sustainability
agricultural practices
odor
industrial ecology
non-point pollution
UNREGULATED TOXICS
financial eco-metrics
Public pressure to go beyond compliance
Compliance Standard
Regulated Aspects
=20%
Problems & Opportunities
Cost of pollution reduction increases as pollution diminishes
Focused reallocation of effort
Wis. Dept of Natural Resources, June, 1999
Source; Multi-State Working Group, Dec. 1997

EMS Attributes

- Beyond Point in Time Compliance Tests
- Systems based
- Business driven
- Performance
- Continual Improvement
- Responsive to market drivers
- Internationally recognized

12 EMS Elements

- Environmental Policy
- Environmental Footprint
- Achieve and maintain compliance
- Know your environmental requirements
- Act to set and meet environmental objectives
- Structure, operational control and responsibility

12 EMS Elements (Continued)

- Training
- Preventative and Corrective Action
- Communication
- Document control and record keeping
- Audit
- Senior management engaged

GREEN TIER

Tier 1	•Commitment from entity - EMS within 1 yr. •Superior environmental performance •Annual System Audit & reported violations	•Logo & Certificate •Lowest Insp. Frequency •Single Pt of Contact •Limited Civil Immunity •Publicity
Tier 2	•Demonstrated Performance of EMS •Superior environmental performance •System Audits and Compliance Audits	•Incentives from Tier 1 plus •Contract for "Incentives proportional to Superior Environmental Performance"

GREEN TIER INFORMATION

Environmental Management Systems - General Information
http://www.epa.gov/ems/index.htm

Green Tier - General Information
http://dnr.wi.gov/org/caer/cea/environmental/

EMS or Green Tier - Questions?
608.267.3125 or mark.mcdermid@dnr.state.wi.us

AGRICULTURAL ENVIRONMENTAL MANAGEMENT SYSTEMS

Karl Hakanson [1/]

Voluntary, self-directed systems of environmental management are proving to be good business tools for a diverse set of manufacturing sectors. Rather than approach environmental management as a necessary cost of doing business to satisfy government regulators, businesses are finding that a proactive, self-directed program of continuous improvement in environmental management has benefits for profits, investor relations, and enlightened regulatory relations. Such environmental management systems (EMS), appropriately adopted, appear to have much to offer farmers.

Why EMS in Agriculture?

Reasons that EMSs merit consideration by the agricultural enterprises include observations that:

- Voluntary, self-directed environmental management systems in some form are part of the next generation of environmental regulation,
- Customers and community stakeholders are increasingly asserting their standing on agriculture's impact on the environment,
- Agriculture's impacts on the environment are significant and increasingly regulated, and,
- Product differentiation based on verifiable environmentally sound production methods offers farmers a strategy for improved profitability.

The next generation of improvements to water and air quality will most likely come from voluntary self-management by businesses, as parts of collaborative agreements between government regulators and individual firms or associations of like firms. The stunning progress in improving environmental quality during the 1970s and 1980s came about because it was possible to identify a relatively small number of relatively important pollutants and polluters. Conditions were so obvious that broad public commitment was relatively easy to orchestrate.

Today most water quality impairment derives from a very large number of relatively small sources scattered widely on the landscape; i.e., nonpoint source pollution. Additionally, some of the most significant environmental impacts, such as loss of wildlife habitat or energy use, while not specifically regulated at the level of the individual business, are significant issues of public concern.

Interest in regulatory reform related to the environment is widespread as governments find it increasingly difficult to allocate resources to enforce existing rules and provide timely and high quality reviews of new proposals. Businesses are increasingly intolerant

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of wasteful regulatory review and compliance requirements as globalization of capital and information flows increases competitive pressures.

Thus the increasingly diffuse nature of pollutant sources, tight government resources, and refined business management are leading both the public and private sectors to explore innovative ways of encouraging environmental stewardship as part-and-parcel of sound business practice.

Farmers in many parts of the country are finding that a range of stakeholders now assert their standing to object to agriculture's contributions to water (surface and groundwater) and air pollution (emissions and odor). This is most readily seen when rural non-farm residents raise objections to new and expanded large-scale livestock facilities near their homes and communities. There are broader examples, though, such as recreational anglers seeking lessened impacts on streams.

Farming is responsible for about 40% of water bodies falling short of the goals articulated 30 years ago in the Clean Water Act. Pollution caused by agriculture is largely nonpoint, and so tracking its origins is difficult. Most soil erosion occurs in rare events, and managing for such worst-case scenarios is difficult in a business that offers relatively low returns on investment. It is not clear the extent to which political interest in increasing environmental regulation of agriculture will prevail in the coming decades.

What does seem likely is that new technologies will improve our ability to monitor environmental performance and ascribe with greater certainty the sources of pollutants. The public's demands on agriculture to demonstrate "due diligence" relative to environmental performance is also not likely to subside. Thus it appears in agriculture's best interest to learn techniques for minimizing negative impacts on the environment and making this goal systemic in management.

Finally, farming within the framework of an EMS may soon play a role in product differentiation, allowing the farmer to obtain a price premium. Organically-grown products are one example of how independent third-party organizations assure consumers that products adhere to certain production criteria or standards. While an EMS is about the system by which a farmer continuously works to improve environmental performance, rather than particular production technology, independent external audits are a component of the complete EMS model.

Wisconsin's legislature passed SB61, creating the "Environmental Results Program," which gives the EMS a role in state environmental regulation. The significance of this for agriculture remains to be seen, but it is possible, for example, that a cheese maker and associated dairy farmers could be granted a unique set of operating conditions by state regulators, as a result of (among other conditions) their following an EMS. Food products made by this collaboration could be labeled with a (yet-to-be-designed) logo that businesses in the product chain are regulated under the Environmental Results Program.

What's an EMS?

An Environmental Management System, or EMS, is a systematic way to manage impacts on the environment that covers all levels of farm management, from daily operations to long range planning. An EMS is farmer-directed and voluntary and focuses on business efficiency.

The EMS process is built on the proven "Plan, Do, Check, Act" model of continual improvement. It ensures environmental matters are systematically **identified, controlled,** and **monitored** so that environmental performance **improves** over time.

An EMS is not a specific document or set of documents, nor is it a specific practice, set of practices, technology or engineering. While all these things are important parts of an EMS, it is the disciplined commitment to continually improving environmental stewardship and business efficiency that make it a true system. Management systems can be used to address additional aspects of farming operations, such as: product quality; worker health and safety; livestock health and welfare; crop production and financial management.

Farmers' decisions and actions on the landscape impact the environment in significant ways. Farmers have a special responsibility in this regard as they manage 100's or 1,000's of acres of land that often includes forests, wetlands and riparian areas. If you stop and think about it, *almost every activity on a farm affects or has the potential to affect the environment*. Increasingly, farmland is also boarded by housing developments and other non-farm land uses that may come in conflict with farming operations.

The goal of an EMS is to ensure that, over time, negative environmental impacts from farming operations are minimized and positive impacts like clean water, clean air and wildlife habitat are enhanced.

Most farms already have many practices related to environmental management in place. Current environmental plans and practices may be recorded and scattered in a variety of file folders, computer disks, three-ring binders, at the LCD or NRCS office, managed by a consultant, or in the farmer's head. By undertaking a formal EMS, a farm would not be duplicating, replacing or negating what has already been accomplished. *Implementing an EMS does not mean starting from scratch.*

With an EMS efforts are organize into a coherent system that includes feedback loops for evaluating effectiveness and making further improvements. It is a system that emphasizes the benefits of sharing information with family, employees, consultants, suppliers, specialists, and neighbors. This sharing of information can lead to greater recognition of the good things already in place to protect the environment and provides fresh ideas that can help improve business management.

Potential Benefits of an EMS:

- A mechanism for finding cost savings and improving efficiency.
- A pro-active atmosphere and commitment to environmental improvement.

- Improvements in employee training, knowledge, responsibility and morale.
- Improvement in communications among family and employees.
- Better organize and integrate ongoing environmental improvements.
- Improved relationships with regulators, neighbors, community members.
- Improved long-term productivity of farmland.
- Opportunity to negotiate lower insurance or interest rates.
- Formal registration or recognition of the EMS as a way to realize market premiums or maintain or obtain access to markets.
- Cleaner water and air, more abundant wildlife and a beautiful, healthy place to live, work and play.

Key Concepts:

- An EMS focuses on improving efficiency and reducing waste
- Farm owners and managers lead their own unique EMS
- It is a thoughtful, deliberate *process*, not a static final product
- It is a commitment to improving all aspects of farm management
- The EMS process can redefine *farmer* leadership in agriculture

For more on EMSs in agriculture see: http://www.uwex.edu/AgEMS/

The Challenge of AgEMS

While most people would agree that the potential benefits of an EMS are laudable, bringing theory into practice on real farms is, however, quit another matter. The development of an EMS takes considerable time and effort directed at thoughtful, deliberate management of a farm's impact on the environment. Time is a very precious commodity on farms. It is difficult for most farm owners and managers to take the time necessary to learn about and incorporate a new approach to business management. A major drawback to the EMS process is that any benefits are not readily apparent and take time to accrue.

An EMS is unlike the adoption of a specific "BMP" that has measurable, predicable outcomes that a farm manager can evaluate. It is difficult for a farmer to spend a lot of time and effort on a major new project where the benefits are ambiguous at the outset. The very largest farms with staff dedicated to the management of the farm business are the most likely to be able to incorporate and benefit from an EMS.

The Wisconsin Dairy EMS Livestock Project (www.uwex.edu/AgEMS/livestock/) has been working with farmers and farm managers researching and testing EMS educational approaches and delivery methods. One of the goals was to create an EMS process that is functional, farmer-friendly and results focused. A simplified process has been developed that incorporates the main components of the ISO 14000 EMS standard, the recognized standard used by businesses world-wide. Collaborators in nine other states have been engaged in similar research in dairy, beef and poultry farms. Educational approaches and AgEMS guidebooks, templates, environmental assessment tools and worksheets have been designed, through on-farm pilot testing, that address many of the challenges of the EMS process.

Opportunity for "TSPs"

One of the lessons learned is that the development of EMSs on farms, and other small businesses (even the largest farms would be considered small enterprises compared to the typical EMS-certified firm), will require "coaches" to assist farms with EMS implementation. Agricultural consultants, or "technical service providers", could fill this role. If the Green Tier program and similar voluntary, verifiable environmental management and marketing programs gain in popularity there will be a need for consultants versed in management systems and environmental assessment and sustainability.

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The EMS, ISO and the 14000 Standard

The most well-known EMS standard is the International Standards Organization (ISO) 14001. An ISO registered EMS has to conform to the specific requirements of the ISO and will need to be audited and approved before you can enjoy marketing or other benefits. Registration to the ISO standard means that a farm has complied with an internationally recognized process for demonstrating commitments to pollution prevention, regulatory compliance and continual improvement. For more information on ISO 14001, go to: http://www.iso14000.com/

Elements of an ISO 14001 EMS: A Snapshot

- **Environmental Policy -** Develop a statement of your organization's commitment to the environment. Use this policy as a framework for planning and action.
- **Environmental Aspects -** Identify environmental attributes of your products, activities and services.
- **Legal and other requirements -** Identify and ensure access to relevant laws and regulations (and other requirements to which your organization adheres).
- **Objectives and Targets -** Establish environmental goals for your organization, in line with your policy, environmental impacts, views of interested parties and other factors.
- **Environmental Management Program -** Plan actions to achieve objectives and targets.
- **Structure and Responsibility -** Establish roles and responsibilities and provide resources.
- **Training, Awareness and Competence -** Ensure that your employees are trained and capable of carrying out their environmental responsibilities.
- **Communication -** Establish processes for internal and external communications on environmental management issues.
- **EMS documentation -** Maintain information on your EMS aid related documents.
- **Document Control -** Ensure effective management of procedures and other system documents.
- **Operational control -** Identify, plan and manage your operations and activities in line with your policy, objectives and targets.
- **Emergency Preparedness and Response -** Identify potential emergencies and develop procedures for preventing and responding to them.
- **Monitoring and Measurement -** Monitor key activities and track performance.

- **Nonconformance and Corrective and Preventive Action -** Identify and correct problems and prevent recurrences.
- **Records -** Keep adequate records of EMS performance.
- **EMS audit-** Periodically verify that your EMS is operating as intended.
- **Management Review -** Periodically review your EMS with an eye to continual improvement.

United States Department of Agriculture
Natural Resources Conservation Service

Conservation Security Program

Overview

United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

CSP
A new way to think about conservation.

2004 Summary

- 18 watersheds in 22 states
  - $41.4 M in funding (TA=15%)
- Lower Chippewa and Kishwaukee in WI
  - 219 contracts
  - Over $2 M in payments

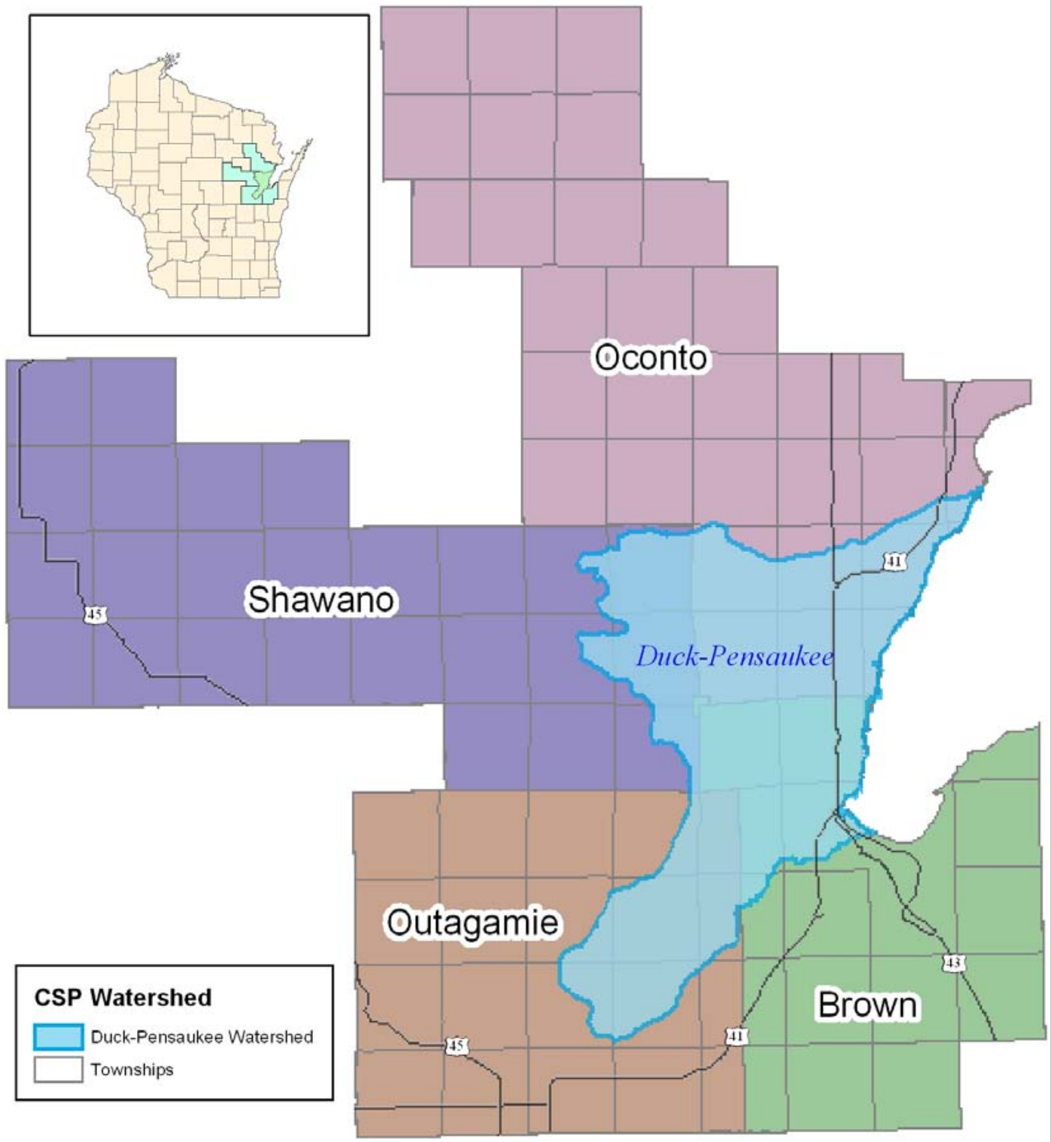
What's new for 2005?

- No longer a pilot program
  - Will be in all 50 states, approx. $200 M
- New watersheds
- More time to prepare, sign-up, and process
- Program tweaks and improvements

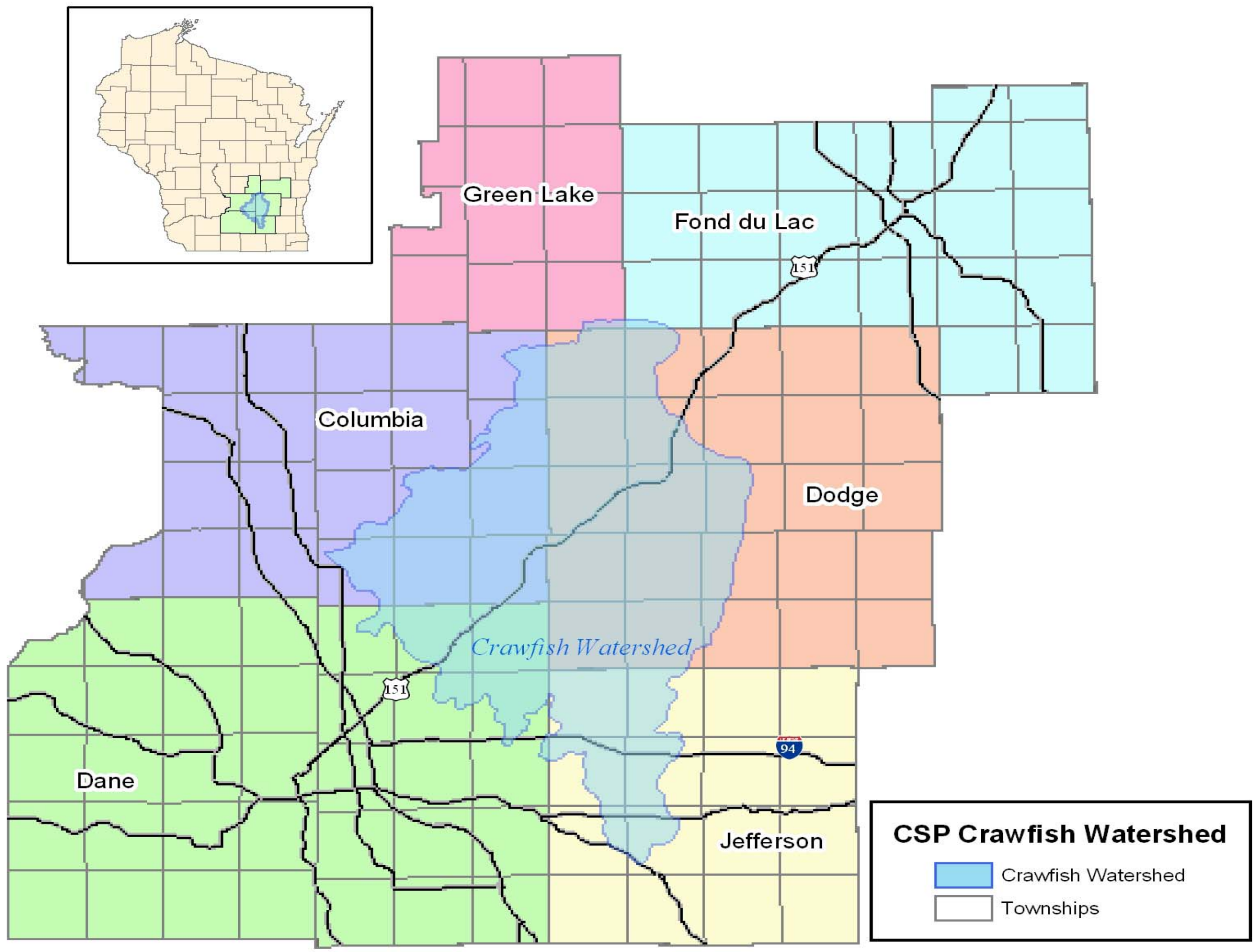
FY 2005 CSP Timeline

- November- Watersheds announced (Duck -Pensaukee and Crawfish River)
- December-January: final rule development, prepare materials
- February- train employees and partners
- March- public workshops, “hands-on” meetings and potential sign-up period

2005 Wisconsin Conservation Security Program
Duck-Pensaukee Watershed



2005 Wisconsin Conservation Security Program
Crawfish Watershed



Conservation Security Program

- **Basics**
  - **Authorized by 2002 Farm Bill**
  - **Voluntary program**
- **Why participate?**
  - **Rewards producers that are practicing good conservation**
  - **Opportunities and incentives for future conservation practices**

CSP Area Selection

Criteria for CSP Areas

– History of good land stewardship

– Wide variety of land uses

– High-priority resource issues to be addressed

– Availability of necessary technical tools

CSP: Application Process

Eligibility Requirements

- Privately owned or Tribal lands
- Majority of operation within CSP watershed
- In compliance with HEL/wetland provisions
- Active interest in operation
- Own or rent land
- Applicant shares risk and is entitled to share of crops/livestock

Defining the CSP Operation

- Applicant defines the operation
  - Can be owned or rented but applicant needs to control for length of contract
  - Only one contract per applicant
- Change in ownership or loss of rented land
  - Request a modification, a transfer or withdraw
  - Refund NRCS for practices paid for but not in place

CSP: Application Process

Eligibility Requirements, cont'd

- Eligible lands include
  - Cropland, orchards, vineyards, pasture
- Lands that are not eligible include
  - Land in the Conservation Reserve Program, Wetlands Reserve Program, or Grasslands Reserve Program cannot receive stewardship payments
  - Recently converted cropland
  - Forest land

CSP: Application Process

- Treatment Requirements (already in place)
  - **In compliance with HEL and wetland provisions**
  - **Erosion control, including gullies**
  - **Nutrient management and pest management**
  - **Maintaining or improving soil condition**
  - **Minimum requirements for pasture condition**
  - **Requirements vary with soil, slope, crop, etc.**

CSP: Application Process

Self-Assessment Workbook and Worksheets

- Determine eligibility
- Document current conservation practices
- Obtain field and rotation data
- Identify additional stewardship practices and activities the operation is willing to implement

United States Department of Agriculture
Natural Resources Conservation Service

Managed Grazing

United States Department of Agriculture
Natural Resources Conservation Service

Residue Management: No-till

United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

Grassed Waterway

CSP: Application Process

- Complete and submit to NRCS the Self-assessment workbook and worksheets
- Make an appointment with NRCS to review supporting documents
  - Ex. Soil tests and manure spreading records (see workbook and worksheets for complete list)

CSP Screening Process

- NRCS determines enrollment categories
  - Method for comparing applications
  - Based on practices in place, agreed to practices, soil condition and pasture condition
- NRCS (nationally) selects categories to be funded
  - Contract completed if enrollment category funded

Conservation Security Program

- **Tier Structure**
- **Payment Components**
- **Enhancement Component**

Conservation Security Program

Tier Structure

Tier	Resources Treated	Scope	Contract
Tier 1	Water & soil quality	Part of operation	5 years
Tier 2	Water & soil quality	Entire operation	5 to 10 years
Plus: Agree to address one other resource concern			
Tier 3	All resources	Entire operation	5 to 10 years
Plus: Agree to additional activities			

L. Chippewa R. Contract limits*

*does not include new practice payments (50% c/s up to $10,000)

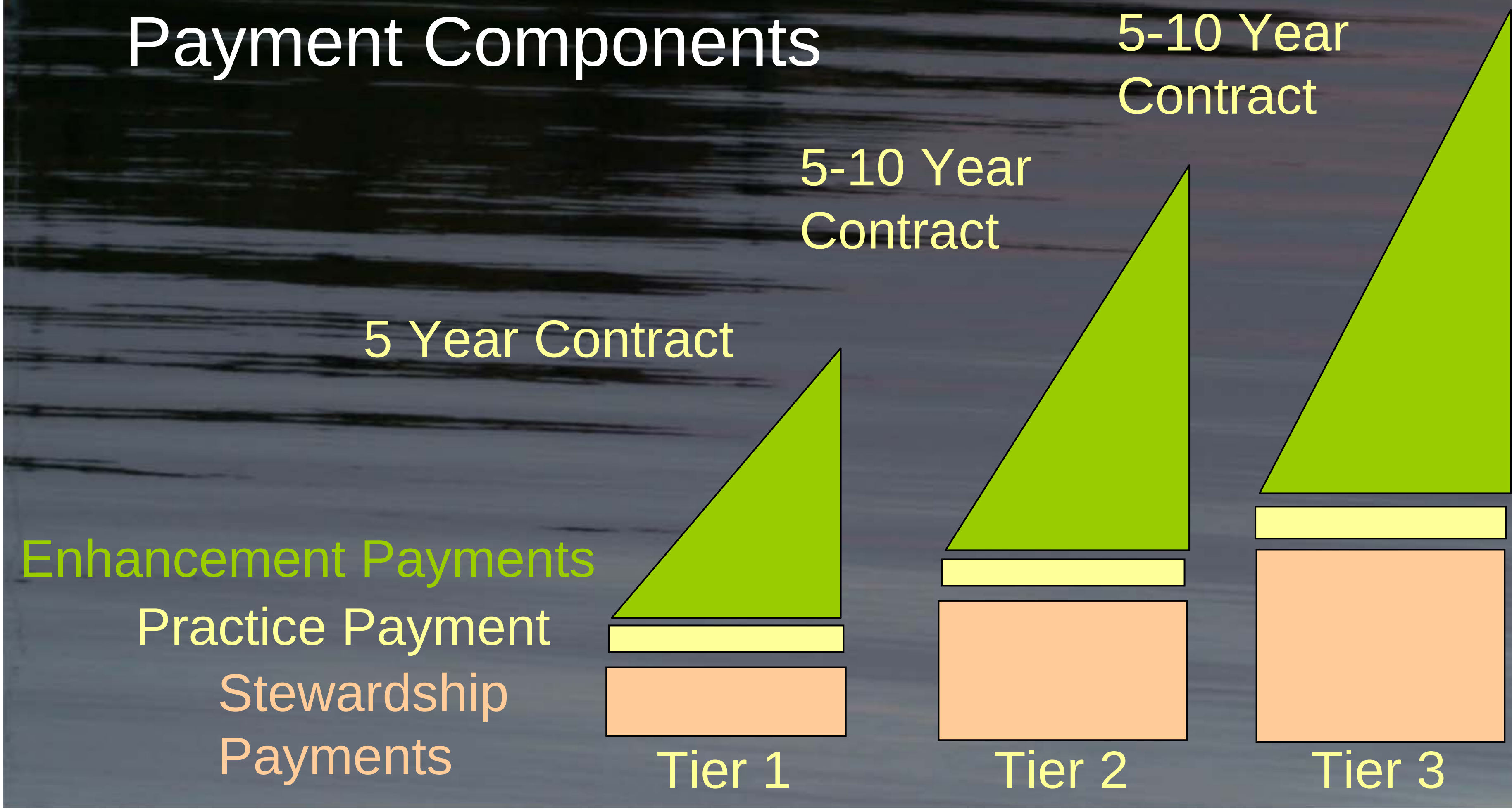
Tier 1	**Cropland**	$10.35/ac/yr max.
	Pastureland	$4.20/ac/yr max.
Tier 2	**Cropland**	$17.25/ac/yr max.
	Pastureland	$7.00/ac/yr max
Tier 3	**Cropland**	$27.60/ac/yr max
	Pastureland	$11.20/ac/yr max

CSP: Four Payment Components

- An annual stewardship payment for the benchmark (existing) conservation treatment.
- An annual existing practice payment for maintaining conservation practices.
- An enhancement component for exceptional conservation effort.
- One-time new practice component for additional practices

Conservation Security Program

Payment Components



CSP: Enhancement Components

Payments for producers who add resource benefits beyond the prescribed level. Can be the largest $ component.

Enhancement examples:

- Split Nitrogen Application
- Soil Conditioning Index (from RUSLE2) higher than program minimum
- Use cover crops to build soil organic matter and reduce runoff and erosion

CSP Payment Example (Lower Chippewa rates)

- Example farm consists of 150 acres of cropland and 50 acres of pasture.
- MAXIMUM annual payments for each tier on this farm are:
  - Tier 1: $1762.50/yr for 5 years
  - Tier 2: $2937.50/yr for 5 to 10 years
  - Tier 3: $4,700.00/yr for 5 to 10 years
- Not all contracts will reach the maximum $

How can CCA's help clients?

- Stay in touch with your local NRCS office
  - CSP still developing for 2005
  - Participate in local workshops (TBA)
- Organize client nutrient and pest management plans and records
- Group fields with same cropping/tillage history on CSP sheets
  - Still need to determine "planning" soil so include field numbers and show on maps

United States Department of Agriculture
Natural Resources Conservation Service

Thank you!

- Questions or comments?
- For more information, visit our web site: http://www.wi.nrcs.usda.gov/programs/csp.html
- Matt Otto
  - (608) 662-4422 x245
  - matt.otto@wi.usda.gov

GloTell: A Marker for Anhydrous Security

Scott Spelman [1/]

GloTell, is an anhydrous ammonia additive, formulated to be introduced into ammonia to serve not only as a theft deterrent for methamphetamine production, but also a leak detector and marking agent. GloTell, when injected into the anhydrous ammonia, stains exposed surfaces pink. This pink color is detectable by ultraviolet light, affording law enforcement personnel a method to detect persons that have encountered the product while producing the illegal drug, while also reducing the quality of methamphetamines.

[1/] Director of Sales–GloTell, Royster Clark.

FACTORS IMPACTING INSURANCE PREMIUMS

David W. Stiltz
Marketing Manager
Agri-Business Insurance Services
Des Moines, IA

Introduction

This presentation is designed to discuss the factors that impact premiums in the agribusiness industry and the techniques that can be used to control those costs. The discussion will include insight on the components of premium, and cost reduction techniques.

Components of the Insurance Premium

Fixed costs also referred to as overhead, normally comprise 25% to 35% of the total premium. These are the costs that are normal to the operations of an insurance company. The breakdown of what comprises these fixed costs is as follows:

Table 1

Selling Expense/Commissions
Underwriting Expense/Rating
Loss Control/Safety Engineering
General Administrative/Clerical
Depreciation/Amortization
Boards & Bureaus/Premium Tax

Profit normally runs about 2 to 5%, varying by the type of insurance. Losses and loss adjustment expenses comprise from 65 to 80% of costs, again varying by the type of insurance. As premiums are collected and held by the insurance companies in advance of losses being paid, insurance companies accumulate substantial reserves. The investment income on those reserves allows insurance companies to have losses in excess of earned premiums.

Major Types of Property/Casualty Insurance

A. To insure against direct loss of physical assets
   1. Fixed plant and equipment – Normally referred to as Property Insurance
   2. Inventory – Also a part of Property Insurance.
   3. Rolling Stock other than autos, e.g. augers, tractors, wagons - Referred to as Inland Marine Insurance.
   4. Autos, trucks and other vehicles licensed for road use. Referred to as Auto and/or Fleet Insurance.

B. To insure against loss of cash flow, e.g., a decrease in revenue or an increase in expenses as a result of a direct loss to physical assets. Referred to as Business Income Insurance.
C. To insure against lawsuits resulting from Bodily Injury to a third party or damage to their property. If the lawsuit results from the use of an auto, Auto Fleet would be the appropriate coverage. If the lawsuit is the result of other than an auto accident, the appropriate insurance is General Liability Insurance.
D. To insure against injury to your own employees, e.g. Workers Compensation Insurance.

Cost Reduction Techniques

Property/Inland Marine Insurance

A. Rating – Rates are generally expressed as a rate/$100 of valuation. Rates multiplied by the limit of insurance determine the base premium.
B. Construction – The more fire resistive, the lower the rate. Concrete carries a lower rate than steel, steel carries a lower rate than frame. The cost per dollar value of commodity will be higher in a frame elevator than it is in a concrete elevator. Consider the type of construction when building.
C. Protection – Characteristics of construction that reduce the chance of loss can reduce the rate. This would include fire suppression systems (sprinklers, extinguishing systems, fire walls), alarms, fences, locks, lighting, wind resistive roofs, etc. Install property protection equipment where cost effective. Determine prior to construction if there is any protection systems that can be installed to lower the insurance cost.
D. Exposure – The proximity of your property to external loss from another source or hazard. Three flat storage grain warehouses 50' apart may be rated as one unit. The same three buildings 100' apart may be considered three separate risks which could result in a lower premium. Other hazards that can influence rating would be to locate in a flood zone, high crime area, locating adjacent to non-owned high-risk property, or locating a concrete elevator with nearby residential, school or commercial exposures. Consider these factors when determining placement of new construction.
E. Valuation – Be sure that all assets are properly valued. Actual cash value (ACV) is generally defined as "replacement cost minus depreciation". Other criteria such as obsolescence and deterioration can be included as part of the definition. Replacement cost (RV) is generally defined as "the replacement of existing property with like and kind materials". If you have a building that would not be replaced, it should not be insured for RV. Most policies have a provision that if a building insured at RV is not replaced, valuation will shift to ACV. Don't waste your money. Review your facilities to determine what valuations should be used. Inland marine equipment is usually insured at ACV. RV options are available with some companies on newer units. Rates are usually the same but the RV costs more because you are using a higher value.
F. Reporting Form – As a general rule, agribusiness facilities should be on an inventory reporting form. Due to the seasonal nature of the industry, reporting allows you to pay inventory premium based on "average" values. Limits are based on maximum exposures.
G. Deductibles – Use deductibles to decrease the cost of your insurance. Credits are normally given for higher deductibles. Determine what deductible level works for your company. Deductible aggregates may also be available to limit the number of deductibles applied in any given year.

H. Self-Insure – Are there any lowered valued building that you can self-insure? It is possible to insure inventory without insuring the building. What is an acceptable amount of risk for you to assume? For inland marine equipment, do you need to insure all of the lowered valued augers and tractors or only the higher valued equipment engines?
I. Ask questions – Request information on specific cost reduction techniques from the insurance company.

General Liability Insurance

A. Rating – Premiums are determined by applying a rate/$1,000 of sales, payroll or a rate/square foot of building. Separate rates will apply to each type of product sold or each type of business activity. Identity preserved, food grade or organic grains can carry higher rates than typical field grade commodities.
B. Premises Exposures – The general condition of the premises will be considered when rating. How the property is maintained, access by the general public, "nuisance hazards" such as abandoned buildings will be a factor in rating. Keep your premises and property maintained in good condition.
C. Off-premises exposures – Do you have any operations that are conducted off-premises? Do you send your personnel and equipment to the farm to pick up grain? If you do, what controls and procedures are in place to limit the potential for damaging non-owned property or persons? Do you let other people "borrow" your equipment with or without a company operator? Review these exposures to determine if the risk is acceptable?
D. Product Losses – Do you make any warranties or representations concerning the quality of your product whether expressed in a contract or implied? What controls are in place to protect the integrity of product from the time it is received until it is shipped? Has the recent acts of terrorism caused you to consider if your facilities provide reasonable protection for products in the food chain?
E. Payroll rating issues – Determine if specific issues related to payroll are being addressed.
    a. Eliminate clerical payroll from rating
    b. Eliminate driver payroll
    c. Eliminate overtime payroll from the rating basis
    d. Limit Executive Office payroll as allowed by the insurance company
    e. Excise or sales taxes should be removed from gross sales
    f. How are inter-company sales handled? Are you paying twice?
    g. Ask if sales and payroll is being properly classified.
    h. Consider property damage deductibles if they are available. What level of deductible should be a "cost of doing business"?

Auto Fleet Insurance

A. Rating – Liability and physical damage rates are normally expressed per the type of vehicle being insured. Factors such as garage location, cost, usage, GVWR and radius of operation factor into the rating on a vehicle.
B. Classification – Ask if all the vehicles are properly classified. Review your list of vehicles to determine if any are used on-premises only. Vehicles used strictly on premises or not licensed for road use may be able to be insured under lower general liability rates. Make sure GVWR ratings and original cost figures are correct.

C. Seasonal Rating – Most insurance companies offer seasonal rating. The use of seasonal rating is more prevalent in fertilizer/chemical operations but it may have merit in grain operations.
D. Self-Insurance – Consider self-insuring comprehensive and collision coverage, at least on older units. One caution, comprehensive or specified perils coverage apply to vehicles damaged by wind, hail and fire. Determine and evaluate the potential for loss if you store a large number of vehicles in one building that would be susceptible to a single loss.
E. Deductibles – Determine what level of deductible is acceptable to your company. The insurance company can supply premium credit information.

Workers Compensation

A. Rating – Job duties are classified into a descriptive code such as Grain Elevator Operations, Hay, Grain & Feed Operations, Clerical, Outside Sales, etc. Each class code has its own rate that varies with the risk of occupational injury and the state where the employee is located. Premiums are determined by applying a rate/$100 of net payroll. An authorized rating bureau, in most states the National Council on Compensation Insurance (NCCI), establishes rates or loss costs.
B. Experience Rating – Unlike General Liability and Auto Fleet Liability, where underwriters determine experience rating, Workers Compensation experience rating is mandatory. The formula used by NCCI evaluates the number and cost of claims in relation to payroll to establish each accounts experience rating. Monitor claim reserves to make sure they are not overstated and adversely affecting the experience modification.
C. Classification – Make sure that payroll is correctly classified. A trend has developed among commercial agribusiness insurance companies to follow strict NCCI rules pertaining to classifying employees. Manual rules require that if a person performs multiple job duties their entire payroll will be assigned to the highest rated class code. Some insurance carriers in the past have allowed payroll to be assigned according to the primary duties of the employee. NCCI rules do allow for splitting payrolls under certain guidelines.
D. Executive Officer Payroll – In most states, Executive Officers can be excluded from Workers Compensation. Determine if this will work for your business.
E. Overtime Payroll – Manual rules allow payroll to be reduced by the cost of overtime payroll. If you are not reporting overtime payroll, this is likely not being done.
F. Self-Insure – Some states allow deductibles or retentions that will reduce the cost of your insurance. Know what is available to you.

Experience/Schedule Rating

A. Experience rating is based on the frequency and severity of claims. Insurance carriers file these credits for each line of insurance or package filed in each state. A typical range of experience rating will be from a 25% debit to a 25% credit.
B. Scheduled rating is based on certain characteristics of an account. Years in business, tenure and experience of management, general housekeeping and maintenance, safety programs and the financial condition of an account are factors used in the rating determination. The more that is done to positively affect these factors, the better. Typical schedule rating filings will be from a 25% debit to 25% credit.

C. Optional Basis – Insurance company underwriters can apply schedule and experience rating to property/inland marine, general liability, auto fleet insurance and workers compensation on an optional basis. Soft markets tend to see a more liberal use of scheduled and experience rating. Package credits/debits can have a sizeable affect on premium.

Safety Programs

"Components of the Insurance Premium" provided information that expected losses comprise between 60-85% of insurance premiums. One way to impact losses is to have an effective safety program that incorporates the following characteristics.

A. Goals – Successful safety programs seek to reduce the number of hazards and risks of injury, decrease the rates of accidents and injury and control the cost of accidents and injuries.
B. Causes – Understand that most accidents result from unsafe acts, not unsafe conditions. An effective safety program will work to influence employees to make decisions with their and others safety in mind.
C. Accountability – Safety standards are words on paper. Accountability is what makes them work. Housekeeping and maintenance schedules are a road map. The process of following the schedules, supervisory oversight that the schedules are being followed and management oversight makes everybody accountable.
D. Evaluation – Establish a system to evaluate and change your safety program to meet changing needs.
E. Measure and Reward – Positive reinforcement is more powerful than negative actions. Timing of rewards, whether positive or negative, is critical. The closer to the event the better.
F. Structure – There is no "one size fits all" structure for a safety program. Every organization needs to constantly change and adapt to fit their programs needs.

Claims Management Program

When claims do occur, your claims management program should be designed to reduce the cost of those accidents. An effective claims management program will incorporate the following characteristics.

A. Claim Reporting Procedure – An expedient claims reporting process that eliminates delays so that notification of a claim is made in a timely manner.
B. Mitigation – A process to minimize the size or impact of a claim. This can range from maintaining a list of contractors with specific equipment that can be utilized to establishing on-site, pre-loss products and tools.
C. Cause/Correction – Procedures to determine the cause of losses that will prompt corrective actions that prevent or reduce future losses.
D. Communications – Develop procedures to maintain lines of communication with claimants (can include employees), health providers, insurance adjustors, legal representatives, etc.

Conclusion

Treat your insurance program like you own it and take an active role in developing the program. Pick insurance agencies and companies that are good stewards of your money.

1. Understand each type of insurance you have, how premium is determined and use cost reduction techniques to control or lower the cost of your insurance.
2. Establish or maintain an effective Safety Program.
3. Minimize the cost of losses that cannot be avoided with an effective Claims Management Program.
4. Select an insurance company and agent that will understand your needs and is committed to commercial agribusiness insurance.

IMPACT OF RECENT LABOR STANDARDS CHANGES ON FARM RELATED BUSINESSES

Bob Anderson [1/]

What is a farm related business?

Many farmers choose to contract with businesses to provide services that farmers traditionally have performed as part of an agricultural business. These services may include land preparation for planting (plowing, disking, or fertilizer and insecticide application), custom harvesting of crops or the hauling/dispersal of manure.

November 1, 2003 Wisconsin's Overtime Exemption for Secondary Agriculture Expanded

- ✓ DWD 274.04(9) now is identical to the secondary overtime exemption contained in the Fair Labor Standards Act.

- ✓ Employees who engage in farm type activities for their entire work week are considered to be overtime exempt under this exemption.

- ✓ Wisconsin's prior secondary agriculture exemption only applied to construction type activities on the farm. The new exemption applies to custom farm-type activities performed by non-agricultural employers.

Impact of Recent [August 23, 2004] changes to federal salary overtime exemptions on state salary overtime exemptions

- ✓ At this time Wisconsin has not chosen to adopt the federal changes into the state overtime regulations.

- ✓ Businesses located in Wisconsin will have to comply with both the new federal salary overtime exemption standards and the Wisconsin salary overtime exemption standards in order to consider a salaried overtime employee exempt.

- ✓ The most noticeable impact of the federal changes is the increased salary standard of $455 per week.

- ✓ The most noticeable difference in the state salary overtime exemption standards is the requirement that workers not spend more than 20% of their working hours performing non-exempt work.

[1/] Wisconsin Department of Workforce Development.

IMPACTS OF THE 2004 GROWING SEASON ON SILAGE QUALITY

Joe Lauer[1]

Most farmers and agronomists were happy to put the 2004 growing season behind them! The season can best be characterized as wet during May and June, cool during July and August, and ideal during September. Spring planting conditions were good through early May after which conditions were cooler and wetter than the 30-yr average. The north and eastern areas of Wisconsin had record rainfall during May and early June often delaying planting. Many acres in eastern Wisconsin were not planted until July. Accumulation of growing degree units was below average. Plant emergence and stands were above average. Insect and disease pressure was not significant. Corn development was behind average due to cool growing conditions, but development caught up somewhat during September. A killing frost did not occur until early-October, but in some areas light frost occurred in late August. Both corn silage and grain harvest were delayed due to slow development caused by cool temperatures during the growing season.

Yields in the UW corn silage trials were quite variable by location, but in general performed better than the 10-yr average (Table 1). Yields were above average in southwestern Wisconsin, with Lancaster the highest yielding site. The plots at Fond du Lac were variable due to wet field conditions after planting. Valders was 28% above its 10-yr average. *In vitro* dry matter digestibility and NDFD (neutral detergent fiber digestibility) was typical of previous UW trials (Lauer et al., 2004), although much variability occurred between sites with northeastern Wisconsin sites tending to have higher quality values.

Table 1. Summary of the 2004 UW corn hybrid performance trials for silage yield (T/A) conducted at nine locations in Wisconsin. N = number of hybrids tested.

	1994-2003		2004		Percent
Location	N	Yield	N	Yield	yield change
Arlington	491	9.4	52	9.7	2
Lancaster	491	7.9	52	10.1	27
Fond du Lac	476	8.5	57	7.7	-10
Galesville	477	8.6	61	9.1	6
Chippewa Falls	104	7.5	51	8.1	8
Marshfield	486	6.8	52	7.1	5
Valders	491	6.6	52	8.5	28
Rhinelander	42	6.3	27	6.4	2
Spooner	84	6.6	54	7.9	19

Data collected during 2004 from the Arlington and Marshfield Agricultural Research Stations show that by the end of May accumulated precipitation was above the 30-yr average (Figure 1). By the first part of September total precipitation was equal to the 30-yr average. No days at either location had maximum temperatures above 90F, and rarely were daily maximum temperatures above the 30-yr average. Growing degree units (GDUs) begin to lag

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behind the 30-yr average by early June. Towards the end of August a scare occurred when the minimum temperature was 35 F on August 21.

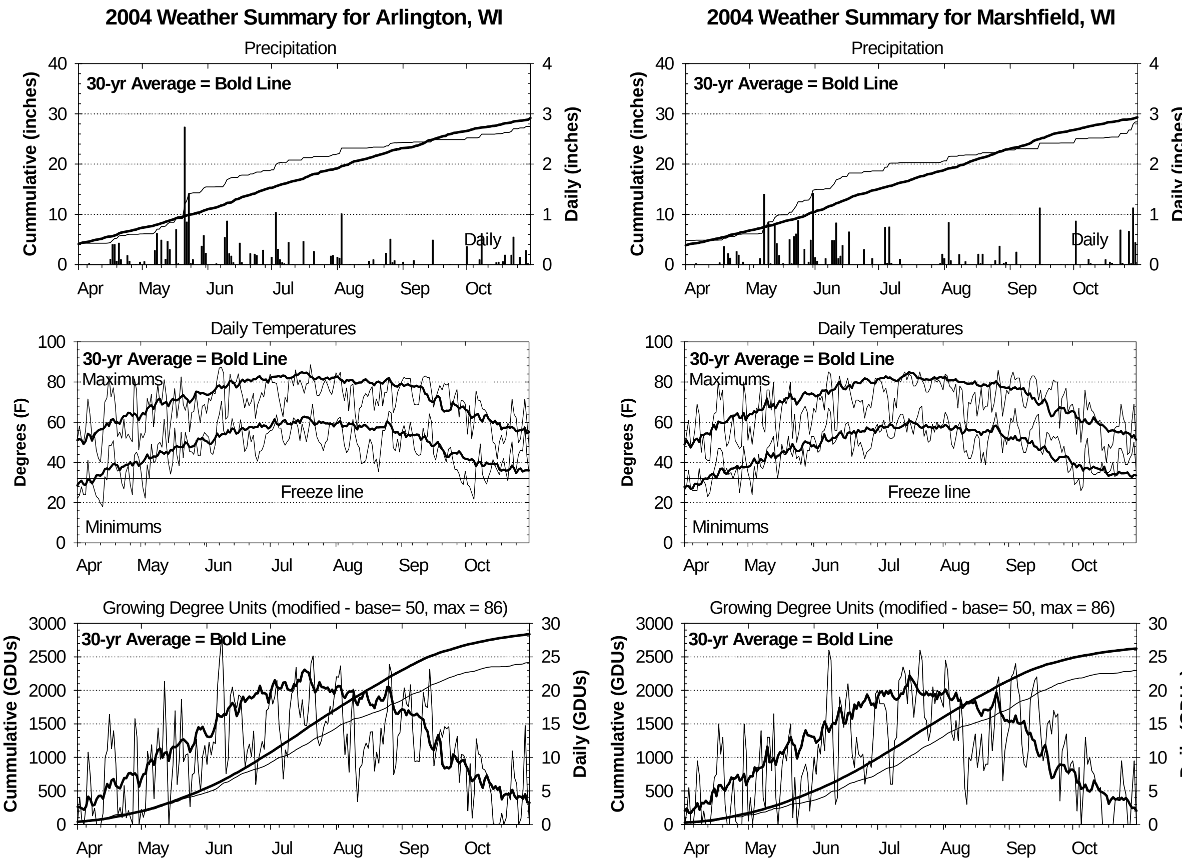

Figure 1. Precipitation, Daily Temperatures and Growing Degree Unit (GDU) accumulation between April and October during 2004 at Arlington and Marshfield, WI. Weather data were obtained from Bill Bland (AWON, UW-Soils), Mike Bertram (UW-ARS) and the Midwest Region Climatological Center.

Corn forage is unique among forages. Like most other forages, optimum quality occurs just prior to flowering (Figure 2E). Like other forages, quality decreases as harvest is delayed after flowering due to decreasing stover digestibility (Figure 2C). Unlike other forages, as corn nears maturity, quality improves due to greater starch content in corn grain (Figure 2D). By maturity forage yield (Figure 2A), milk per ton (Figure 2E), and milk per acre (Figure 2F) are maximized. Harvest timing is dependent upon optimum moisture content (Figure 2B) for the storage structures.

Table 2 describes what is known in the literature for the response of corn silage to climatic effects and cultural practices. Temperature effects at different growth stages under well watered conditions have shown that high temperatures before tassel emergence increase forage yield, but later during grain filling greatly influences the rate of dry matter production. Higher temperatures tend to reduce digestibility due to increased cell wall content and decreased cell wall digestibility of the stover. Greater light intensity has the same effect on forage yield, particularly the grain fraction, and also the nutritive value of the stover by decreasing sell wall contents.

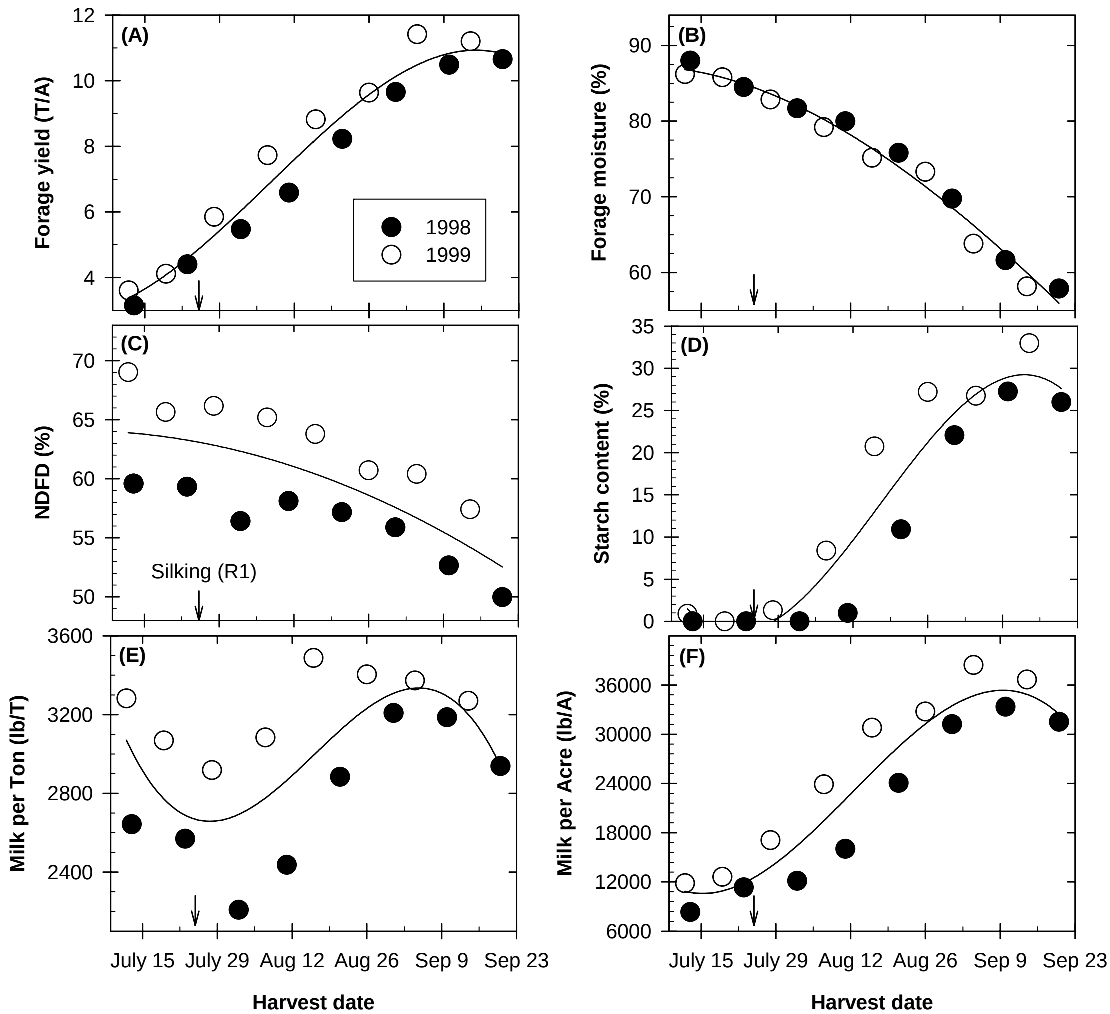

Figure 2. Forage yield, moisture, NDFD, starch content, milk per ton, and milk per acre of corn harvested at Arlington during 1998 and 1999. The arrow indicates the average silking date of July 25. Derived from Darby and Lauer (2002).

These developmental relationships are important as we attempt to describe the impact of the 2004 growing season on corn silage quality. The dominant climatic effect and cultural practice change during 2004 were cooler temperatures and delayed planting. Both decrease corn silage yield. But, little effect on silage yield was observed this year in the UW corn trials (Table 1) because sites were planted early. Only the Fond du Lac site was impacted and that was due to soil water ponding. Most farmers would have seen reduced forage yield given these conditions.

Delayed planting can increase or decrease NDFD (Table 2). Cooler temperatures improve NDFD. At silking, NDFD is greatest, and decreases as the crop approaches maturity (Figure 2C). Many fields in Wisconsin had delayed planting dates and when combined with cooler temperatures effectively delayed development with harvest “earlier” developmentally resulting in higher NDFD, especially in northeastern Wisconsin.

Table 2. The yield and quality response of silage corn to climatic effects and cultural practices.

Factor	**Forage yield**	**Dry matter digestibility**	**NDF**	**NDFD**
Increasing temperature	+	-	+	-
Increasing light intensity	+	+	-	±
Increasing stand density	+	-	+	±
Delayed planting date	-	-	+	±
Delayed harvest date	-	-	+	-
Increasing N rate	+	-	+	±

Source: (Struik, 1983) and (Deinum and Struik, 1989) as modified by (Coors and Lauer, 2001).

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IMPACT OF AGRONOMIC PRACTICES ON SOYBEAN SEED QUALITY

Roger Borges [1/]

A single soybean variety can express a wide range of grain protein and oil content when exposed to different environmental conditions. Information about the impact of manageable factors on the protein and oil content of soybeans grain is scarce at best.

Eight thousand eight hundred and forty nine soybean grain samples from 72 experiments were analyzed for protein and oil content at the University of Wisconsin in Madison. The two main objectives were (1) to identify management practices that can have an impact on soybean grain composition, and (2) to demonstrate the extent to which some management variables can impact the protein and oil content of soybean grain.

Grain from over 200 fields planted with NK S20-F8 soybean revealed several significant correlations between soil and grain variables (see companion slides). A randomized complete block design in six site years showed up to 20% increase in protein concentration and 16% decrease in oil concentration as soil pH rouse from 4.5 to 7.0. A rhizobium inoculant study conducted as a complete randomized block design at two locations showed a positive correlation between nodule counts at R1 and protein output per acre. A randomized complete block study on row spacing and plant density showed a higher protein and lower oil content at 19 cm compared to 75-cm row spacing.

Higher plant densities also increased protein and decreased oil contents. Addition of soil amendments such as animal manure and paper mill residue increased the protein content of soybean grain at multiple locations.

Fifty-six soybean plots from a long-term corn/soybean rotation study were evaluated to determine the effects of crop rotation and tillage has on grain composition. The trail consists of two different tillage systems and seven different crop rotations. More year of consecutive soybean in conventional tillage systems tend to lower the protein concentration of soybean grain. Also, higher protein and lower oil concentrations were observed in no-till plots compared to tilled plots.

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FUTURE DEMAND FOR CORN AS AN INDUSTRIAL INPUT

T. Randall Fortenbery [1/]

Industrial uses of corn have increased significantly in recent years. It is currently estimated that 26% of total consumption of US corn this marketing year will be comprised of food and industrial uses. The largest single factor in the growth of industrial use has been increased corn use in ethanol production. Ethanol production alone is expected to consume almost 13% of the record corn crop harvested fall 2004. Further, as additional ethanol plant capacity develops in the near term, this percentage is likely to increase.

While much of the current discussion of corn as an industrial input is focused on ethanol, technologies are developing that could make corn starch an important input in other industrial processes as well. The growth in industrial corn markets, however, will result in demands for specific corn traits based on use. It is anticipated that this will result in a more heterogeneous market for corn, with prices differing based on specific characteristics.

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HOW AN ETHANOL PLANT WORKS

Erik Huschitt [1/]

Ethanol at a Glance

- 82 ethanol plants currently have the capacity to produce nearly 3.5 billion gallons annually.
- It is estimated that the ethanol industry produced 3.35 billion gallons in 2004 up from 2.8 billion gallons in 2003. That is almost 20% growth in one year.
- There are 16 ethanol plants under construction with a combined capacity of over 750 million gallons.
- If one were to think real big and imagine a 10% share of the U.S. motor gasoline market, ethanol could grow to a 13 billion gallons industry.

Dry Milling Process

[1/] Commodity Merchandiser, Badger State Ethanol, Monroe, Wisconsin.

Improve Your Profit Potential From the Field to the Fuel Pump

Fuel Your Profits [sm] is a Processor Preferred® High Fermentable Corn (HFC) solutions package offered to dry mill ethanol plants and corn growers.

Processor Preferred High Fermentable Corn products can deliver higher levels of fermentable starch. This characteristic makes ethanol production more efficient and increases profit potential for ethanol plants and you.

Processor Preferred High Fermentable Corn products are as dependable as they are consistent. High Fermentable Corn products are selected for their solid agronomic characteristics and ethanol yields. With Processor Preferred High Fermentable Corn, you can get top performance in the ethanol plant and in the field.

Monsanto scientists confirm the value of Processor Preferred HFC products through worldclass research and quality control. Monsanto also offers:

- Leadership in bringing biotech trait solutions to the marketplace.
- One of the largest and most diverse pools of corn germplasm.
- Two of the only labs in the world with ISO 17025 accreditation for grain analysis, which ensures data is repeatable, reliable and consistent.
- Development of measurement tools that help processing plants determine the most effective products for producing ethanol.

How Can You *Fuel Your Profits?*

By enrolling in *Fuel Your Profits* and planting Processor Preferred High Fermentable Corn, growers can:

- ▲ **Capture the opportunity to become a preferred grain supplier to the expanding ethanol industry.**
  - ■ The ethanol industry has grown significantly in the last 20 years, and dry mill production capacity is rapidly expanding. The ethanol industry already consumes about one billion bushels of corn per year. By 2012, the industry could use 20 percent of U.S. corn production.[1]
- ▲ **Utilize a natural market for biotech crops.**
  - ■ Processor Preferred High Fermentable Corn is offered in over 90 independent seed brands and a wide selection of biotech traits. Roundup Ready®, YieldGard® Corn Borer and YieldGard Rootworm traits have been proven to increase yields in the field. By having the choice to select the right hybrids that fit your farm, you have the potential to improve your profitability while participating in this enduse market.
- ▲ **Improve the return on investment as an ethanol plant growerinvestor.**
  - ■ More than 60% of the ethanol plants across the U.S. are farmerowned. Thousands of growers have recognized the value-added benefits of ethanol production, thus capitalizing on profits from the plants' proceeds as well as ensuring a reliable market for their crop.[1]

[1] 2004 Renewable Fuels Association "Synergy in Energy" guide

BETTING THE FARM ON RACEHORSE HYBRIDS

J.G. Lauer and D.R. Hicks[1]

Seed agronomists often talk about "racehorse" hybrids (RH) and suggest they are high yielding and require extra good growing conditions to express their high yield potential. Other terms used by company seed agronomists to describe RH hybrids include “offensive/defensive” and “fix/flex” hybrids. They suggest planting RH hybrids on the best, most productive fields. We wondered if we could identify RH hybrids from yield tests and if so how much better do they perform compared with other hybrids under high yielding conditions? And how do they perform when growing conditions are not as good for corn growth and yield?

Eberhart and Russell defined a stable hybrid as one with “the ability to show a minimum of interaction with the environment.” They concluded that a stable hybrid would have a regression coefficient of 1 when the yield of a hybrid grown in several environments is regressed on an environmental index (EI). The EI for each hybrid is expressed as the deviation (bu/A) of the trial average yield from the grand mean of all trials where the hybrid is grown. A stable hybrid is shown graphically in Figure 1. If hybrids exist that yield better in high yielding environments, their regression coefficients should be greater than 1. Likewise, hybrids may exist that yield better than others in low yielding environments with regression coefficients less than 1. These we would call “workhorse” hybrids (WH) and are shown graphically in Figure 1. If RH and WH hybrids exist, then ideally a RH hybrid might yield as well as stable hybrids in low yielding environments and yield higher than stable hybrids in high yielding environments (shown in Fig. 2 as an “Ideal RH” hybrid). And ideally, if they exist, there might be WH hybrids that yield competitively in high yielding environments and yield higher than stable hybrids in low yielding environments (Fig. 2, “Ideal WH” hybrids).

We used the Eberhart and Russell stability analysis to characterize hybrids into categories with regression coefficients greater than 1, not different from 1, and less than 1 and called them "racehorse, stable, and workhorse" hybrids, respectively. We believe this is the concept that growers have regarding these terms associated with corn hybrids, i.e. RH hybrids yield better in high yielding environments and WH hybrids yield higher in low yielding environments.

We used corn yield information from the 2003 Minnesota County Corn Grower Strip Trials, the 2003 Central Missouri Corn Performance Trials, and corn yield trials from several states which are included in the University of Wisconsin SELECT data files for corn hybrids. For the first two data sets, we chose the highest yielding ten hybrids, ten average yielding, and the ten lowest yielding hybrids and calculated the regression coefficients for each hybrid.

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For these preliminary data sets, we assumed that the highest yielding hybrids would include RH hybrids and the lowest yielding hybrids would include WH hybrids, if they existed.

For all groups of hybrids from the MN county trials and the Missouri central location tests, there were no significant differences among regression coefficients within hybrid groups and no significant differences for regression coefficients among groups. All hybrids were stable in that the regression coefficients were not different from 1.0. Generally, the highest yielding groups of hybrids had higher average yields in low and high yielding environments than did the average yielding group. Likewise, the low yielding groups of hybrids consistently yielded lower in all environments than did the average yielding groups. These data are graphed in Figures 3 and 4 for hybrid groups, averaged over ten hybrids in each group. The average regression coefficients and average yields are shown for each hybrid group for each data set.

The SELECT data set included 2,563 hybrids from university corn performance trials for years 1996 to 2003 and for states including Wisconsin, Minnesota, Illinois, Iowa, Kansas, Michigan, Nebraska, Pennsylvania, and Wyoming. Regression coefficients (b's) were calculated for all hybrids entered in at least 7 trials and grouped into those with b's greater than 1.0, not different from 1.0, and less than 1.0. The summary of these groups of hybrids is given in Table 1.

Of the 2,563 hybrids in the data set, 86% were stable with regression coefficients not different from 1.0. As a group, the stable hybrids averaged 164 bushels with a range of 95 bushels per acre. In these trials, environments ranged in yield by 120 bushels per acre. Only 6% of the hybrids could be classified as RH hybrids with regression coefficients greater than 1.0. As a group, the RH hybrids yielded higher on average than did the stable hybrids (167 vs. 164 bu/a). They yielded higher in high yielding environments and lower than stable hybrids in the very low yielding environments. For these trials, the RH hybrids ranged in yield by 139 bushels per acre, indicating that as a group they are more risky across environments than are stable hybrids. Only four were classified as Ideal RH hybrids that yielded higher than stable hybrids in low yielding environments.

About 7% of the hybrids could be classified as WH hybrids with regression coefficients less than 1.0. The WH hybrids had a yield range of 83 bushels per acre and yielded higher than either stable or RH hybrids in very low yielding environments, but yielded lower than either stable or RH hybrids in the higher yielding environments. There were 12 hybrids classified as Ideal WH hybrids and there were a few hybrids that showed no relationship to changes in yield as yield levels changed with environments. This group had regression coefficients which were not different from 0.0.

Racehorse and Workhorse hybrids may exist, but at a very low frequency among comercially available corn hybrids. Most corn hybrids are stable – that is their performance is similar to most other hybrids and is not appreciably affected when grown in a wide range of low to high yielding environments. We believe that corn growers should continue to choose high yielding corn hybrids based on unbiased yield information averaged across several environments. Testing environments should be in the geographic area where hybrids are properly maturity adapted. Growers should also consider other agronomic traits that are important to their corn growing area. This process of choosing hybrids should result in producing maximize grain yields and profits over a range of years.

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Table 1. Summary of hybrid categories for SELECT file.

				Predicted grain yield in EI		
Hybrid class	**N**	**%**	**Slope**	**Low**	**Average**	**High**
			Bu/EI	**Bu/A**	**Bu/A**	**Bu/A**
Racehorse	**141**	**5.5**	**1.28**	**91**	**167**	**230**
Ideal Racehorse	**4**	**0.2**	**1.30**	**131**	**168**	**234**
Stable	**2198**	**85.8**	**1.00**	**112**	**164**	**207**
Workhorse	**187**	**7.3**	**0.74**	**115**	**159**	**198**
Ideal Workhorse	**12**	**0.5**	**0.71**	**105**	**154**	**184**
No relationship	**21**	**0.8**	**0.00**	**---**	**---**	**---**
Total	**2563**	**100**				

Fig. 1. Graphic representation of Racehorse, Stable, and Workhorse hybrids

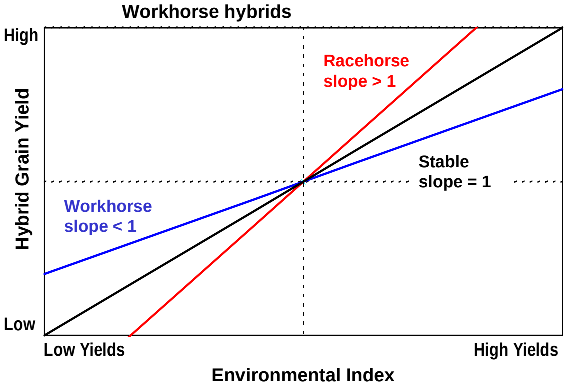


Fig. 2. Graphic representation of Ideal Racehorse and Ideal Workhorse hybrids

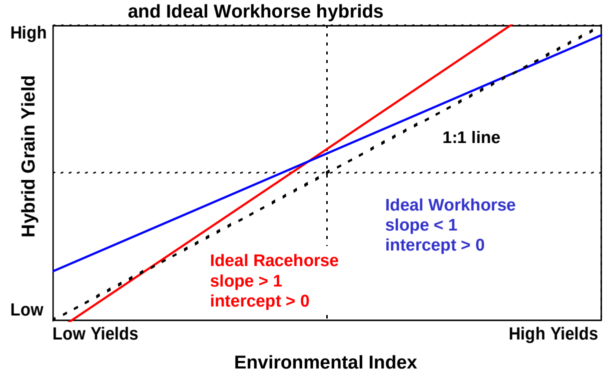


Fig. 3. Three groups of hybrids based on yield levels, Minnesota County Corn Tests, 2003.

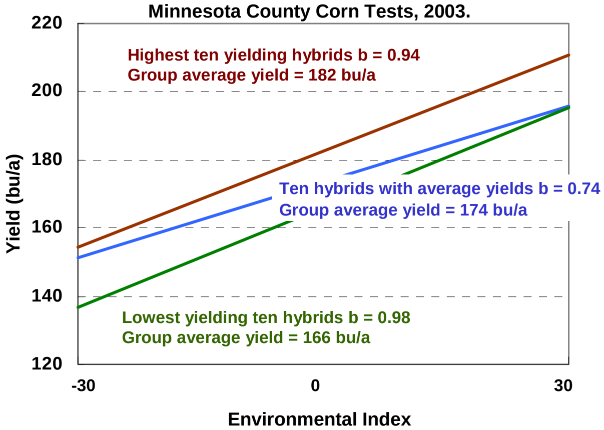
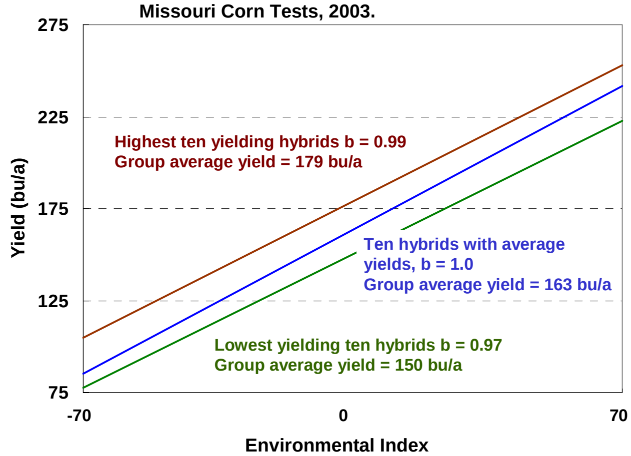


Fig. 4. Three groups of hybrids based on yield levels, Central Missouri Corn Tests, 2003.



CRUISER-TREATED SNAP BEANS FOR INSECT MANAGEMENT

Jeff Wyman[1] and Scott Chapman[2]

In the Midwestern United States, snap beans are grown primarily for processing with production areas in Wisconsin, Illinois, Minnesota, and Michigan. Wisconsin ranks first nationally with 35% of national production on over 80,000 acres valued at $36 million annually.

The most damaging insect pests are those that attack the pods and result in either damage or contamination of the processed product. The European corn borer (ECB) and to a lesser extent the corn earworm (CEW) are the major pod feeding pests with damage primarily from second generation ECB and late flights of CEW in August/September. Damage from both species occurs from flowering to harvest, creating a treatment window of 30 to 7 days before harvest. Pods are protected during this window wit a 2-4 spray program when crop maturity coincides with moth flights. A typical spray program in Wisconsin includes pyrethroid sprays (Capture, Warrior or Mustang Max) sometimes used in rotation with an organophosphate (Orthene).

Although much of the insecticide used on snap beans is targeted at bloom/pod pests, there is never the less a complex of insects with frequently attacks snap beans prior to bloom. These insect pests in Wisconsin have traditionally been the seed corn maggot (SCM) and potato leafhopper (PLH).

SCM adults lay eggs in the soil over freshly planted bean seed and larvae (maggots) tunnel in germinating seeds and plants causing seedling distortion and stand loss. Control of SCM has been achieved with a seed treatment using the organophosphate insecticide Lorsban with most of the snap bean acreage being treated.

PLH adults migrate into emerged beans and feed by extracting sap and causing leaf chlorosis, necrosis and yield loss. Control of PLH is achieved with foliar sprays at threshold using low rates of pyrethroids (Capture, Warrior, Asana, and Mustang Max), organophosphates (Dimethoate) or carbamates (Sevin, Lannate).

In the past 3-5 years, two additional pre-bloom insect pests have become prevalent and emphasized the need for an effective pre-bloom insect management program. The bean leaf beetle (BLB) which was primarily a problem in

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southern Midwestern production areas, has increased its range in recent years and is now established in parts of Wisconsin and Minnesota. Foliage feeding by first generation adults must be controlled early to avoid pod feeding by the second generation and foliar sprays used for PLH are equally effective against BLB.

The second newly introduced pest is the soybean aphid that was first noted in Wisconsin in 2000. Although not a direct pest of snap beans, the soybean aphid reproduces prolifically on soybean and the winged migrants have become significant vectors of virus diseases on late planted snap beans. Cucumber mosaic virus (CMV) and alfalfa mosaic virus (AMV) are present in all Wisconsin production areas and have caused significant yield and quality losses annually since 2001. Additionally, feeding by the large flights of winged soybean aphids occurring from July through August have been associated with phytotoxicity symptoms on snap beans which are also thought to reduce yield. Virus transmission cannot be prevented by foliar insecticide sprays since viruses are transmitted in seconds and large influxes of winged aphids occur daily. However, the potential for reductions of secondary virus spread within fields and the reduction of phytotoxic injury on plants has resulted in the use of both pyrethroid (Capture, Warrior, and Asana) and organophosphate (Dimethoate and Orthene) foliar sprays during the pre-bloom period.

Pre-bloom insect protection in snap beans is often required for only the first 30 days of the crop since the pod protection program for ECB effectively controls all insects for the remainder of the season. Seed treatments which are incorporated on the seed in small amounts prior to planting represent a potential new delivery system for insecticides with systemic activity which could provide effective early season protection during the pre-bloom period. Two neonicotinoid insecticides, imidacloprid (Gaucho, registered in 2003) and thiamethoxam (Cruiser, registered in 2004) are now available to the industry and these were evaluated for efficacy against pre-bloom insect pests in 2003 and 2004.

In small plot replicated trials at the Arlington Agricultural Research Station, seed of Histyle variety snap beans was treated with insecticide and planted late (July 14 in 2003 and July 8 in 2004). Lorsban (62 g a.i./100 Kg seed), Gaucho (60 g a.i./100 Kg seed in 2003), Poncho (125 g. a.i./Ha in 2004) and Cruiser (30, 50 and 75 g a.i./100 Kg seed) were evaluated. The late planting was used to evaluate SCM, PLH, aphid and impact on virus spread.

SCM control was evaluated by carefully examining emerged seedlings for larval feeding at 2 weeks after planting. Final plant stands and percent damaged plants were recorded (Table 1 and 2). PLH control was evaluated with weekly sweep counts (20 sweeps/plot) and is presented as season totals since populations were low. Winged and wingless soybean aphids were counted weekly on 10 leaf samples and are also reported as season totals (Table 1). In 2003, prior to harvest, 2 x 10 leaf samples were taken and analyzed for cucumber mosaic virus using ELISA assays (Table 1). In 2004, aphid populations were very low and winged and wingless totals were combined (Table 2). Plots were mechanically harvested for yield both years (Tables 1 and 2).

In 2003, SCM damage was moderate and stands in the untreated control were significantly reduced (Table 1) compared to all seed treatments. Damaged seedlings were also significantly higher in the untreated control than the seed treatments that did not differ significantly.

Yields, which were very low in 2003 as a result of dry conditions, were significantly higher in all the nicotinoid seed treatment plots (Table 1) than in the untreated controls. The Lorsban treatment was intermediate and since SCM control in this plot was similar to that in the nicotinyl treatments it is assumed that the higher yields in the nicotinyl plots resulted from superior control of foliar feeding aphids.

In 2004, SCM injury was low but plant stand was significantly lower in the untreated control (Table 2) than in the seed treatment plots. Seed treatments did not differ in plant stand. The proportions of damaged plants were also higher in the control than in the seed treatment plots which did not differ significantly from each other.

Yields were much higher in 2004 and the seed treatment plots significantly out yielded the untreated control. Poncho treated plots had the highest yield but these were not significantly better than those in the Lorsban and higher rate Cruiser plots (Table 2).

In 2003, potato leafhopper populations were low throughout sampling and although fewer leafhoppers were generally found in the seed and foliar treated plots these did not differ significantly from the control.

Soybean aphids were counted weekly with winged and wingless forms counted on leaf samples. Winged aphids peaked on July 29 when a sudden influx was noted. Populations declined equally rapidly and since over 90% of winged aphids were present on 7/29, season totals only are presented in Table 1. The nicotinoid seed treatments provided 30-40% reduction in alate aphid numbers that were occasionally significantly lower in weekly count analysis. However, none of the systemic nicotinoid treatments provided commercially acceptable control of winged aphids and all plots were infected 100% with cucumber mosaic virus.

Control of wingless aphids was slightly more effective with the Cruiser treatments being better than the Gaucho treatment. However, none of the seed treatments provided acceptable wingless aphid reduction.

Yields (Table 1) were significantly higher in the nicotinoid seed and foliar spray plots than in the control and reflected a combination of aphid control and SCM damage.

In 2004 potato leafhopper populations were extremely low throughout the season and no significant differences were seen among any of the treatments in PLH adults or nymphs (Table 2).

Soybean aphids were also extremely low in 2004 and table 2 represents the combined season totals of both winged and wingless aphids. No differences were detected between the plots in aphid numbers and since these were so low, no virus assays were conducted.

The impact of neonicotinoid seed treatments on prebloom insect control in commercial snap beans was also evaluated in 2004. In cooperation with Del Monte Foods seven commercial snap bean fields in Central Wisconsin, ranging in size from 50 to 160 acres with planting dates ranging from 5/27 through 7/20 were selected for study. Each field was split into approximate halves and seed in one half was pretreated with Lorsban (62 g a.i./100 Kg seed) and the other with Cruiser (50 g a.i./100 Kg seed). Agronomic practices, weed control, disease control and corn borer control were the same in both halves but prebloom insect control was dependent on weekly scouting. Fields were scouted weekly from emergence to pod formation using 25 sweeps and 25 leaf samples/sample site. There were 10 sample sites per field half. Potato leafhopper adults were counted in sweep samples and leafhopper nymphs and soybean aphids were counted on leaves. Capture 2E at 1.5 fl. oz/acre was applied to whole or half fields based on scouting data. Yields were taken at harvest.

Insect populations in the pre-bloom period during 2004 were extremely low throughout Central Wisconsin. No injury from seed corn maggot was seen I any fields and no differences in plant stand was detected. PLH populations were highest in the first 3 May/June plantings and in these both the Cruiser and Lorsban field halves each required a supplemental spray (Table 3). In the next 2 planting dates only the Lorsban halves required treatment and in the final 2 plantings no foliar sprays were applied.

Soybean aphids (Table 3) were essentially absent from all fields and no virus assays were conducted.

Yields ranged from 5.4 to 9.5 tons/acre (Table 3) and were not related to insect control. Overall, a slight yield advantage was gained from Cruiser use (0.23 tons/acre) but this was not significant.

These studies demonstrated that nicotinoid seed treatments have the potential to provide pre-bloom protection against the primary insect pests of snap bean. The systemic efficacy of the nicotinoids provides growers with an organophosphate alternative to Lorsban seed treatment and Dimethoate foliar spray, which could be an added value as the Food Quality Protection Act proceeds with its review of organophosphate insecticides.

The impact of systemic seed treatments was least against the soybean aphid where little reduction of either winged or wingless aphids were seen in 2003 when aphid populations were high and the systemic neonicotinoid seed treatments had no effect in reducing spread of CMV to snap beans in late season. The commercial field trials demonstrated that Cruiser was an effective seed treatment alternative to the organophosphate Lorsban for seed corn maggot which could also provide systemic control of bean leaf beetle and potato leafhopper.

Table 1. Control of foliage feeding insects on Hystyle variety snap beans treated with seed and foliar insecticides. Entomology Research Farm, Arlington, WI 2003.

Treatment	Rate (g. a.i./100 Kg)	Seed corn maggot damage		Season total PLH (20 sweeps)	Season total soybean aphids/10 leaves[3]		%CMV	Yield (tons/a)
		Final stand	% damaged plants		Winged	Wingless		
Untreated	---	211 b	9.3 a	5.8	91	180	100	1.1 b
Seed treatments[1]								
Lorsban	62	280 a	3.5 b	3.8	102	178	100	1.3 ab
Gaucho	60	263 a	2.3 b	9.6	72	147	100	1.4 a
Cruiser	30	264 a	2.5 b	3.8	63	109	100	1.4 a
Cruiser	50	279 a	4.3 ab	2.8	65	104	100	1.4 a
Cruiser	75	241 a	3.0 b	3.3	72	95	100	1.5 a
Foliar sprays[2]								
Dimethoate	16 oz./a	---	---	2.1	73	140	100	1.4 a
Warrior	3.2 oz./a	---	---	2.1	76	110	100	1.4 a

[1]Planted 7/14, [2]Sprayed 7/29, 8/8, 8/13, 8/21, [3]Weekly counts 7/29-8/28.

Table 2. Control of foliage feeding insects on Hystyle variety snap beans treated with seed and foliar insecticides. Entomology Research Farm, Arlington, WI 2004.

Treatment	Rate (g. a.i./100 Kg)	Seed corn maggot damage		Season total[2]			Yield (tons/a)
		Final stand	% damaged plants	PLH adults	PLH nymphs	Soybean aphids	
Untreated	---	102.25 b	6.11 a	3.75 a	1.25 a	24.00 a	7.06 c
Seed treatments[1]							
Lorsban	62	147.5 a	2.37 a	2.75 a	0.00 a	18.75 a	8.54 ab
Poncho	125 g. a.i./Ha	141.5 a	3.89 a	4.00 a	0.25 a	23.00 a	9.40 a
Cruiser	30	129.25 a	2.32 a	5.00 a	0.75 a	26.25 a	7.97 b
Cruiser	50	141.25 a	3.54 a	4.00 a	0.50 a	23.00 a	8.66 ab
Cruiser	75	142.75 a	3.33 a	2.75 a	0.00 a	23.75 a	8.69 ab

[1]Planted 7/8, [2]Weekly counts 7/16-8/24.

Table 3. Impact of Cruiser vs. Lorsban seed treatments on prebloom insect control in commercial snap bean production fields, Central WI 2004.

Field	Seed treatment[1/]	Acres	PLH adults[2/] (25 sweeps)	PLH nymphs[2/] (25 leaves)	SA[3/] (25 leaves)	Prebloom sprays[3/]	Yield (tons/a)	Yield difference (C-L) (tons/a)
1	L	73	12.7	6.0	5	1	8.33	+0.49
	C	70	18.1	24.6	3	1	8.82	
2	L	25	4.2	1.6	0	1	5.75	-1.25
	C	25	1.1	0	0	1	4.51	
3	L	75	2.3	0	0	1	9.47	-1.47
	C	75	2.5	1.8	1	1	8.00	
4	L	72	2.2	1.0	0	1	5.48	+1.85
	C	93	1.0	0.1	0	0	7.34	
5	L	80	1.6	0.2	0	1	5.86	+0.72
	C	65	0.6	0	0	0	6.59	
6	L	56	1.5	2.5	0	0	5.40	+1.76
	C	56	1.1	0.3	0	0	7.16	
7	L	74	0.2	0	1	0	6.57	-1.02
	C	74	0.4	0.3	1	0	5.55	
Average	L	---	3.5	1.6	0.8	0.7	6.58	+0.23
	C	---	3.5	3.8	0.7	0.4	6.81	

[1/] L=Lorsban @ 62g. a.i./100 Kg seed; C=Cruiser @ 50 g. a.i./100 Kg seed;
[2/] Potato leafhopper (PLH) and Soybean aphid (SA) counts are season totals.
[3/] Capture 2EC @ 1.5 fl. oz./a.

EVALUATING SNAP BEAN CULTIVARS FOR THEIR REACTION TO APHID TRANSMITTED VIRUSES

Walter R. Stevenson[1/], Ben Lockhart[2/] and Craig R. Grau[3/]

Aphid transmitted virus diseases remain at the forefront of management concerns for the processing industry. In Wisconsin during 2000, symptoms of what turned out to be a virus complex were first noted in eastern WI in a narrow strip extending from north of Milwaukee to the Door County peninsula. Additional areas reporting plant symptoms and related yield and quality loss included Michigan, southern Ontario and New York State. The problem has reappeared in each succeeding year, although the severity of losses and the distribution of the problem is largely dependant on prevailing environmental conditions and the timing of aphid flights. Several viruses including cucumber mosaic virus (CMV), alfalfa mosaic virus (AMV) and clover yellow vein virus (CYVV) alone and in combination have been identified in symptomatic plants each of the production years since 2000. All of these viruses are transmitted by aphids in a non-persistent manner. The soybean aphid appears to be the primary vector of this complex of viruses. This past summer, a year characterized by cool temperatures coupled with the limited distribution and low numbers of the soybean aphid, we observed limited distribution of symptomatic plants and a low impact of virus on pod yield and quality.

Host resistance to virus incited problems has historically been an effective tool in crop protection for many crops. Beginning in 2001, we initiated a program for screening the susceptibility of processing bean cultivars and advanced breeding lines under field conditions. In 2001, 50 plot entries were evaluated in two plantings at the West Madison Ag Research Station. There were significant differences in the susceptibility of the plot entries and plans were laid to expand the trial in 2002. Trials were planted in early and mid July including two plantings (early and late) at the W. Madison site and one planting on a grower farm near Manitowoc. Each planting contained 150 cultivars and breeding lines replicated three times. The trials contained those lines with the lowest symptom severity in the 2001 trial along with a sizeable increase in new lines. By the end of the season, there were significant differences in symptom expression between plot entries. Based on both visual and ELISA assay, there was a wide range of susceptibility among the cultivars and breeding lines included in the 2002 trial. Data from these field trials provided valuable information to breeders for use in their pursuit of virus resistance in their varietal improvement programs. The data also assisted processor personnel in making cultivar decisions, especially for those late planted fields that appear to be at the greatest risk of virus transmission from migratory aphids.

During 2003, our evaluations continued with 50 plot entries that included the most promising entries from 2003 along with additional promising entries from breeders. Plots were planted on two dates at the W. Madison Ag Research Station and on a single date on a grower farm north of Manitowoc near Denmark, WI. Although the planting dates of the 2003 trials were within two

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weeks of one another, they provided an opportunity to evaluate the plot entries under quite different conditions. Aphid pressure at all sites was heavy and all trials exhibited virus symptoms. The severity of virus symptoms on the W. Madison plots generally followed a progression of mild severity on the first evaluation, moderate severity on the second evaluation and severe at the final evaluation. There were several plot entries in either the early or late planting where the symptom severity remained mild to moderate for the entire season. However, the severity on the final assessment of the first planting at W. Madison was not predictive of the severity on the final assessment of the second planting. At the Manitowoc site, virus symptoms were severe on some lines on the first date of assessment, the plants appeared to recover somewhat by the time of the second assessment and by the time of the third assessment, severity had increased. Symptom severity declined on a few lines as the plants matured while on other entries, symptom severity was highest on the final date of assessment. Severity at the W. Madison site was not necessarily a good predictor of severity at the Manitowoc site. While pods on both plantings at W. Madison remained symptom free, pods on several entries at the Manitowoc site exhibited a range of symptoms including internal and external pod discoloration, mosaic, curvature and suture discoloration. Pod set on the two plantings at W. Madison appeared to approximate what would be considered normal. However, pod set on the same lines at the Manitowoc site ranged from a heavy set of over 15 pods per plant to a very light set of less than 5 pods per plant. ELISA evaluation of the plot entries indicated that the predominant virus in all plants was cucumber mosaic virus (CMV), although AMV (alfalfa mosaic virus) was present as well in some lines.

During 2004, we continued field testing of the most promising entries in the 2003 trial along with additional breeding lines selected by several snap bean breeders. A total of 38 entries were planted at three locations including W. Madison, Fox Lake (30 miles northeast of Madison) and Oostburg (about 90 miles northeast of Madison) (Figure 1). Soybean aphid pressure was light throughout the trial period at all locations, but flights of other aphids were observed including the corn aphid at the Fox Lake site. In general, the incidence of symptomatic plants (Figure 2) was lower in 2004 than all previous years although distinct symptoms were present on some lines in all plots. Symptom severity declined on several lines as the plants reached maturity. Several breeding lines were virtually symptom free at each of the trial sites (Table 1) (Figure 3). Some of the plot entries such as Sirio (Syngenta/Rogers), Yukon (Pop Vriend), Arras (Harris Moran) and Romano Gold (Seminis) are among those lines with the lowest symptom severity in each of the 2002-4 trials. ELISA evaluation of all plot entries by Dr. Ben Lockhart of the University of Minnesota indicates the presence of either CMV, CYVV or AMV in a relatively few plot entries, even though significantly more of the plot entries were symptomatic of virus symptoms. There were several plot entries where these three viruses were not detected on any of the sampling dates at all three field sites (Figure 4). It appears that there is still a yet to be identified virus associated with plants at each of the locations. Studies are underway in an attempt to determine additional causal viruses so that carefully designed assays can be implemented on future plant samples.

Data from this series of field trials in Wisconsin indicates several promising pieces of information that may be helpful in reducing future losses to the virus complex affecting processing beans in the Midwest.

1) Researchers have identified at least three key viruses involved in the virus complex – cucumber mosaic virus (CMV), alfalfa mosaic virus (AMV) and clover yellow vein virus (CYVV). There are likely additional, as yet unidentified, viruses involved in this complex that are vectored by aphid species other than the soybean aphid or perhaps another type of vector.

2) The severity of symptoms appears related to the population levels of the soybean aphid and the timing of aphid influx in the season as this relates to the growth and development of snap bean plantings. The early season appearance of winged soybean aphids in high populations appears to be correlated with the widespread appearance of virus symptoms, reduced pod set, lower yields and reduced pod quality.

3) Several cultivars have consistently ranked high in terms of low symptom severity and the ability to withstand a range of aphid and virus pressure. It is likely that several of the promising breeding lines will advance in commercial breeding programs and that other lines will be developed so that there are multiple options for processors to evaluate in their management systems.

We plan to continue the evaluation of promising cultivars and advanced breeding lines during 2005 at three Wisconsin locations including W. Madison, Fox Lake and Manitowoc/Oostburg to take advantage of differences in environmental conditions, aphid pressure and cultural management practices between the three locations. We plan to limit the size of the plots to the top 10 entries from the 2004 trials plus another 10-15 entries representing promising breeding lines from commercial breeding programs. We welcome your suggestions for entries into the 2005 trial.

Figure 1. Details of the 2004 snap bean variety evaluation trials.

Snap bean variety trial – virus evaluation 2004

Three locations:

- **West Madison Agricultural Research Station**
- **Two commercial fields**

Arrangement:

- **2-row plots (UW breeding lines 1-row), 20' long**
- **3 replicates**

Data collected for each trial:

- **Leaf samples for ELISA virus assay - composite sample of 10 leaves/replicate from each trial, analyzed for AMV, CMV ClYVV.**
- **Two ratings for foliar symptom severity**

	Fox Lake	**West Madison**	**Oostburg**
Planted	7/2/04	7/13/04	7/15/04
Leaf sample 1 collected	8/17	8/23	8/24
Leaf sample 2 collected	8/31	9/7	9/8
Visual rating #1	8/17	8/23	8/24
#2	8/31	9/7	9/8

Figure 2. Virus-like symptoms (mosaic, leaf malformation, thickened leathery leaves) observed at field trial near Fox Lake, WI during 2004.

Table 1. List of lines in 2004 trials and incidence of symptoms.

UW Trt No.	Source	Entry Name	In 2002 2003 trials?	Number of plants with virus symptoms per foot of row					
				West Madison		Fox Lake		Oostburg	
				23 Aug	7 Sep	17 Aug	31 Aug	24 Aug	8 Sep
1	Harris-Moran	Hystyle	2002 2003	0.25	0.12	0.27	0.06	0.02	0.23
2	Harris-Moran	Trueblue	No	0.15	0.05	0.31	0.27	0.00	0.00
3	Harris-Moran	Arras (MV-185)	2002 2003	0.02	0.01	0.37	0.13	0.00	0.00
4	Seminis	Romano Gold (08190506)	2002 2003	0.06	0.16	0.82	0.14	0.01	0.00
5	Seminis	15330733	No	0.25	0.00	0.21	0.21	0.01	0.00
6	Seminis	R00.11142	No	0.06	0.00	0.06	0.09	0.00	0.00
7	Seminis	08120670	No	0.16	0.00	0.35	0.25	0.00	0.00
8	Seminis	R00.35558	No	0.52	0.34	0.23	0.06	0.02	0.42
9	Syngenta/ Rogers	SYNMV 85	No	0.75	0.05	0.98	0.44	0.00	0.17
10	Syngenta/ Rogers	Lexus	2002 2003	0.16	0.08	1.52	0.97	0.03	0.00
11	Syngenta/ Rogers	Redon	No	0.06	0.05	0.92	1.04	0.01	0.03
12	Syngenta/ Rogers	Mayon	2002 2003	0.05	0.00	0.98	0.38	0.00	0.00
13	Syngenta/ Rogers	Sirio	2002 2003	0.06	0.03	0.08	0.04	0.01	0.06
14	Brotherton	Orion	2002 2003	0.43	0.07	1.53	1.43	0.04	0.00
15	Brotherton	#835	No	0.24	0.29	0.15	0.01	0.00	0.01
16	Brotherton	HS 906	No	0.03	0.02	0.52	0.16	0.00	0.00
17	Del Monte	IDC IX	No	0.07	0.04	0.18	0.09	0.01	0.01
18	Del Monte	IDB 374	No	0.20	0.08	2.21	1.33	0.00	0.32
19	Del Monte	IDA 555	No	0.05	0.02	0.26	0.19	0.01	0.00
20	Pure Line Seeds	PLS 87	2002 2003	0.03	0.08	1.75	0.64	0.00	0.00
21	Pure Line Seeds	PLS 118 Romano	2002 2003	0.55	0.01	0.88	0.23	0.03	0.04
22	Pop Vriend	Yellowstone	No	0.13	0.05	0.26	0.05	0.01	0.00
23	Pop Vriend	Yukon (YKN)	2002 2003	0.09	0.03	0.18	0.09	0.01	0.00
24	Pop Vriend	Artemis	No	0.09	0.06	0.39	0.14	0.00	0.00
25	Pop Vriend	Laguna	No	0.07	0.01	0.26	0.11	0.00	0.00
26	UW Hort, J. Nienhaus, M. Sass	2292.1.200	No	0.06	0.00	0.31	0.00	0.00	0.00
27	UW Hort, J. Nienhaus, M. Sass	PI309881	No	0.12	0.00	0.06	0.00	0.00	0.00
28	UW Hort, J. Nienhaus, M. Sass	2292.2.1000	No	0.10	0.00	0.08	0.00	0.00	0.00
29	UW Hort, J. Nienhaus, M. Sass	2292.11.200	No	0.00	0.00	0.08	0.02	0.02	0.00
30	UW Hort, J. Nienhaus, M. Sass	2319.1.1000	No	0.06	0.03	0.12	0.00	0.00	0.00
31	UW Hort, J. Nienhaus, M. Sass	2313.9.3000	No	0.02	0.00	0.14	0.00	0.00	0.00
32	UW Hort, J. Nienhaus, M. Sass	2313.9.1000	No	0.02	0.00	0.02	0.00	0.00	0.00
33	UW Hort, J. Nienhaus, M. Sass	2313.4.3000	No	0.02	0.00	0.39	0.00	0.02	0.00
34	UW Hort, J. Nienhaus, M. Sass	2313.9.2000	No	0.02	0.00	0.14	0.02	0.00	0.00
35	UW Hort, J. Nienhaus, M. Sass	2313.10.3000	No	0.00	0.00	0.25	0.00	0.00	0.00
36	UW Hort, J. Nienhaus, M. Sass	2319.1.3000	No	0.00	0.00	0.08	0.00	0.00	0.00
37	UW Hort, J. Nienhaus, M. Sass	2319.4.2000	No	0.04	0.02	0.18	0.04	0.00	0.04
38	UW Hort, J. Nienhaus, M. Sass	2295.5.3000	No	0.00	0.00	0.24	0.00	0.00	0.00
Pr > F				<0.01	<0.01	<0.01	<0.01	0.72	<0.01
LSD				0.34	0.14	0.58	0.35	NS	0.09

Figure 3. Average incidence of symptomatic plants inclusive of three field locations.

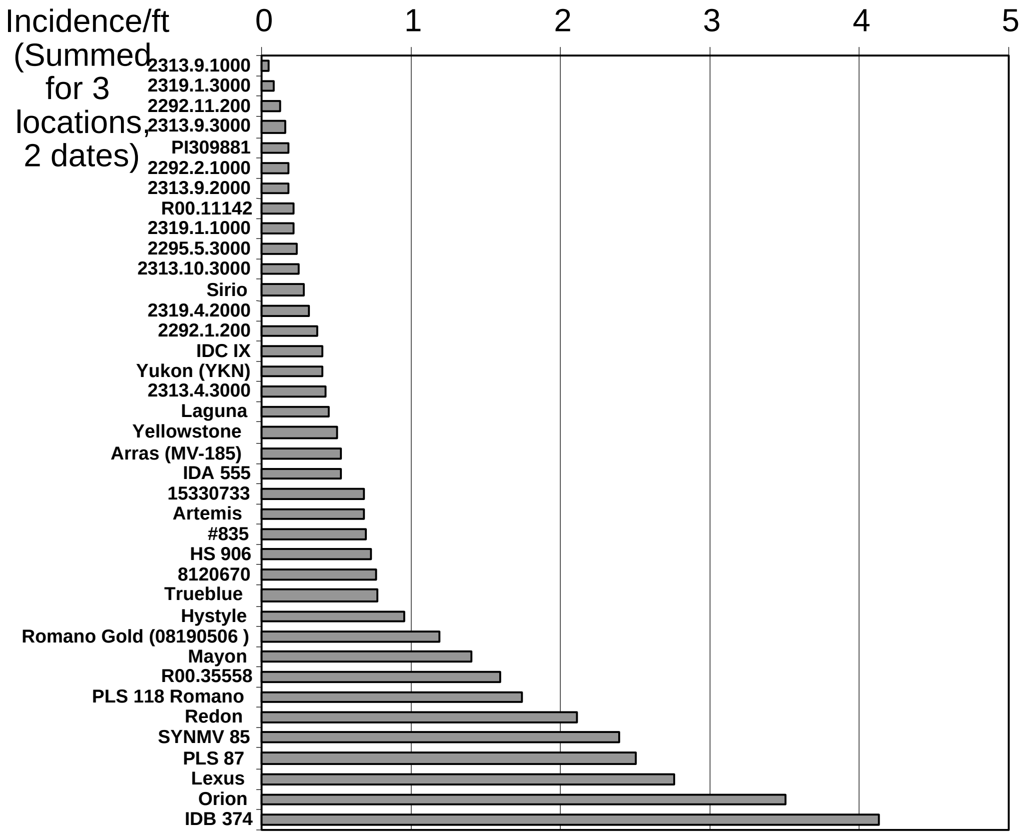

Figure 4. List of plot entries where plant viruses (AMV, CLYVV or CMV) were not detected at any of the three field plot locations.

4	Romano Gold (08190506)	**30**	2319.1.1000
7	08120670	**31**	2313.9.3000
8	R00.35558	**32**	2313.9.1000
11	Redon	**33**	2313.4.3000
20	PLS 87	**34**	2313.9.2000
25	Laguna	**35**	2313.10.3000
26	2292.1.200	**36**	2319.1.3000
27	PI309881	**37**	2319.4.2000
28	2292.2.1000	**38**	2295.5.3000
29	2292.11.200		

Pesticide Labels Vs Liability Concerns in High Value Crops

Dave Fredrickson

Wisconsin Department of Agriculture Trade and Consumer Protection

Special Registrations

- States have authority to issue Special Local Needs Pesticide Registrations
- Section 24 c of FIFRA
- ATCP 29.72 Wis. Adm. Code
- This process is for registering a new use, not already approved under FIFRA Sec 3

Special Local Needs Registration

- The product must have a section 3 registration and label
- If the same SLN is issued in >5 states EPA may question.
- If > 15 states issue a SLN-EPA will deny further Registrations
- No Unreasonable Adverse Effects

Special Registrations and Liability

- Most Special Registrations are for minor crops
- Low revenues for Registrants
- Many Minor crops are of very high value
- “Selling $50 of product to treat a crop worth $50,000”

24 c Request, April 2003

- Clopyralid for Strawberries by Dow Agrosciences on 4/23/2003
- Section 3 registration had been granted on 10/17/2002
- Risk Management Model by Dow, low sales volume and big risk of claims
- Pulled back from full label

24 c on Strawberries

- 24 c requests made to 11 states
- Most states filed with EPA
- Request to Wisconsin and Indiana were denied - Based on Sec 3 registration already accomplished
- 24 c request and labels included a Waiver of liability requirement

Liability Waivers

- Registrant X intends that this section 24 c label be distributed only to end users and growers who agree in writing to a waiver and release from all liability and indemnification by the user….

Liability Waivers

- Issue taken to SFIREG Pesticide Operations and Management Committee 4/2004
- EPA Legal Opinion that labels can not require a user to sign a waiver
- The use of Liability Waivers actually started in the NW, by state lead agencies and grower groups

Liability Issues

- Things had gotten way out of hand
- Registrants were using the SLN process to limit liability
- 24 c registrations granted for Sec 3 registered uses

Liability Issues

- Growers need Special Registrations
- Registrants Need to be concerned about Risk
- Requiring Written Waivers is not Allowed under Federal Guidelines
- Growers need to be made aware of risks

Possible Alternatives

- Incorporate The Risk and Liability statements into the 24 c Label
- Require Users to Log onto a web site to obtain labels and have a "licensing Agreement" type drop box
- Have Liability issues dealt with by a third party (e.g. Grower Group)

What Happens Next

- POM SFIREG Workgroup
- EPA will deny any Spec Reg For Sec 3 Uses
- EPA will deny Spec Regs that require a written waiver
- Bates Vs DowAgrosciences/US Supreme Court

Stinger®
EPA Reg. No. 62719-73

Postemergence Broadleaf Weed Control in Strawberry

(For Distribution and Use Only in the State of Wisconsin)
24(c) Special Local Need Registration EPA SLN No. WI____________

IMPORTANT – READ BEFORE USE!

Because of the POSSIBILITY that Use of Stinger® herbicide (the "Product") on STRAWBERRY (the "Crop") IN THE MANNER Described in this Section 24(C) Labeling COULD result in INJURY TO THE CROP and/OR yield reduction or Crop failure, USE THIS PRODUCT ONLY AFTER YOU HAVE READ AND ACCEPTED THE "SPECIAL CONDITIONS OF USE" AT THE END OF THIS LABELING!

If the Special Conditions of Use are not acceptable to you, return the unopened Product to your seller for a refund or use the Product for a different labeled use in accordance with the label affixed to the Product container.

The Special Conditions of Use are specified by the manufacturer of this Product and not the state of Wisconsin or the US EPA.

SPECIAL CONDITIONS OF USE

Dow AgroSciences (the "Manufacturer") may not have sufficient phytotoxicity (crop safety) data with respect to the use of the Product on the Crop in the manner described in this 24(c) labeling or may have data demonstrating that, under certain conditions, the Product will cause injury to Crop and resulting yield reduction or Crop failure.

(2) they assume all risk of injury to the Crop and any resulting yield reduction or Crop failure arising from or relating to use of the Product on the Crop in the manner described in this Section 24(c); and

(3) will release and hold harmless, the Manufacturer, and all parties in the chain of distribution of Product, and their respective agents and representatives, from any and all losses, damages, claims, causes of action, expenses (including attorney's fees and court costs), relating to injury to the Crop and any resulting yield reduction or Crop failure arising from or relating to use of the Product on the Crop in the manner described in this Section 24(c) labeling

Special Registrations and Liability Issues

- Questions or Helpful Comments

TRIED AND TRUE ASSESSMENT OF SNAP BEAN AND PEA ROOT ROT POTENTIAL

Walter R. Stevenson[1/] and Robert E. Rand[2/]

Wisconsin continues to rank first in the production of snap beans and the acreage planted to green peas comes in third in the nation. Yields, however, continue to be variable and depend, in large measure, on paying close attention to rotations, following crops where fumigation is used, close observation of root health and careful irrigation to avoid the ravages of white mold. The five year (1998-2002) yield average for snap beans was 3.79 ton/acre while peas averaged 1.86 tons/acre. We can all look at exceptional snap bean fields yielding close to 5 tons/acre and pea fields running 3 tons or more, but we can also recall fields where the grower is lucky to recover the cost of the seed. Root rot is one of the key limiting factors determining the yield of both crops. Years ago I heard the story about a snap bean producer who was warned by the world famous plant pathologist, Dr. J.C. Walker, that he needed to follow a minimum of a three-year rotation to avoid root rot and that the grower would have no future if he grew snap beans as a monoculture in the central sands area of Wisconsin. The grower promptly responded that he already followed a three year rotation, growing for Company A the first year, Company B during the second year and completing the rotation with Company C during the third year. I can only imagine Dr. Walker's response and wish that I'd been there in person. The story still gets a chuckle at grower meetings, but the message is still just as pertinent. Without careful attention to rotation and the root rot that accompanies a lack of rotation, disease losses can be costly. Root rot is still prevalent today, especially in seasons with wet soils during the early portion of the growing season and particularly in fields with too short a rotation between susceptible crops. The early portion of the past growing season provided the cool wet conditions that favor root rot on peas and the excessive rainfall of May and June provided just the right conditions favoring bean root rot on the early planted fields. Subsequent stands of both crops were often spotty and plant roots were commonly decayed. As we moved into July, pea fields turned yellow before harvest, maturity was spotty within fields and yields were highly variable. The saving grace for many growers was the cooler than normal temperatures that helped to reduce potential losses and the number of passed fields.

Back in the late 50's, UW researcher Dr. Don Hagedorn, developed a simple test for determining the potential for common root rot development in pea fields. Details of the soil assay include the collection of soil by processor fieldmen. Soil samples consist of at

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least 5 quarts of soil collected in a random pattern from each designated field. Samples are then transported in late fall to the UW-Madison for evaluation. Each sample is thoroughly mixed and used to fill three earthenware pots. The pots are then planted with a root rot susceptible pea cultivar, watered to maintain a moderate moisture level during germination and emergence and kept in a greenhouse at 75ºF. When plants reach the two leaf stage, the soil is thoroughly watered and kept at or near saturation to encourage root rot development. For comparison purposes, additional pots are filled with soil from a field heavily infested with the root rot pathogen. Filled pots are then planted and watered the same as the pots filled with the test soils. About 4-5 weeks after planting, when the check plants in the infested soil begin to die, each plant in every pot is carefully evaluated for symptoms of root rot based on a scale of 0 (healthy) to 4 (severe symptoms or plant death). When all the plants are rated, a Disease Index is calculated on a 0 to 100 scale for each soil sample. Samples with a low Disease Index of 0 to 50 are considered safe for planting while samples with an index of 70 or higher are considered dangerous for planting. The safety of the soils with an index of 51-69 is considered questionable, but in years conducive to root rot, it's likely that yield losses will occur in the questionable fields.

A similar procedure was subsequently developed for assessment of snap bean root rot and this test has been in use since the early 80's. Samples with a Disease Index of 0 to 40 are considered safe for planting and fields with an index of 50 or above are viewed as high risk fields where root rot is likely to appear at economically damaging levels. An index of 41-49 is considered a moderate risk and fields with this index range may suffer losses in seasons when environmental conditions are highly favorable for root rot development. While some snap bean processors have observed fewer losses to root rot when they plant in a rotation with potato where the field is fumigated with metam sodium the fall before the potato production year, there is still a benefit in using the root rot assay to help insure consistency in snap bean production.

Over the past decades of use, these tests helped processors and growers to avoid fields where the risk of root rot was judged unacceptable. While the value of the tests to the Midwest vegetable industry is poorly documented, it's likely that the tests have collectively saved millions of dollars related to improved yields crop stands and processing quality. Just a few short years ago, in an era when there were still over 25 food processors in our state, submission of soil samples was common. We routinely received over 350 soil samples each year and in addition some processors conducted their own testing program in private greenhouses. In recent years the number of samples coming to the university has declined to the point where I wonder whether the current generation of growers and processor field personnel are familiar with the value of the test for avoiding risky fields. The root rot assays are still available at the UW – Madison for a cost of $50 per soil sample. Soil samples collected in the Fall before the snow begins to fly and the soil freezes can be tested during the winter months in heated greenhouses. Results are then available prior to the contracting period so that those fields with the highest risk of root rot can be avoided until such time as the disease indices return to a safe level. Samples can also be processed in the spring as soon as fields thaw. Since it takes us over a month to process each sample and calculate the Disease Index, there may not be sufficient lead time for processors to make contracting decisions on these fields. Thus we strongly suggest collecting samples in late summer and early fall so that the information gained through sampling can be effectively used in subsequent planting decisions.

Given the amount of root rot present in many pea fields this past summer that resulted in passed acreage and reduced yield at harvest and the amount of root rot showing up in some snap bean fields, it may be time to take a hard look at resuming the use of the root rot test. For more information, check out “Analysis of the snap bean root rot potential of Wisconsin fields” at http://cecommerce.uwex.edu/pdfs/A3242.PDF.

Germination of Supersweets: Imbibitional Chilling Injury

William F. Tracy [1/]

Germination can be divided into a number of distinct stages including imbibition, starch breakdown and energy mobilization, and cell differentiation and elongation. These stages involve very different biological mechanisms and are sensitive to different environmental stimuli. Normally, during imbibition, water and oxygen move slowly into the kernel through the tipcap region. Membranes rehydrate and hormones are activated. During starch breakdown and energy mobilization, hormones induce embryo and aleurone cells to release enzymes that break down starch and convert it to sugar. Energy contained in the sugar is moved into the embryo. Embryo cells use the sugars to fuel cellular process including cell division, elongation, and differentiation. As root cells elongate the radicle emerges from the kernel followed by the plumule. After the plumule emerges from the soil the seedling begins photosynthesis and the plant becomes independent of the food supply stored in the kernel

Supersweet (*shrunken2*) kernels are more susceptible to damage during imbibition than are sugary kernels. Because of the extreme shrinkage that sweet corn kernels undergo as they dry, the pericarp often develops many tiny cracks. When kernels with cracked pericarp are planted in moist soil, water rushes in from all directions. This results in disruption of membrane reorganization. If membranes are disrupted cellular contents including sugars and salts leak out of the kernel and provide a food supply for potential seed pathogens. Cold soil temperatures greatly aggravate this situation. This syndrome is called imbibitional chilling injury.

We wanted to determine when supersweet seed is most sensitive to imbibitional chilling injury. We carried out a number of experiments to pin down the time.

Materials and Methods

Experiment 1:

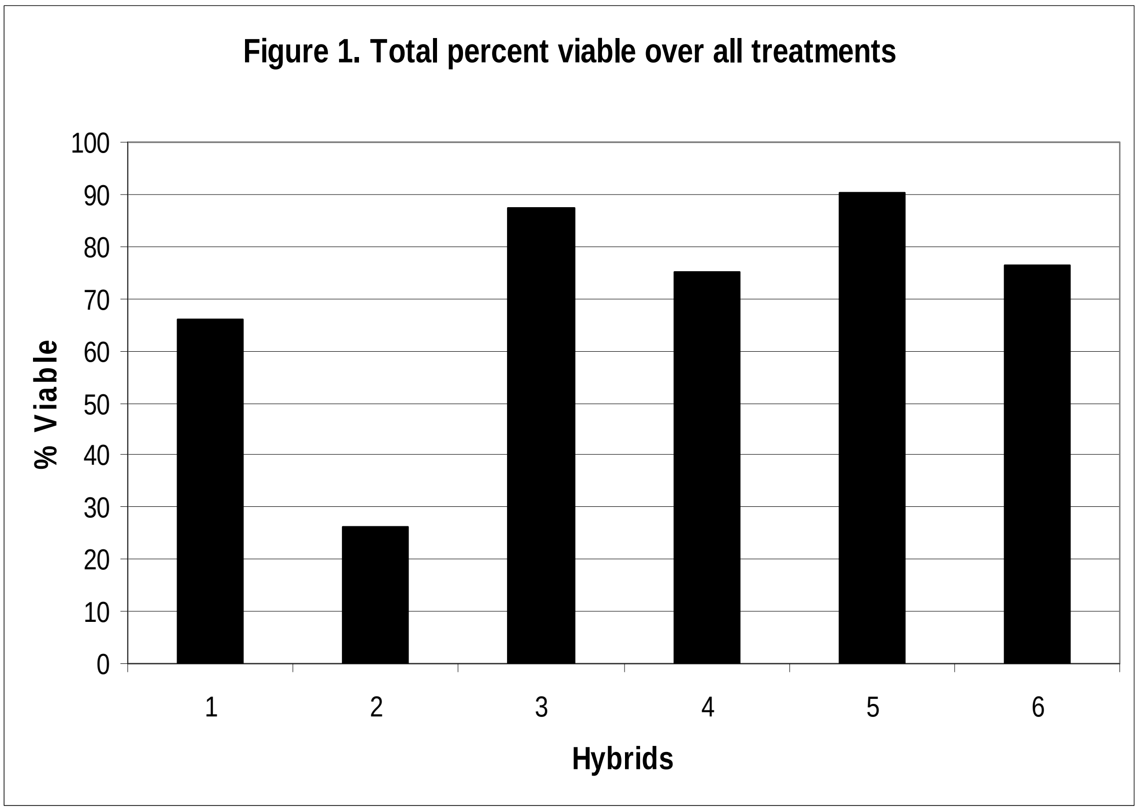
- Untreated seed of six supersweet hybrids.
- Six imbibition treatments
    - Each treatment consisted of one 24-hour period at 40°F and five days at 75°F. Treatment one consisted of the first 24 hours at 40°F and the following 5 days at 75°F. For treatment two, the seeds were exposed to 24 hours at 75°F followed by 24 hours at 40°F and then four days at 75°F and so on.

[1/] Department of Agronomy, College of Agricultural and Life Sciences, Univ. of Wisconsin-Madison.

- The treatment number corresponds to the 24-hour cold period.
- We used rag dolls with no soil.
- Eight replications 25 seeds per replication

Results

As expected the hybrids performed differently when averaged over all six treatments (Fig. 1). Hybrids 3 and 5 had nearly 90% germination, while only about 25% of the seeds in hybrid 2 germinated.



For every hybrid, treatment one resulted in significant reductions in viability (Figures 2 & 3). None of the other treatments had any significant effects on viability (Figure 2 & 3). Thus all the damage due to chilling imbibition occurred in the first 24 hours after planting. The reductions in some of the hybrids were large. In hybrid four 50% of the kernels were killed by chilling imbibition in the first 24 hours. Only about 5% of kernels in hybrid four were killed by treatment 2 (warm on day 1 and cold on day 2) and this was not significantly different from the control. Hybrids one, two and six all had greater than 30% damage due to treatment 1. On the other hand only 18% of the kernels of hybrid 5 were killed by imbibitional chilling injury on day 1. This was still a significant number.

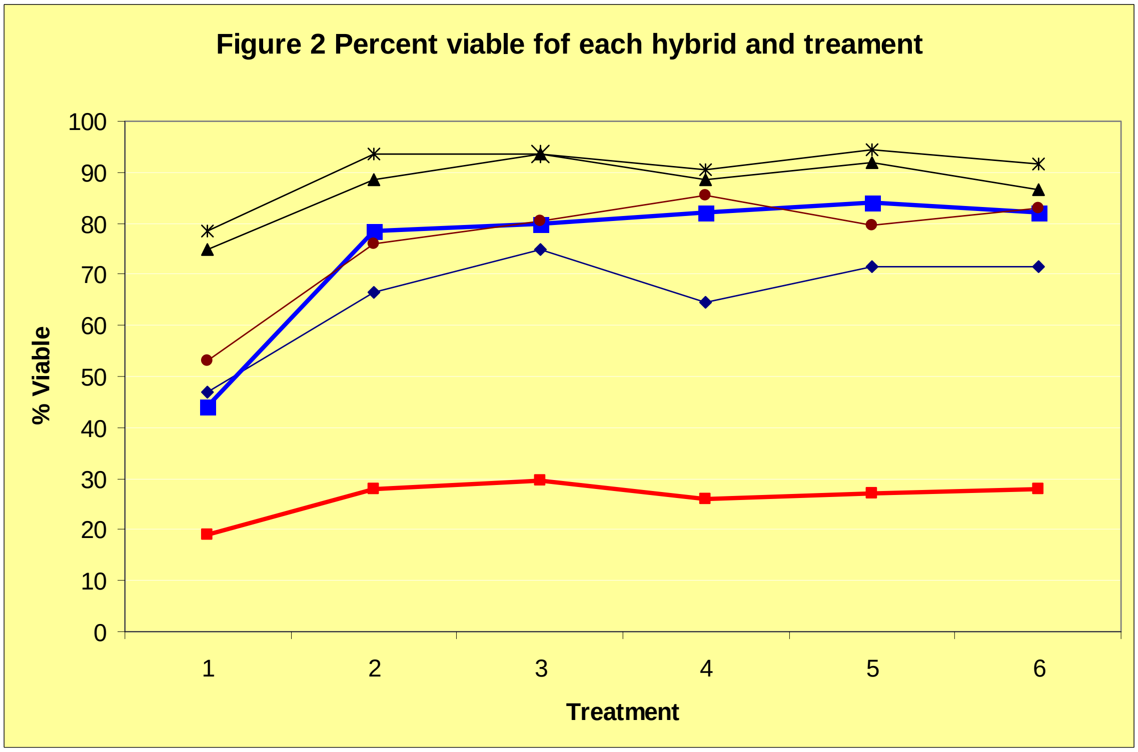


Figure 2 Percent viable fof each hybrid and treament
100
90
80
70
60
50
40
30
20
10
0
% Viable
1
2
3
4
5
6
Treatment

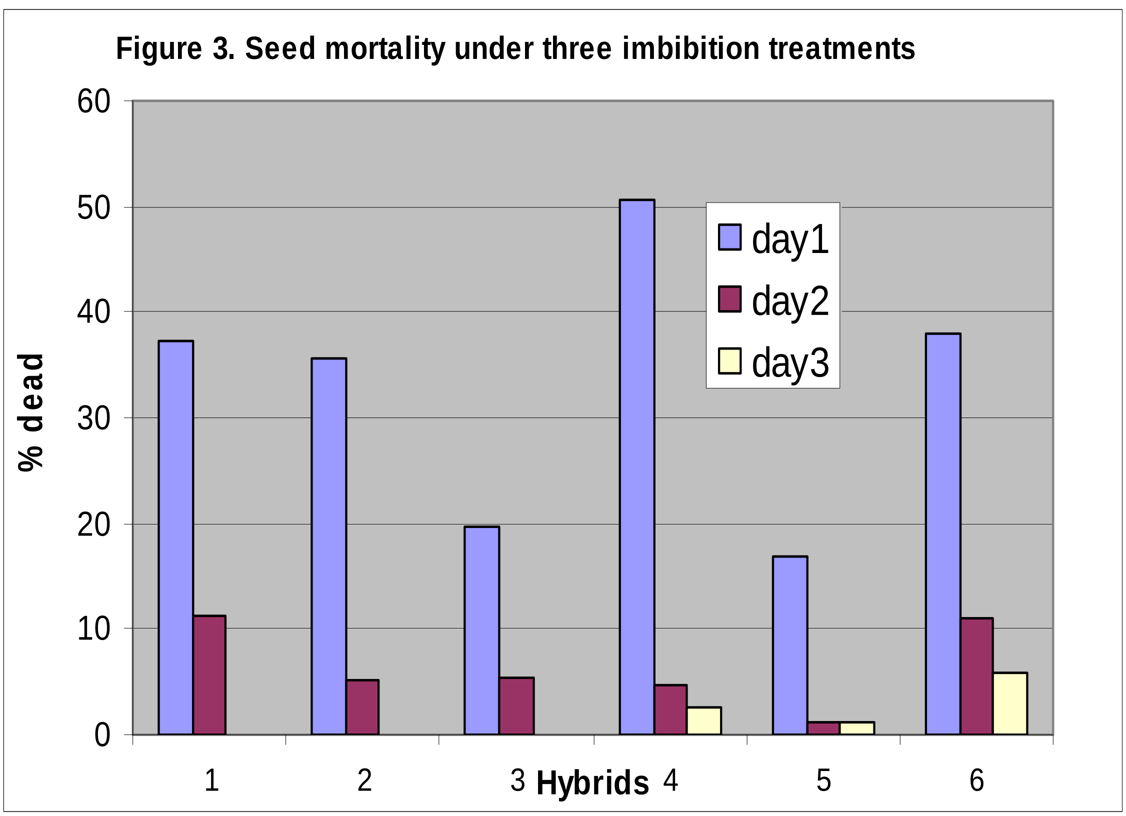
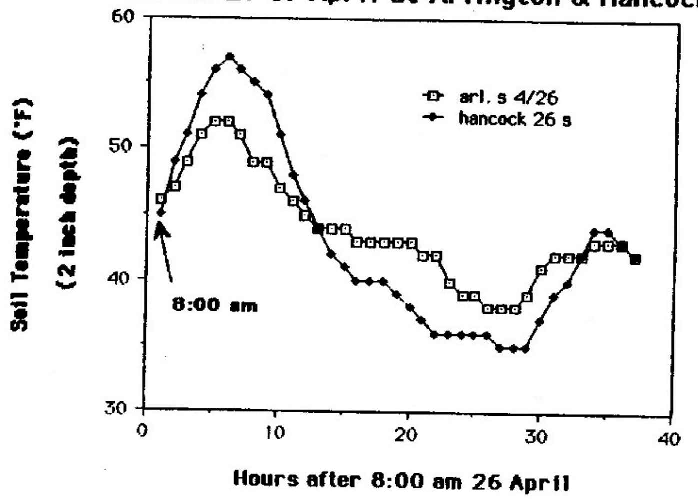


Figure 3. Seed mortality under three imbibition treatments
60
50
40
30
20
10
0
% dead
day1
day2
day3
1
2
3
Hybrids
4
5
6

To avoid imbibitional chilling injury supersweets should be planted in warmer soils. Sandy soils warm more quickly than do other soils, however they also cool more quickly. The figure below comes from a MWFPA Proceedings of a number of years ago. It shows the actual temperature fluctuations at planting depth for a 36 hour period starting at 8:00AM on 26 at Arlington and Hancock. If 40°F was the critical temperature the Hancock seed would have spent more time below this temperature.

Fig. 1. Soil temperature over a 36 hour period on 26 and 27 of April at Arlington & Hancock



We did additional experiments attempting to narrow the critical period further and we did not find any significant differences within the first 24 hours.

Conclusion

- Supersweet corn seeds are sensitive to imbibitional chilling damage.
- The critical time for imbibitional chilling damage occurs is the first 24 hours after planting.
- We could not narrow the critical time down further.
- While sandy soils warm more quickly they cool more quickly as well.

HERBICIDE CHECK LIST FOR VEGETABLE SUCCESS

Daniel J. Heider[1/]

Although the pace of new herbicide registrations in both field and vegetable crops has slowed in recent years, existing labels continue to evolve in response to events or problems encountered in the field. Most herbicides are broken down by microbial decomposition and/or chemical reactions in the soil. Whether a particular herbicide persists in the soil from one season to the next is affected by many variables including the herbicides chemistry, field moisture, soil type, and soil pH. Labeled crop rotation restrictions (length of time required after application prior to planting certain crops) try to account for the effects of these variables, but local experiences, weather extremes and other unforeseen circumstances provide information needed to adjust these labeled intervals to help protect growers from herbicide carryover problems. Table 1 contains the rotational restrictions to selected vegetable crops for many of the more recent herbicide registrations. Vegetable crops may be particularly sensitive to some herbicide residues, so it is of utmost importance for growers to always read the label for changes to rotation restrictions prior to using any product.

Table 1. Crop rotational restrictions of herbicides to vegetable crops.

Herbicide	Snap Bean	Sweet Corn	Peas	Potato	Cabbage	Cucumber
Aim	12 M	0	12M	30 D	30 D	12 M
Authority	30 M	18 M	30 M	30 M	18 M	30 M
Boundary	12 M	8 M	8 M	8 M	12 M	12 M
Callisto[a]	18 M	FY	18 M	FY	18 M	18 M
Camix[a]	18 M	FY	18 M	FY	18 M	18 M
Canopy EX	12 M	18 M	12 M	30 M	18 M	18 M
Define	12 M	12 M	12 M	1 M	4 M	12 M
Extreme	4 M	18 M[b]	4 M	26 M	40 M	40 M
Gauntlet	30 M	18 M	30 M	30 M	30 M	30 M
G-Max Lite	18 M	0	18 M	18 M	18 M	18 M
Lumax[a]	18 M	FY	18 M	18 M	18 M	18 M
Option	60 D	60 D	60 D	60 D	60 D	60 D
Phoenix	None Listed					
Priority	12 M	3 M	12 M	12 M	15 M	12 M
Spartan	18 M	18 M	18 M	0	0	18 M
Starane	None Listed					
Ultra Blazer	AH	AH	AH	18 M	AH	AH
Valor/Chateau	12 M	4 M	12 M	12 M	12 M	12 M
Yukon	9 M	3 M	9 M	9 M	15 M	9 M

Notes: M-month, D-day, AH-after harvest

[a]If applied after June 1st, only corn or sorghum may be planted the following season.

[b]12 M for processing sweet corn – check for varietal tolerance.

Herbicide drift generally consists of spray droplet or vapor movement away from the intended application site. Most herbicide labels contain language indicating that prevention of

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herbicide drift is the responsibility of the applicator and then go on to provide useful information about nozzle selection, boom height, application speed, drift reducing additives, and so on. However, recently many herbicide labels have begun to add wind speed restrictions as well. At first, maximum wind speeds were listed to help prevent direct horizontal herbicide movement. Now, the addition of minimum wind speed restrictions to reduce the potential of vertical movement through temperature inversions has been added as well. Vertically stable air which allows small spray droplets to remain suspended and then potentially move to neighboring fields is most common near sunrise and generally is associated with low wind and clear skies. Table 2 contains some of the minimum and maximum wind speed restrictions of many of the new herbicides. As always, be sure to read the label for any changes prior to use.

Table 2. Wind speed restrictions of selected herbicides when applied by ground

Herbicide	Minimum (mph)	Maximum (mph)
Aim	3	None listed
Callisto	None listed	10
Camix	None listed	10
Canopy Ex	None listed	None listed
Extreme	None listed	None listed
G-Max Lite	3	None listed
Gauntlet	None listed	10
Harmony GT	None listed	None listed
Lumax	None listed	10
Option	2	None listed
Phoenix	None listed	None listed
Priority	None listed	None listed
Roundup WeatherMax	2	10
Spartan	3	10
Starane	2	None listed
Ultra Blazer	None listed	10
Valor	2	10
Yukon	2	5 if towards sensitive plants

Tank contamination is an herbicide issue which seems to be growing in importance each year. Vegetable crops are of particular concern since in addition to crop injury and possible illegal herbicide residue, there is the possibility of damaging the harvested commodity beyond what the marketplace will tolerate. One main reason for an increase in tank contamination problems is the increased popularity of post-emergence herbicide programs coupled with an increase in non-herbicide application trips due to other pests (soybean aphid/virus complex, potentially soybean rust, etc.) have created a situation where switches to and from herbicides have become common. Nearly every herbicide label provides detailed instructions for proper spray tank cleanout after use. Always read the label and follow all listed procedures. University of Wisconsin, Extension Weed Scientist Chris Boerboom suggests the following general guidelines to consider in avoiding tank contamination:

1. Once injury occurs, there is no fix.

2. Post-emergence applied herbicide residues are more likely to injure crops than with pre-emergence applications because the herbicide is applied directly to the leaves rather than being diluted in the soil. Also, several pre-emergence herbicides have little or no post-emergence activity. Therefore, be especially careful to clean post-emergence herbicide residues from spray equipment.

3. Systemic herbicides like glyphosate, dicamba and other growth regulators, ALS inhibitors (Accent, Raptor, etc) and ACCase inhibitors (Assure, Poast, etc.) are a greater concern than contact herbicides because systemic herbicides damage the growing point. Contact (non-mobile) herbicides only damage sprayed leaves. Relatively high concentrations of residues of contact herbicides are required to cause long-term damage. However, low concentrations of systemic herbicides can cause serious damage.

4. Clean spray equipment as soon as possible after use. Dried residues are more difficult to clean and remove.

5. Follow the label's directions for the best cleaning agent to use. On several labels, you will note that the cleaning procedures recommend that the cleaning solution stand in the sprayer for several hours to overnight. Cleaning a spray tank is not a job that should be rushed, especially with certain herbicides that are highly active on sensitive crops.

6. Never add chlorine bleach to ammonia or liquid fertilizers that contain ammonia because toxic chlorine gas can be formed.

LIMA BEAN MANAGEMENT FOR WISCONSIN

Alvin J. Bussan[1]

Lima bean (*Phaseolus lunatus*) is an important vegetable crop in Wisconsin. Acreage is limited relative to snap bean or pea, but several thousand acres are grown and processed within Wisconsin. Lima beans for processing are primarily grown in California, Wisconsin, and Delaware. Similar to snap bean, lima bean originates from Central and South America. Several lima bean types exist with small seeded, dwarf bush types being the primary processed type compared to the larger seeded, pole types. Lima beans are related to snap bean (*Phaseolus vulgarus*), but there are distinct differences in their growth that influences important management needs.

Field selection, field preparation, and planting are the first crucial steps toward successful lima bean production. Lima bean is susceptible to multiple soil born diseases and the large seed can be easily damaged or have difficulty emerging. As a result, poor stand establishment commonly causes the greatest yield limitations in lima bean. Sensitivity to soil borne diseases may be increased by the large seed, warm temperature requirement for emergence, and long season crop with slow emergence. Wet and compacted soils can inhibit germination and increase potential for poor stands so lima beans should be planted in well drained soils. Lima beans are typically planted in fields with medium to light loamy soils and high organic matter content. These soils facilitate good germination and crop emergence and have good soil moisture holding capacity. Lima beans are fairly drought tolerant relative to snap bean and tend to produce better under rain fed conditions on medium textured soils than under irrigation in Wisconsin.

Crop rotation is critical for successful long-term production of lima beans. Crop rotation is important for successful management of weeds as well as diseases. Lima bean is highly susceptible to white mold so fields should be selected with low white mold pressure. In addition, lima bean should only be planted once every 3 years and should never follow soybean in rotation. Other crops or weeds that can serve as alternative hosts for white mold or root rot disease complexes should also be avoided in the rotation. The rotation should be designed to manage weeds due to the limited herbicide tools available for use in lima bean. Avoid fields with chronic weed issues such as perennial weeds, nightshade, or field sandbur. If these weeds occur within lima bean, there are no herbicides available that will provide adequate control.

Most lima bean fields are clean tilled to provide a firm friable seed bed. Heavy soils should be chiseled or deep tilled the fall prior to planting lima beans to ensure good drainage and minimize the potential for wet soils in the spring. Do not till to much as aggregate stability of surface soil can be lessened and the field may become susceptible crusting with precipitation. Crusting can dramatically reduce emergence of lima bean. Lima beans should be planted after soil temperatures exceed 65 F (late May), but they

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can be planted at a minimum soil temperature of 60 F. The minimum planting temperature for lima bean is higher than snap bean and other crops as lima beans prefer warmer temperatures. Optimal temperature for lima bean growth is 75 to 85 F.

Lima bean seed can be brittle so great care must be used during planting to prevent crushing or splitting of the seed. Damage to seed can increase the potential for infection by pathogens or inhibit the ability of the seed to germinate. Adjust planter and planting speed appropriately to minimize potential damage to seed. Prevent seed from drying to extensively to prevent cracking. Simultaneously, seed that has too much moisture may be vulnerable to damage as well. Seed should be placed in moist soil at 1 to 1 ½ inches below the soil surface. Never plant seed below 2 inches. Seed treatments can effectively protect seed from insects and pathogens and improve emergence. Seed lots should have a minimum germination rate of at least 80%. Lima bean should be planted at 100,000 plants in rows spaced from 12 to 36 inches apart. Narrower row spacings provide more competition against weeds, but are more vulnerable to white mold and cannot be cultivated. In contrast, wider row lima bean has better air movement through the canopy which prevents white molds and weeds can be cultivated, but the open canopy is more vulnerable to late season invasion by weeds.

Fertilizer and weed management recommendations are available in the commercial vegetable production guidelines (A3422). Lima beans require management of macronutrients nitrogen, phosphorous, and potassium as well as micronutrients zinc and manganese. Nitrogen management must be carefully managed as limiting N can reduce yield potential of the crop, but excessive N can result in rank vine growth and poor pod development and yield. Generally, lima beans need between 60 and 100 units of N depending on soil organic matter. Non-fertilizer forms of N (manure, previous legume crop in the rotation) should be credited when deciding upon N rates. Phosphorous and potassium application rates should be based on soil fertility tests and zinc and manganese rates should be based on soil and tissue tests.

Weed management in lima beans is difficult due to the few number of labeled herbicides and because lima beans are a short-statured crop that grows slowly. Perennial weeds should be managed prior to planting lima beans during production of rotational crops or fall prior to planting. Mechanical weed control practices such as stale seed bed techniques and inter-row cultivation can greatly improve weed management in lima bean. Rotary hoeing must be done with great caution as inappropriate timing can result in crop plant damage and loss in stand. Lima beans are sensitive to a number of herbicides used in rotation crops and rotational herbicide guidelines should be followed closely. Atrazine, Balance, Callisto, Harness/Surpass, as well as numerous others can carry over to lima bean. Standard herbicide program in lima bean include Pursuit Plus, Basagran, and Poast or Assure. Other products with potential use in lima bean include Command, Lasso, Dual, Prowl, Treflan, and Sandea. Be sure to read herbicide labels carefully as several products are labeled for use in fresh market lima bean, but cannot be applied to processing lima bean.

HEALTHY GROWN VEGETABLES: WHERE ARE WE GOING?

Deana Sexson [1/]

Potatoes are an intensively managed, high value crop that has traditionally relied heavily on pesticides. In the 1980s Wisconsin farmers became concerned with environmental impact of such practices and worked intensively with the University to reduce pesticide reliance. In 1996, the potato growers sought to expand the scope of this work and entered into a unique partnership with the World Wildlife Fund to further reduce pesticide reliance. Stringent IPM standards were developed by participating growers and the University. An independent certification body was established to chart progress (Protected Harvest) and enable certified growers to market under the nation's first eco-brand for potatoes (Healthy Grown).

The results achieved by the program have been impressive thus far. Approximately 10% of the Wisconsin's fresh market potato farmers have participated in the program. These farmers have achieved a remarkable 64% reduction in the toxicity of pesticidal inputs compared with the general population in the first 3 years of the Healthy Grown program. Within this very select group of participating farmers, adoption of biologically-based IPM has increased by 12% in 3 years and pesticide toxicity has declined a further 22%. These results were recognized nationally in 2003 when the Partnership of farmers received one of the prestigious USDA Secretary's Honor Awards for Maintaining and Enhancing the Nation's Natural Resources and Environment.

This unique Partnership and its participating farmers are now expanding the program to develop measurable standards for ecosystem and wildlife enhancement with cooperative projects restoring wetlands, savannah, prairie, and woodlands in 2003. The potato production system with its unique balance of production agriculture and undisturbed wetland and woodland ecosystems is ideally positioned to showcased this work and they have been in the forefront in hosting local, state and national tours to promote the concept of environmentally friendly production and the attendance t benefits associated with natural resource preservation.

The impact of this potato program, pioneered by progressive farmers, is now beginning to expand into other commodities in other regions of the country. Active programs, based on the Wisconsin Potato Partnership model, are also being pursued for wine grapes in the Lodi-Woodbridge area of California, vegetable processed into baby food by Gerber, tree fruit from California, tomatoes grown in Florida, and sweet potatoes in the southeastern United States.

[1/] BioIPM Field Coordinator for the WWF/WPVGA/UW Collaboration, Dept. of Horticulture, NPM Program, Univ. of Wisconsin-Madison, 1575 Linden Dr., Madison, WI, 53706; 608-265-9798.

Dairy herd management impacts on manure nitrogen cycling

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INTRODUCTION

Recent measurements on fifty-four Wisconsin dairy farms showed that :

- Cows and heifers spend considerable time in outside areas, such as pastures, ‘dirt lots, feed bunk areas and barnyards.

- Average annual deposition rates (lbs/acre) in outside areas range from 17 to 9822 for manure nitrogen (N) and 3 to 1803 for manure phosphorus (P) .

- Some farmers rotate these outside areas with pasture and/or crops.

OBJECTIVE

- Determine impact on soil compaction, crop yields and N uptake of corralling dairy heifers or applying manure on cropland.

HYPOTHESIS

- Substantial gains in manure N recycling through crops can accrue by corralling dairy cows & heifers on cropland.

METHODS

A field trial used a factorial arrangement of two manure application methods: (1) corralling heifers on cropland to apply feces plus urine, and (2) land-applied manure from the barn; two manure application rates: (1) manure deposited during 2 days of corralling (C2) or 2 days in the barn (B2), and (2) manure deposited during 4 days of corralling (C4) or 4 days in the barn (B4); two periods of manure application: (1) spring-summer corresponding to April to September, and (2) fall-winter corresponding to October to March; two cropping patterns: (1) wheat-sorghum-rye-corn silage-rye for plots manured during April to September; (2) corn silage-rye-corn silage-rye for plots manured during October to March.

METHODS

(continued)

■ Experimental units of four dairy heifers in 20’x20’ portable corrals during the summer (PHOTO 1) and the winter (PHOTO 2).

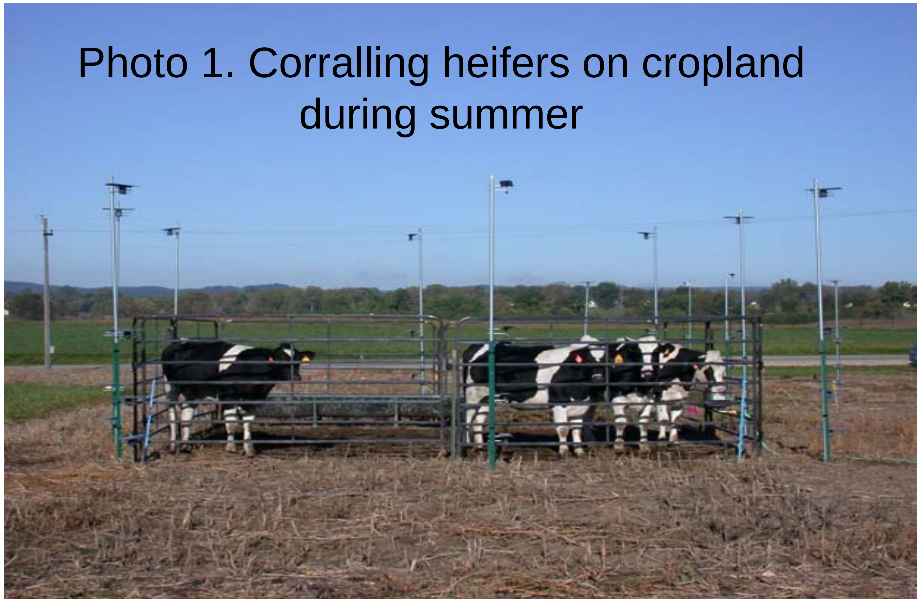


Photo 1. Corralling heifers on cropland during summer

Photo 2. Corralling heifers on cropland during winter

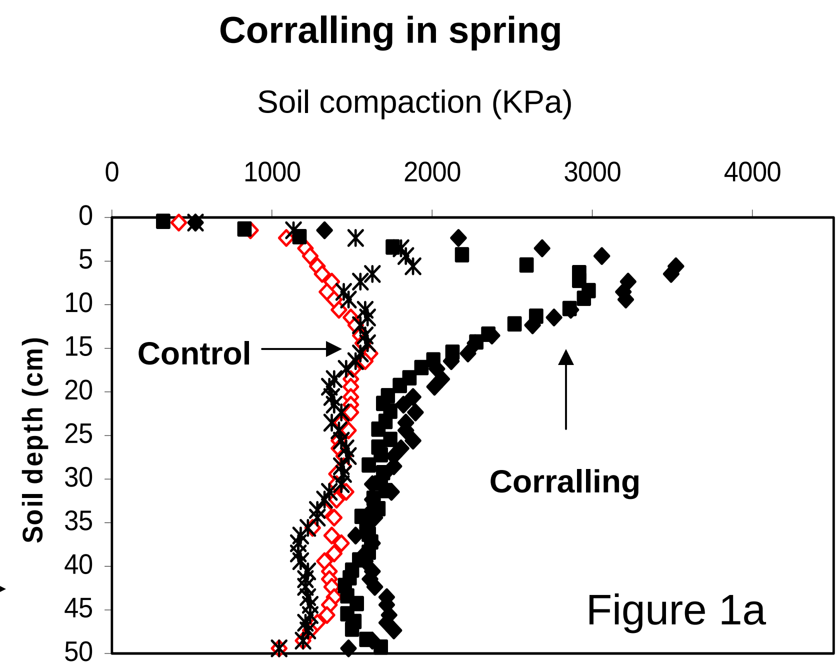
METHODS

(continued)

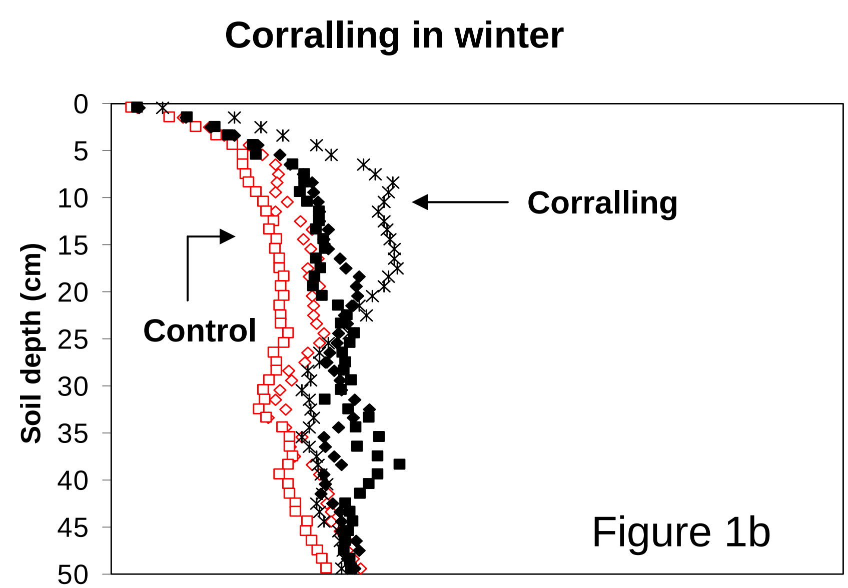
- In addition to crop yields and N uptake, measurements were made of ammonia (via micro-met., masts as in photos), nitrate (via drainage lysimeters to 1.5 m soil depth) and soil inorganic and total N.

- Just prior to first crop planting after corralling, we measured soil compaction with a cone penetrometer in all plots.

- Corralling during the spring caused soil compaction (Figure 1a).



- Corralling during the winter did not cause soil compaction (Figure 1b).



PRELIMINARY RESULTS

Figure 2. Nitrogen applications via corralling and barn manure applications

From 50 to 150% more N is applied via corralling (due to urine) than via barn manure.

- Difference between manure N applications via corralling (C2 and C4) and barn manure (B2 and B4) reflect in-barn manure N losses.
- In-barn manure N losses appear to be lower during cooler months (Nov to Feb).
- Although manure N applications via B4 and C4 are higher than agronomic recommendations, they are well within range of on-farm deposition rates in outside areas.

Figure 2. Nitrogen applications via corralling and barn manure applications

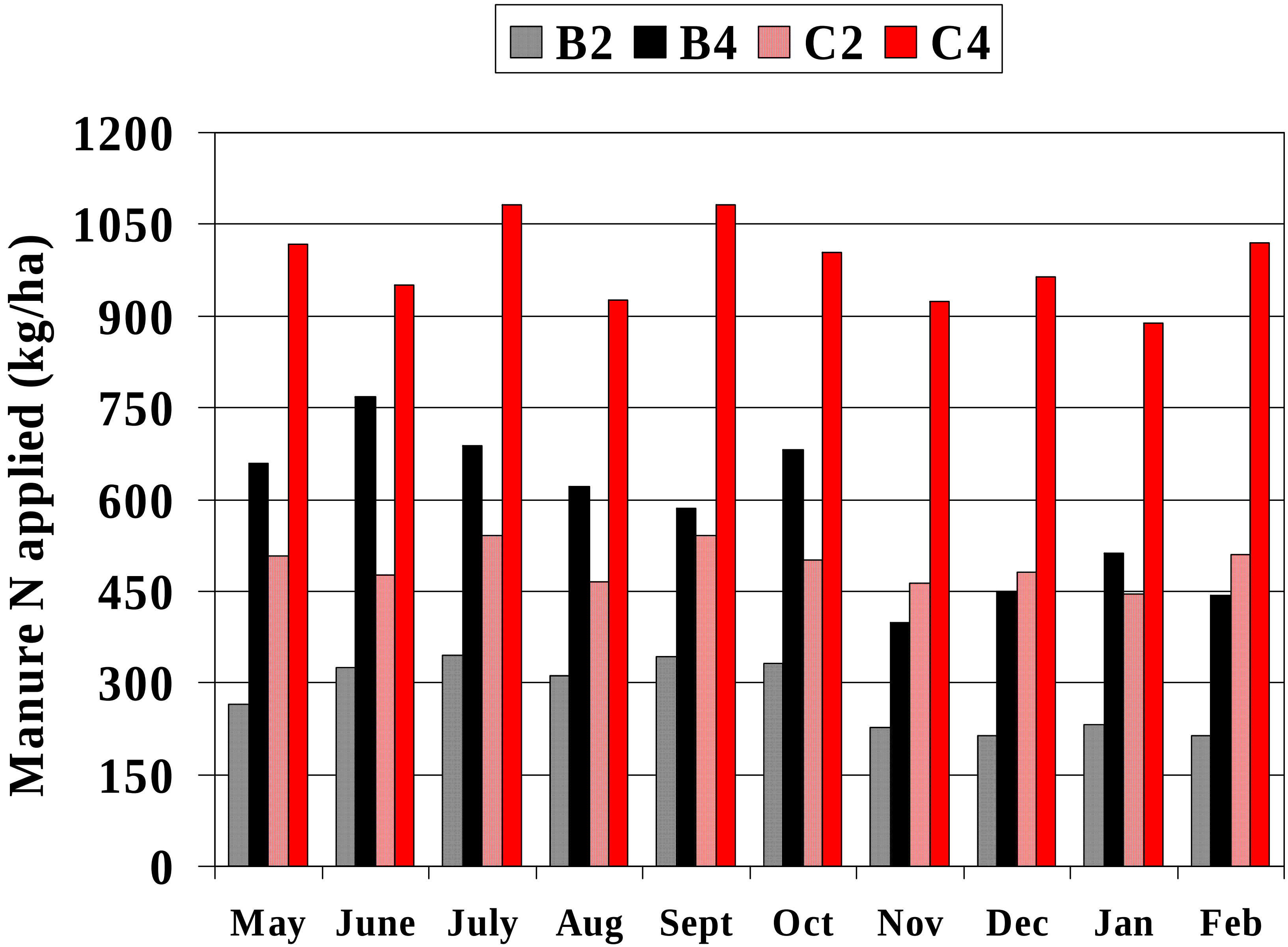


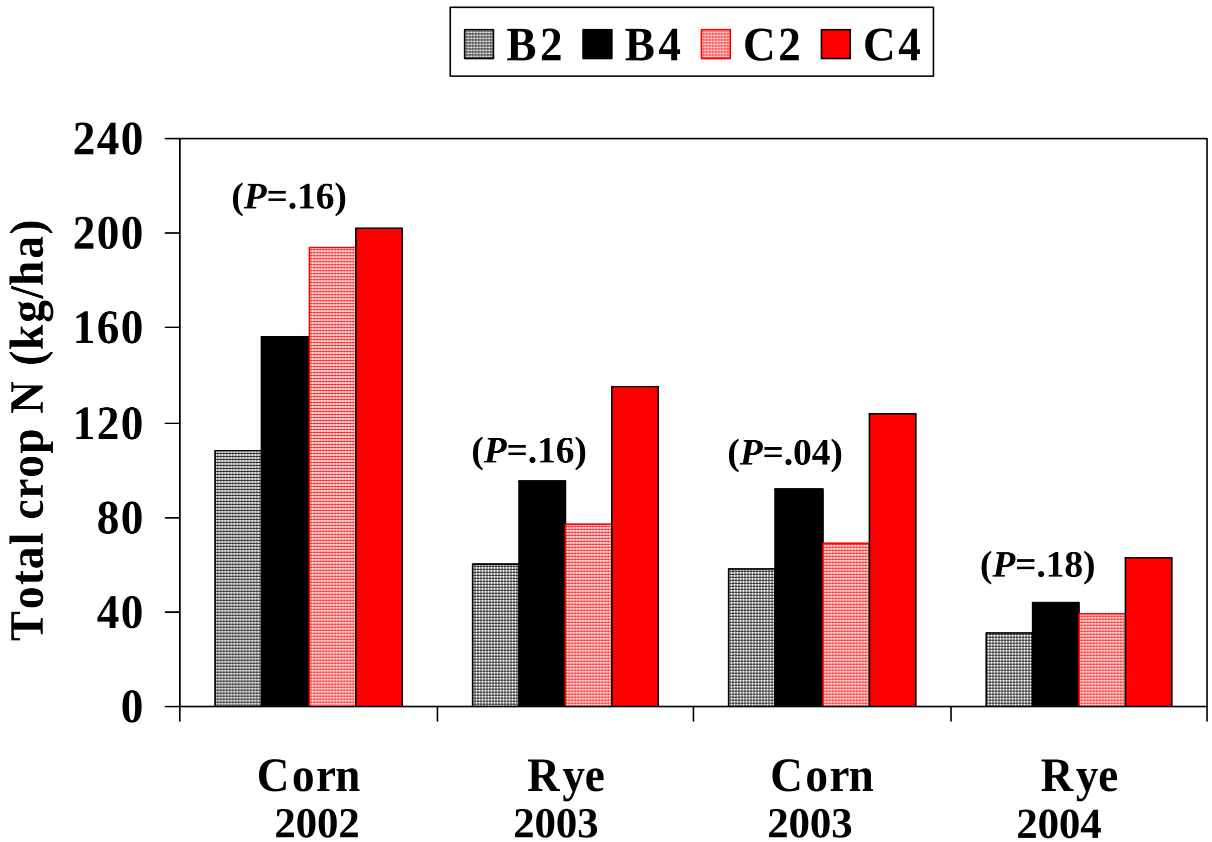
Figure 3. First year and residual crop N uptake after November (winter) manure applications

- Crop N uptake in plots where heifers were corralled were higher than where barn manure was applied (Figures 3 & 4).

- Greater crop N uptake in corralled plots continued for two complete corn silage-rye rotations (Figure 3).

- Positive effects of winter corralling on crop N uptake may last for more than two years (Figure 3).

Figure 3. First year and residual crop N uptake after November (winter) manure applications



P-values compare barn manure (B2 + B4) to corralling (C2 + C4)

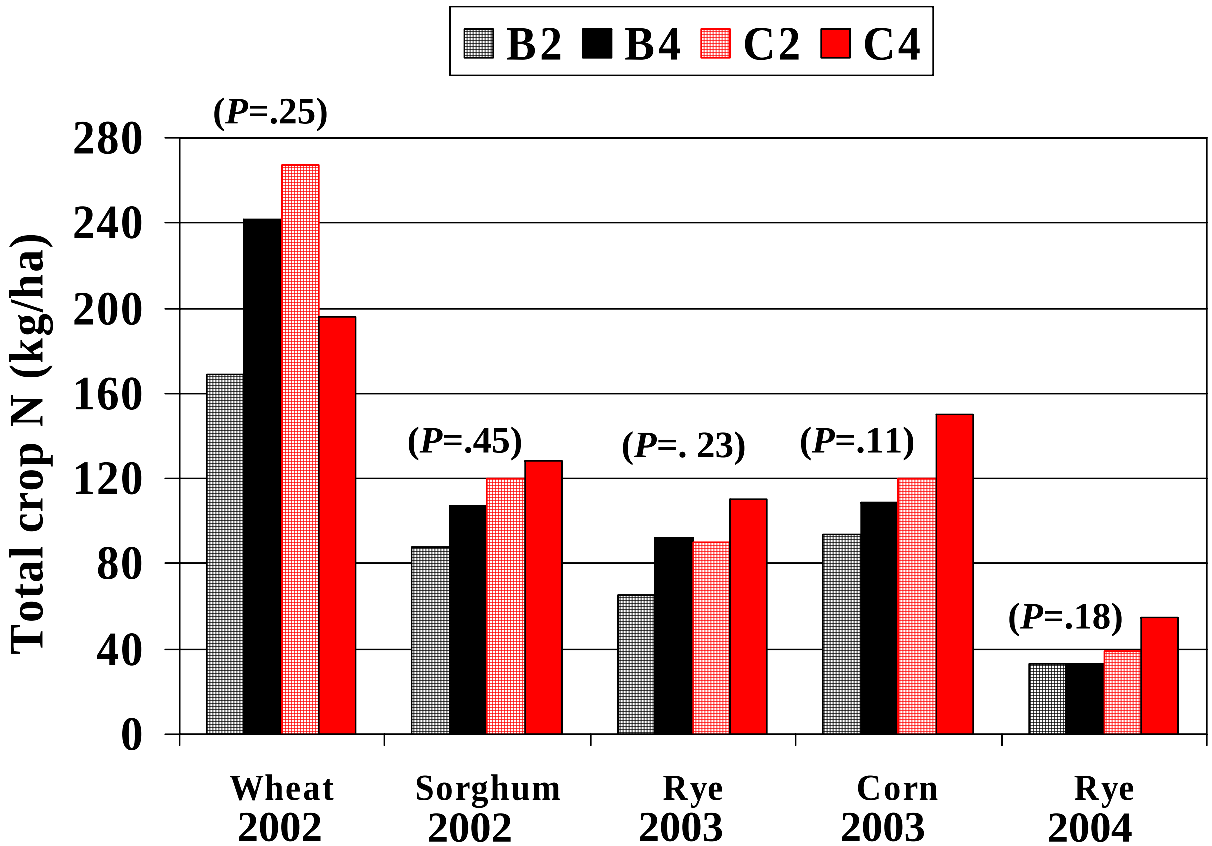
Figure 4. First year and residual crop N uptake after August (summer) manure applications

- Lack of response by wheat to corralling may have been due to high manure N application and subsequent crop lodging (Figure 4).

- The four crops after wheat each had higher crop N uptake in plots where heifers were corralled than in plots that received barn manure (Figure 4).

- Positive effects of summer corralling on crop N uptake may last for more than two years (Figure 4).

Figure 4. First year and residual crop N uptake after August (summer) manure applications



P-values compare barn manure (B2 + B4) to corralling (C2 + C4)

Next steps

- Corn silage yields and N uptake for 2004 will complete crop data component of experiment;
- Larger-scale on-farm trials and economic analysis of manure management practices will be initiated

LIVESTOCK FACILITY EMISSION AND ODOR MONITORING

Kevan Klingberg[1]
January 2005

Introduction

Air quality has moved to the forefront of environmental issues facing Wisconsin livestock producers. State agencies are exploring how livestock facility emissions and odors are impacting air quality. Producers will soon be faced with regulatory pressure to manage livestock facilities and feedlots to comply with air quality standards. The Wisconsin livestock industry has limited quantitative data to document actual on-farm emissions associated with housing facilities and feedlots. As regulatory agencies begin assembling air quality standards, the livestock industry has requested a baseline be identified for ammonia, hydrogen sulfide and odor currently generated from a variety of real farm facilities. Minimizing livestock facility impact on air quality will benefit public health, the environment and improve public perception of livestock agriculture.

Ammonia is emitted from livestock housing facilities, manure storage areas, and manure / fertilizer application areas. Ammonia (N gas) that is emitted to the atmosphere from agricultural areas either remains in the air as particulate haze or gets re-deposited back to land and water. Ammonia emission concerns include: 1) atmospheric particulates that cause haze and stimulate human respiratory health issues; and 2) ecosystem N fertilization where extra N causes plant species to shift from native to grassy, soil acidification, and adds extra N into the Mississippi River / Gulf of Mexico surface water system where a hypoxia zone has developed.

Hydrogen sulfide is a product of anaerobic decomposition of organic matter. Liquid livestock manure storage areas generate hydrogen sulfide. Hydrogen sulfide is toxic and causes human and animal health concerns. Exposure to hydrogen sulfide will cause dizziness, headache, nausea @ 50 ppm; and death from respiratory paralysis @ 1,000 ppm. The OSHA indoor workplace standard for hydrogen sulfide is 10 ppm for an 8 hour day. Periodically, farm workers are overcome by manure pit gas and die as a result of hydrogen sulfide.

Odor from livestock facilities arises from a mixture of different gases, existing at low concentrations. The actual odor can be from any combination of manure, dust, decaying feed, and other material. Odors evoke a wide range of physical and emotional reactions, both positive and negative. Many livestock facility odors are identified by the surrounding neighborhood as negative. Continued exposure and inhalation of very strong odors can cause olfactory fatigue. When people experience odor fatigue their sense of smell is less sensitive (Janni, Jacobson, Schmidt, Norlien, and Rosenstein, 2002).

Hydrogen sulfide, ammonia and odor from livestock facilities can all have an adverse impact on air quality. Table 1 shows Atmospheric gas concentrations used as thresholds for adverse air quality impacts (Baumgartner, 2004).

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Table 1. Atmospheric gas concentration thresholds for adverse air quality impacts

Constituent	Time-Averaging Interval	Time-Averaged Concentration	Reference
Hydrogen Sulfide	Hour	5.3 µg/m3	Odor Threshold Concentration [3]
	Day	335 µg/m3	WI Ambient Standard [4]
	Year	2 µg/m3	U.S. EPA Reference Concentration [5]
Ammonia	Hour	1070 µg/m3	Odor Threshold Concentration[2]
	Day	418 µg/m3	WI Ambient Standard [3]
	Year	100 µg/m3	WI Ambient Standard [3], U.S. EPA Reference Concentration [4]
Odor	Hour	25 OU (d/t)	Odor Threshold Intensity [6]
	Hour	72 OU (d/t)	Annoyance Threshold Intensity [5]

2. Nagy G. Z. 1991. The odor impact model. *Journal of Air & Waste Management Association* 41(10): 1360-1362.
3. Minnesota Environmental Quality Board. 1999. *A Summary of the Literature Related to the Social, Environmental, Economic and Health Effects: Volume 2*. Generic Environmental Impact Statement on Animal Agriculture, Prepared by the University of Minnesota, September 1999. Table 1 presents the geometric mean of the lower and upper odor threshold concentrations obtained from this reference.
4. Section NR 445 of the Wisconsin Administrative Code
5. U.S. EPA Integrated Risk Information System (www.epa.gov/iris)
6. Jacobson L. D. *et al*. 2000. Development of an odor rating system to estimate setback distances from animal feedlots: odor for feedlots setback estimation tool (*OFFSET*). Final Report. Prepared by the Department of Biosystems and Agricultural Engineering, University of Minnesota, St. Paul, MN. 26 pp.

Purpose

The purpose of this paper is to summarize an air quality monitoring project conducted on a western Wisconsin swine finishing operation. Environmental consultants for this project were John Baumgartner and Charles Gantzer from Baumgartner Environics, Olivia, MN. Monitoring conducted during June 21-22, 2004, represents a snapshot in time of emissions generated from the farm. A full report for this project, "Air Quality Impacts at Three Hog Feedlots", was prepared by Baumgartner and is available on the University of Wisconsin - Discovery Farms Program website.

Project Methods

In June of 2004, the University of Wisconsin - Discovery Farms Program coordinated air quality monitoring for ammonia, hydrogen sulfide and odor on a swine farm near Elk Mound, WI. This was a cooperative effort with technical monitoring conducted by Baumgartner Environics, Olivia, MN; WI DNR; with on-site assistance provided by University of Wisconsin - Discovery Farms staff.

Air quality measurements and samples were gathered from 5 swine finishing barns at 3 property locations. Barns were total confinement with mechanical ventilation and manure storage pits below slotted feeding floors. Animal management within barns is "all in – all out", where feeder pigs are brought in at 50 lbs. and finished to 250 lbs. in 16 week cycles.

On the day of air quality monitoring each feedlot / barn had the following hog population:

Location	Hog numbers	Hog weight (lbs)
Feedlot 1, east barn	320	220
	300	120
Feedlot 1, west barn	600	120
Feedlot 2	800	230
Feedlot 3, north barn	1,000	80
Feedlot 3, south barn	1,000	50

Emission rates for ammonia, hydrogen sulfide and odor were determined for each barn. Ammonia was measured directly from barn exhaust fans, as well as manure pit exhaust fans using gas detection colorimetric tubes. Hydrogen sulfide was measured directly from barn exhaust fans, manure pit exhaust fans, as well as property lines using a Jerome 631-X Hydrogen Sulfide Analyzer. Odor was measured by gathering a bag of air from barn exhaust fans for lab analysis by dynamic olfactometry. Odor was also measured on-site using a Nasal Ranger Field Olfactometer.

Baumgartner used the U.S. EPA. CALPUFF air quality model to estimate odorous gas concentrations present at property lines and nearest neighbor residences.

Results and Discussion

Emission gas flux rates for ammonia, hydrogen sulfide and odor for 5 swine finishing barns are shown in Figures 1 – 3. Flux rates are the amount of gas emitted per square meter of barn floor per time unit. For comparison, each figure shows the average emission flux rate for Minnesota swine finishing barns (Wood, 2001).

Figures 1-3 suggest this farm has typical emissions and that individual barn results vary depending on facility design, hog numbers and hog size. Feedlot 2 had 800 hogs weighing 230 lbs each, and had the highest emission of ammonia, hydrogen sulfide and odor measured directly at the barn. Similarly, the south barn of feedlot 3 had 1,000 hogs weighing 50 lbs each, and had the lowest emission of ammonia, hydrogen sulfide and odor measured directly at the barn. Emission flux rates from the project farm were below the MN average for ammonia and hydrogen sulfide and slightly above the MN average for odor. An evaluation of Figure 3 shows that the project farm had an average odor emission flux of 7.1 odor units (OU), compared to the MN average of 6.5 OU. An annoyance – free odor intensity is defined by the University of Minnesota as a detection threshold of 72 OU or less. The UMN defines an odor intensity of 72 OU as a faint odor, a level that an average person might detect the odor if attention is called to the odor, but the odor would not otherwise be noticed (Baumgartner, 2004).

Figure 1

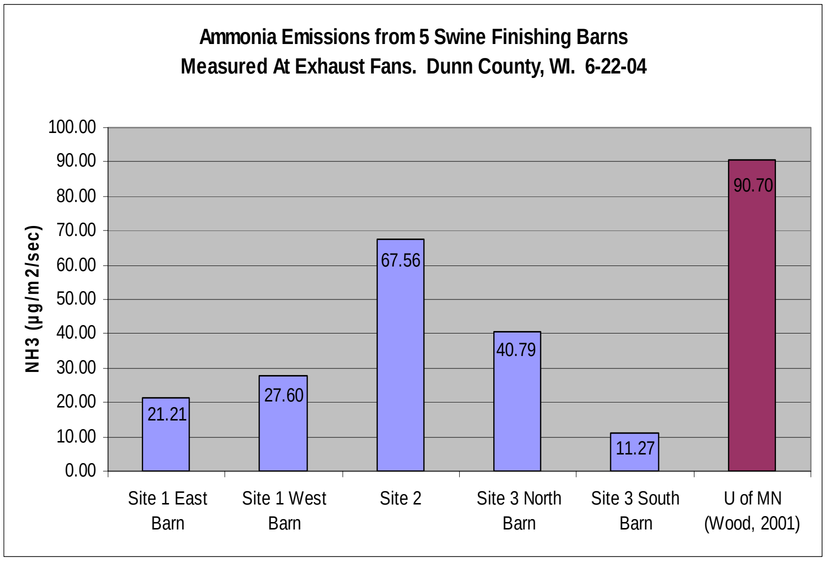


Figure 2

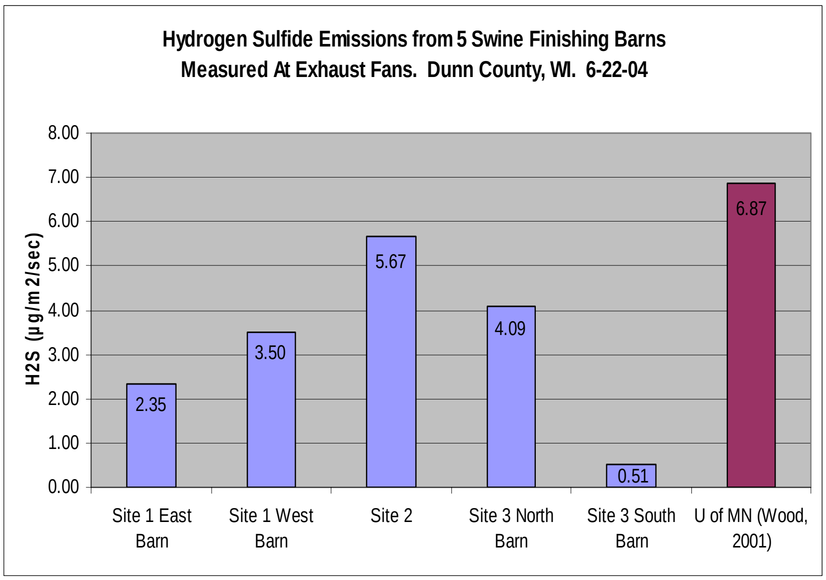
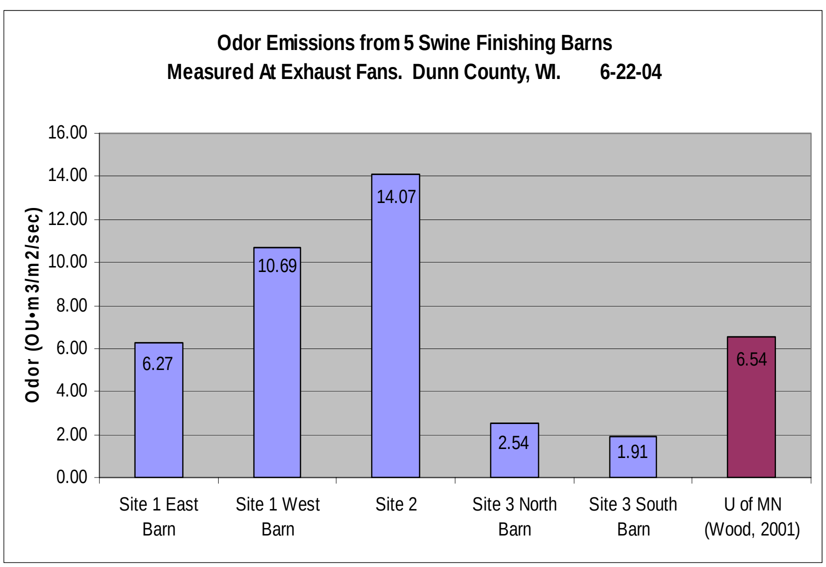


Figure 3



Property line and nearest neighbor hourly emission concentrations for hydrogen sulfide, ammonia and odor are presented for each swine finishing feedlot in Table 2. This table shows the feedlot average, as well as maximum emission rates for each location, per hour. For comparison, the table also includes hourly emission concentration standards for each constituent.

Table 2 shows the project farm has a slightly elevated hourly hydrogen sulfide emission at the property line, a very low hourly ammonia emission at the property line, and an hourly odor emission of +/- 5 units from the standard at the property line. A dilution and distance factor for these gas emissions can be seen in Table 2 as most "nearest neighbor" gas concentrations are considerably less than property line values. All emission values will vary daily and seasonally depending on facility design, hog numbers and size, and weather conditions.

Table 2. Hourly Emission Concentrations At Property Line and Nearest Neighbor For 3 Swine Finishing Feedlots

Location	Hydrogen Sulfide (μg/m^3/hr)		Ammonia (μg/m^3 /hr)		Odor Intensity (OU, d/t)	
	Avg	Max	Avg	Max	Avg	Max
Feedlot 1						
Property Line	6.2	9.3	52	78	18	27
Nearest Neighbor	0.9	1.3	7	11	3	4
Feedlot 2						
Property Line	8.6	16.7	12	20	15	30
Nearest Neighbor	2.2	6.4	3	11	4	11
Feedlot 3						
Property Line	4.8	13.4	50	133	3	8
Nearest Neighbor	1.2	6.8	14	76	1	6
Threshold / Standard	**5.3**	**5.3**	**1070**	**1070**	**25**	**25**

Summary

Through this project, air quality impacts associated with three existing hog feedlots were assessed. Results indicate that the three hog-finishing sites are not a significant public health concern with regard to hydrogen sulfide and ammonia emissions. Detectable gas concentrations and odor intensities are limited to the immediate vicinity of the feedlot barns. The evaluation also indicates the potential for episodes of detectable, yet non-annoying odors at the property lines for two feedlots and at two nearest neighbor locations (Baumgartner 2004).

This project provided a valuable snapshot in time for the Wisconsin swine industry of hydrogen sulfide, ammonia and odor emissions on 1 farm, over a 2 day period in June. It is recommended that similar emission monitoring be conducted on more farms over a longer time period to assess seasonal differences. As a result of this project, the producer may consider building a bio-filter to demonstrate a BMP for livestock facility odor and emission management.

The study report (Baumgartner, 2004) has been shared with many groups to raise awareness of livestock facility impact on air quality and to set the stage for necessary future research. Further on-farm air quality research is needed to better understand the impact of Wisconsin dairy, swine, beef and poultry housing facilities on air quality. Similarly, further study is needed to better understand the role of agricultural livestock facility emissions on regional air quality.

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WISCONSIN'S STATE STANDARDS FOR SITING LIVESTOCK FACILITIES

Richard Castelnuovo[1]

Abstract

In 2004, Wisconsin enacted the Livestock Facility Siting Law (2003 Act 235) designed to reform local regulation affecting livestock facilities. While the new law retains local authority to control rural land use through planning and zoning, it mandates that local governments follow state standards and procedures if they require individual approval for new and expanding livestock facilities. The new law is intended to ensure a more predictable and fairer system of local regulation. Central to Act 235 are science-based standards that local governments must apply whenever they make decisions to approve or deny applications for livestock facilities. These state siting standards will be developed through rule making, in accordance with specific requirements set forth in the legislation. As proposed by the technical expert panel, the standards will protect air and water quality, while providing the livestock industry a predictable regulatory framework within which to grow and modernize. Before the siting standards become law in late 2005, they will be subject to review by policy makers, interest groups and the public.

Introduction

Act 235 is part of a trend among states in the Midwest to standardize and streamline the approval process for new and expanding livestock facilities. Approaches vary among states such as Michigan, Iowa and Illinois, but state officials share a common concern about improving the business climate for animal agriculture in their states. While it may not be the most critical factor in making a state more competitive, improvements in local regulation can create a more attractive business climate. Evaluating the impact of local regulation is challenging, but there is research to suggest that the nature and extent of local regulation can adversely impact business decisions to site or expand livestock facilities (Lazarus 1999). Furthermore, there is a perception in the farm community that regulation in Midwestern states such as Wisconsin is onerous, inhibiting farmers from building new or expanded livestock facilities (Sands 2001). In his "Grow Wisconsin" plan (p. 42, available at http://www.wisgov.state.wi.us/docs/Doyle_Economic_Package.pdf), Governor Doyle recognizes the connection between growth in the livestock industry and local regulation, "Currently, one of the greatest impediments to the location and expansion of agricultural businesses in our state is uncertainty in local government permitting processes and a myriad of standards that vary by jurisdiction."

Ensuring the competitiveness of Wisconsin's dairy industry has significant implications for the state's economic well being. Wisconsin's farms and agricultural businesses generate more than $51.5 billion in economic activity and provide jobs for 420,000 people, according to a March 2004 study (Deller, 2004). To maintain its competitiveness, Wisconsin needs to produce more milk to retain processors, and the state is likely to meet its need for more milk primarily through the growth of larger dairies.

> The fact that large dairy operations will be the source of the milk production gains needed to maintain the state 's dairy industry is

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> noteworthy because it suggests that efforts to restrict the expansion of larger scale dairy farms may be ill-advised. This action would most likely curb growth in total milk production in the state and make it difficult for dairy plants to get the supplies of milk they need to stay in business. If this happens dairy plants could very well shut down their Wisconsin operations. This loss of dairy plants will hurt small and moderate sized dairy operations just as it does large dairies because the pay prices for all milk will decline as fewer dairy plants are left in the state to compete for milk. Thus all Wisconsin dairy producers could lose if milk supplies do not increase at the rates needed to keep existing dairy plants operating in the state. (Jones, 2002)

As the state's agricultural agency, the Department of Agriculture, Trade and Consumer Protection (DATCP) has taken the initiative to address this important issue. In 2003, DATCP's Secretary convened an advisory committee made up of government representatives, farmers and farm groups, and environmentalists to consider issues related to local livestock regulation. The advisory committee unanimously recognized the need to secure the future of our livestock industry, and developed a series of recommendations that formed the basis of Act 235.

Codified at s. 93.90, Stats., Act 235 provides a more predictable and fairer framework for local decisions to approve or deny livestock facility siting proposals. It addresses both the reality and perception that local decision-making is not timely, is based on standards not grounded in sound science, and imposes unpredictable and changing conditions. The new law accomplishes this by superimposing the following requirements on conditional use permits and other forms of approval used by local governments:

a. Preclude regulation of new and expanding livestock facilities under 500 animal units, unless the local government has an ordinance that meets the law's grandfathering provision for use of a lower threshold for regulation.
b. Apply science-based standards in deciding all applications for local approval, and use other standards only if they are justified based on public health and safety and are specified in advance in an ordinance.
c. Follow clear deadlines for processing applications to reduce delay.
d. Recognize that a complete application creates a presumption of compliance with the state standards.

Standards Development

State siting standards are at the core of this new regulatory framework. DATCP is required to adopt these standards by rule, making use of current runoff control standards and other laws related to farms. In specifying standards, DATCP must consider whether the standards are (1) protective of public health or safety, (2) practical and workable, (3) cost-effective, (4) objective, (5) based on scientific information, (6) designed to promote the growth and viability of animal agriculture, (7) designed to balance the economic viability of farm operations with natural resource protection and other community interests, and (8) and usable by local officials. See 93.90(2)(b), Stats.

As required by Act 235, DATCP convened a technical panel to provide recommendations concerning the state siting standards. The panel included university researchers, government experts, conservation officials, and private consultants. Experts were recruited from DATCP, the

Department of Natural Resources, and the Natural Resource Conservation Service (NRCS). The panel had expertise in barnyard runoff control, feed storage, manure storage facilities, nutrient management, and odor management. The work of the panel was enhanced by the participation of an expert from Minnesota to provide information about state-of-the-art methods for odor management. The panel met from June to October 2004 to prepare its recommendations which were presented to DATCP in the form of a preliminary draft rule including an application for local approval and worksheets. The panel's work product was reviewed by the advisory committee that originally developed recommendations for the legislation.

As recommended by the expert panel and later modified by the advisory committee, the siting standards protect air and water quality from the impacts of livestock facilities that are not properly designed, constructed and operated. Unregulated facilities may pose risks to surface water from improperly applied manure, runoff from animal lots and feed storage, and overflowing waste storage facilities. They also may create groundwater risks as a result of leaking waste storage facilities, and runoff that finds its way to sinkholes and other groundwater conduits. Potential sources of pollution include nutrients (phosphorus and nitrogen), bacteria, sediment and organic matter. The biological environment of a waterbody can be impaired by organic matter that can drastically reduce dissolved oxygen levels, nutrient loads that can result in eutrophication, or high ammonia concentrations that can be lethal to aquatic species.

Livestock housing, waste storage areas including lagoons, and field application of waste generate odors. If not properly controlled, odors may become offensive and rise to the level of a nuisance. Offensive odors are distinct from air pollutants such as ammonia and hydrogen that have been linked to public health concerns (UIEHSRC 2002). Regulation of air pollutants is not the direct focus of the siting standards.

Applicants for local approval must meet siting standards by demonstrating compliance with the following requirements designed to protect water quality. Applicants are required to meet existing water quality setbacks in local shoreland, wetland and floodplain ordinances and state well protection codes. They must document that they have adequate land to apply the manure they generate. Facilities with 500 or more animal units or those without an adequate land base for manure application must complete a checklist that demonstrates that they can manage nutrients according to technical standards. As part of this checklist, applicants must use soil test results or other values to determine manure applications.

Applicants must show that all waste storage structures can operate without risk of failure or discharges. For new and substantially altered waste storage structures, applicants must design and construct these structures according to NRCS technical standards 313 and 634. Applicants must evaluate existing facilities to establish that these facilities can operate without risk of failure or discharges. Where appropriate, they also must close storage structures according to NRCS standards 360. Applicants are required to show that they have storage capacity adequate to meet their needs based on anticipated waste the facility will generate.

Applicants must control runoff from animal lots by meeting NRCS technical standard 635 for new and substantially altered lots. They must evaluate existing facilities using the BARNY model to show acceptable phosphorous runoff. A higher level of control is required if a lot is near surface water. No lot can have discharges to sinkholes or other conduits to groundwater. For buildings, bunkers and paved areas used to store high moisture feed, applicants must divert clean water from the structure, and collect and treat leachate. New and substantially altered structures must be built at least 3 feet above groundwater and bedrock. In addition, if a structure covers more than 10,000 square feet, it must have a system to collect leachate that may leak through the structure's floor (if the floor cracks, for example).

The siting standards require livestock operators to follow certain practices near waterways: divert clean water from animal lots and other structures, not maintain unconfined manure stacks near waterways, prevent overflow from waste storage, restrict grazing on streambanks to ensure adequate vegetative cover. Also applicants must have and follow a construction site erosion control plan if one or more acres of land is disturbed by construction. These particular siting standards incorporate the performance standards in NR 151, Wis. Admin. Code, designed to protect water quality.

The siting standards require that applicants manage odor from facilities and land application of manure. If an applicant proposes a new facility with 500 or more animal units or an expansion with 1000 or more animal units, the applicant must demonstrate that the proposed production facilities (animal housing, animal lots and waste storage) will have acceptable odor levels. Odors levels are predicted using an odor index. As the first step in modeling odor, an applicant must calculate the facility's odor generation based on the size of proposed structures. Depending on the separation distance from affected neighbors, an applicant may need to implement best management practices to reduce odor. An applicant can also get credit for implementing certain good neighbor practices (which do not reduce odor but may reduce conflicts with neighbors). A local government has additional latitude to apply a less stringent "odor index" standard, if it wishes.

For applicants that spread stored, untreated liquid manure, they must select one or more options to reduce odors when applying within 500 feet of non-farm residences or high public use areas. The options include injection or incorporation manure within 48 hours (weather permitting), compliance with a locally approved management plan, or adherence with setback requirements.

It is worth noting that the control of odors may be effective in controlling air pollutants such as ammonia and hydrogen sulfide. For example, permeable covers also reduce ammonia emissions from manure storage structures. Likewise biofilters installed to reduce odors from housing can significantly reduce hydrogen sulfide and ammonia emissions.[1] Practices such as incorporation and injection can reduce emissions of ammonia. However, in some cases, other practices such as composting may increase volatilization of ammonia.

Applicants must submit a plan for managing dead animals by identifying the method(s) of temporary storage and disposal. These management plans will reduce risks from foraging animals, public health hazards and odors.

Conclusion

By correcting the shortcomings of local regulation, Act 235 and the implementing regulations should provide a more conducive environment for modernization of existing facilities and construction of new facilities. Livestock operators will know in advance the requirements they must meet to receive local approval, and will have assurances of approval if they submit a completed application showing that the proposed facility meets the siting standards. Local determinations will be simplified by use of approved worksheets that demonstrate compliance with the siting standards. Because the siting standards are objective and based on sound science, the participants and the public will have greater confidence in the local approval process. The standards incorporate water quality protections related manure storage and management, and provide new levels of environmental protection by addressing odor management and feed storage concerns. In their present form, the siting standards have addressed the various factors enumerated in s. 93.90(2)(b). These factors will continue to be touchstones as the standards in the proposed rule are subject to additional review. However the siting standards may change, they will remain central to the implementation of the new legal framework created by Act 235.

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MEASUREMENTS OF RUNOFF, SEDIMENT, AND PHOSPHORUS LOSSES FROM SEVERAL DISCOVERY FARM FIELDS[1]

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Background

The quality of our surface waters is important to human, ecological, and economic health in our state. Certain agricultural practices can degrade surface waters by contributing excess amounts of sediment and phosphorus. If we wish to maintain or improve the quality of surface waters in the state of Wisconsin, or elsewhere, we need to find out how much sediment and phosphorus (P) is being lost by farm fields (a large fraction of the land use in Wisconsin) and the effectiveness of conservation techniques to reduce these losses.

Erosion research in the past has focused mainly on studies on small uniform plots. While this research has been very informative, it is difficult to scale up to entire fields, where topography and soil conditions are not uniform. The research described below is part of two related studies that seek to address the scaling up issue.

Study Objectives

The University of Wisconsin-Madison and Wisconsin's Discovery Farms Program are involved in a pair of studies related to surface water quality. The first is a study to quantify runoff, sediment loss, and P loss on working farm fields and to then use standard management changes to reduce the losses. The second study seeks to measure the effectiveness of vegetated buffers to reduce sediment and P delivery to surface waters. The first stage of these studies was to design and install runoff/sediment/P collectors on working farm fields. Measurements made from these collectors will be used to validate a precision-scale model, which will be capable of simulating runoff/sediment/P losses for individual events in a variety of landcape/management configurations. Once this precision-scale model is validated, it will be used to calibrate an annual-mean sediment/P loss model for use statewide.

This paper outlines findings from the first year of measurement of runoff, sediment and phosphorus from natural runoff events on four farms in Wisconsin's Discovery Farms Program and the Arlington Agricultural Research Farm.

Sites

The five sites used in this study are located in various landscape and soil types across the southern half of the state. The Bragger site, in Buffalo County, is located in the Driftless Area, with relatively steep slopes and silt loam soil. One corn field and one alfalfa field are being

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[1] Funding agencies: USDA Water Quality Program, National Resources Conservation Service, Wisconsin Department of Natural Resources
[2] Cooperative Institute for Meteorological Satellite Studies, Space Science and Engineering Center, UW-Madison
[3] Department of Soil Science, UW-Madison
[4] Department of Biological Systems Engineering, UW-Madison
[5] Wisconsin Discovery Farms Program

monitored. The Knigge site is located in Winnebago County on red clay soils and contains an edge-of-field vegetated buffer on a corn field. The Opitz site, in Ozaukee County, is on sandy loam soil and also contains an edge-of-field vegetated buffer on a corn field. The Koepke farm, in Dodge County, is a loam soil with two collectors on an alfalfa field. The Arlington site is located on a silt loam soil with corn.

The data presented in this paper were collected between from July 2003 through June 2004. Table 1, below, summarizes the conditions at each site.

Table 1. Summary of collection sites

Site	Arlington	Bragger		Knigge		Koepke		Opitz	
Soil	Silt Loam	Silt Loam		Clay Loam		Loam		Sandy Clay Loam	
Crop	Corn	Alfalfa	Corn	Corn	Buffer	Alfalfa	Alfalfa	Corn	Buffer
Tillage	No Till	No Till		Mold Board		No Till		Chisel	
Slope, %	8	13	7	5	5	8	8	10	4
Contributing Area, ha	0.04	1.01	0.10	0.03	0.04	0.05	0.21	0.16	0.17
Rain, mm	564	907		1034		988		970	
Total Runoff, mm	34	51	64	40	32	6	6	158	138
Site Events	13	45		13		16		26	

Instrumentation

The study needed instrumentation that operated under the following requirements: no power source at the site; farm locations 1-3 hours travel distance from university; measurement near discharge location where slopes are small; contributing areas around 0.2 ha; total runoff volume and sediment/P mass per event. The instrumentation that fit these requirements is an adaptation of a design by Daniel Yoder, University of Tennessee.

The basic design consists of two main parts: a runoff collector and a flow sampler. The collector is a triangular piece of plastic sheeting inserted with its uphill edge embedded in the soil surface. The plastic has guides on the lower two edges that direct water flow into a plastic sewer pipe. The whole collector is covered with a tarp roof to prevent rainfall from entering the collector directly. The pipe conducts water to the flow sampler: a wooden box set into the ground a short distance down the slope.

The box contains a series of 4 buckets at four different elevations. The water from the pipe is directed into the first (highest) bucket, which has a volume of 5 gallons (19 liters). Atop the bucket is a divider head that splits any overflow into 12 equal portions. One-twelfth of the overflow (one divider section) is conducted into the next highest 5 gallon bucket. Overflow from the second bucket is divided with a 24 slot divider head. One-twenty-fourth of overflow from the second bucket is directed into an identical bucket with a 24 slot divider head. One-twenty-fourth of overflow from the third bucket is directed into a 20 gallon (76 liter) bucket. The system can sub-sample 540 m^3 (140,000 gallons) of runoff before overflowing the last bucket.

Overflow from the first three buckets is either drained or pumped out of the box back onto the ground surface. If a second runoff collector system is installed below the first, the overflow is spread out by a plastic flow diffuser, so that the water runs down toward the second collector as naturally as possible.

Using the volumes of water in each of the four buckets a simple equation can reconstruct the entire runoff volume, sediment mass and P mass for the runoff event. The collector cannot reconstruct the timing of the event.

Results from First Year

The figures below summarize the runoff, sediment loss, and P loss for the July 2003 through June 2004 sampling period, which includes more than 100 site-events. Runoff for the year and for snowmelt events is shown in Figure 1. Figure 2 shows sediment loss for storm (rainfall) and snowmelt events separately. Note that we use units of T/ac/year as these are the common units for tolerable soil loss "T". Figure 3 shows P loss for storm events in two forms, dissolved reactive P (DRP) and total P (TP). We show values in the commonly used lb/ac. Figure 4 shows the same for snowmelt events. In all figures sites are abbreviated as follows: A) Arlington, B1) Bragger alfalfa, B2) Bragger corn, C1) Knigge above buffer, C2) Knigge below buffer, D1) Koepke east, D2) Koepke west, E1) Opitz above buffer, E2) Opitz after buffer. Note the log scale on the y-axis differs on each figure.

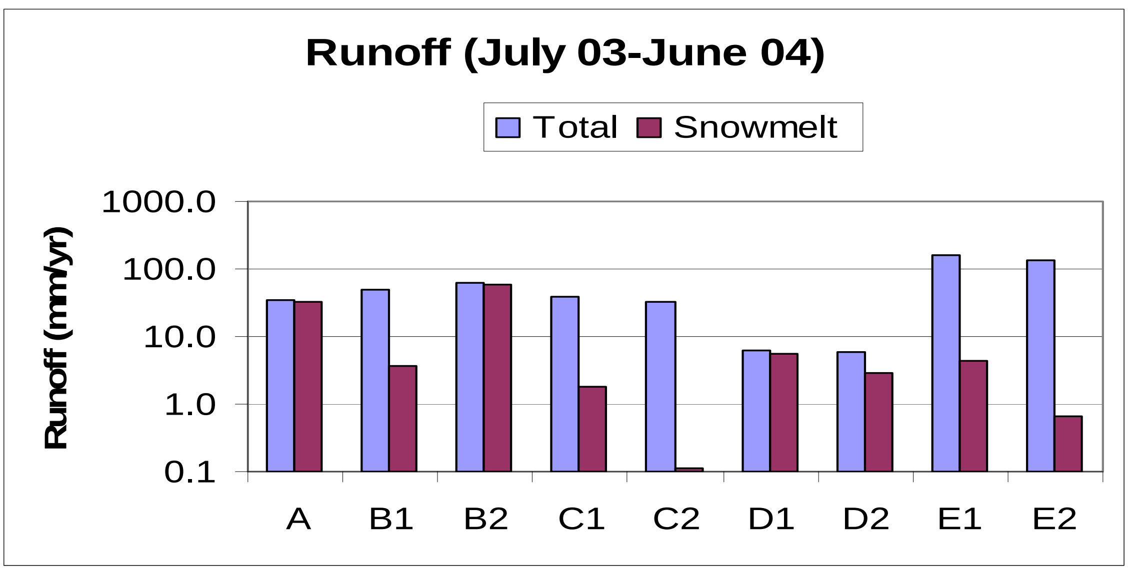

Figure 1. Runoff volume per unit contributing area. Light bars are runoff totals from storm and snowmelt events. Dark bars are from snowmelt only. Note log scale on y-axis. See text above for site abbreviation key.

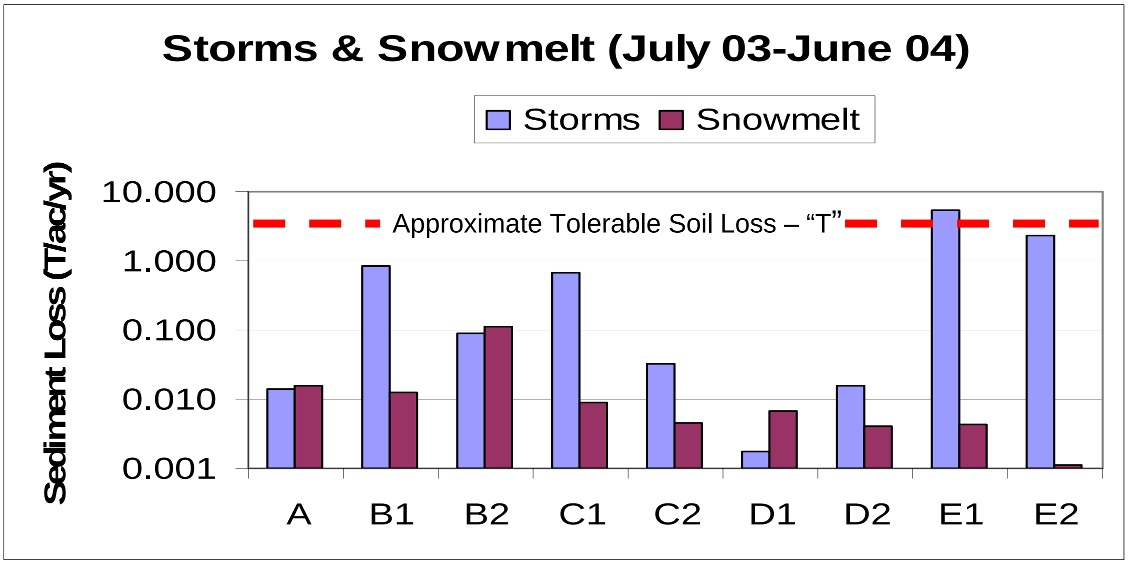

Figure 2. Sediment loss per unit contributing area. Light bars are runoff totals from storm events. Dark bars are from snowmelt events. Note log scale on y-axis. See text above for site abbreviation key.

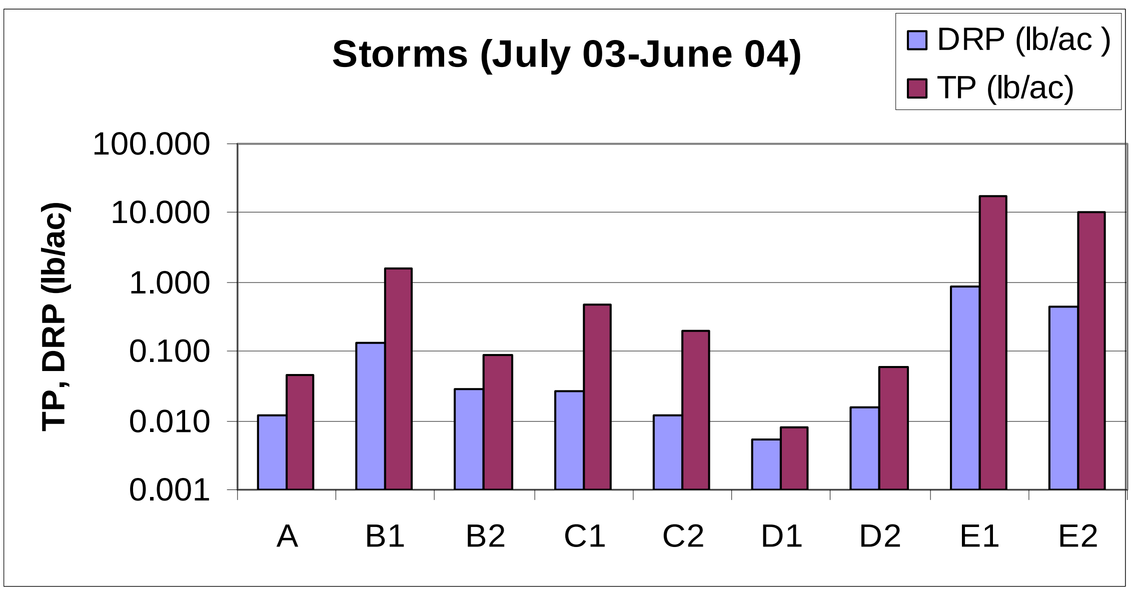

Figure 3. Phosphorus loss during storm events, per unit contributing area. Light bars are dissolved reactive P. Dark bars are total P. Note log scale on y-axis. See text above for site abbreviation key.

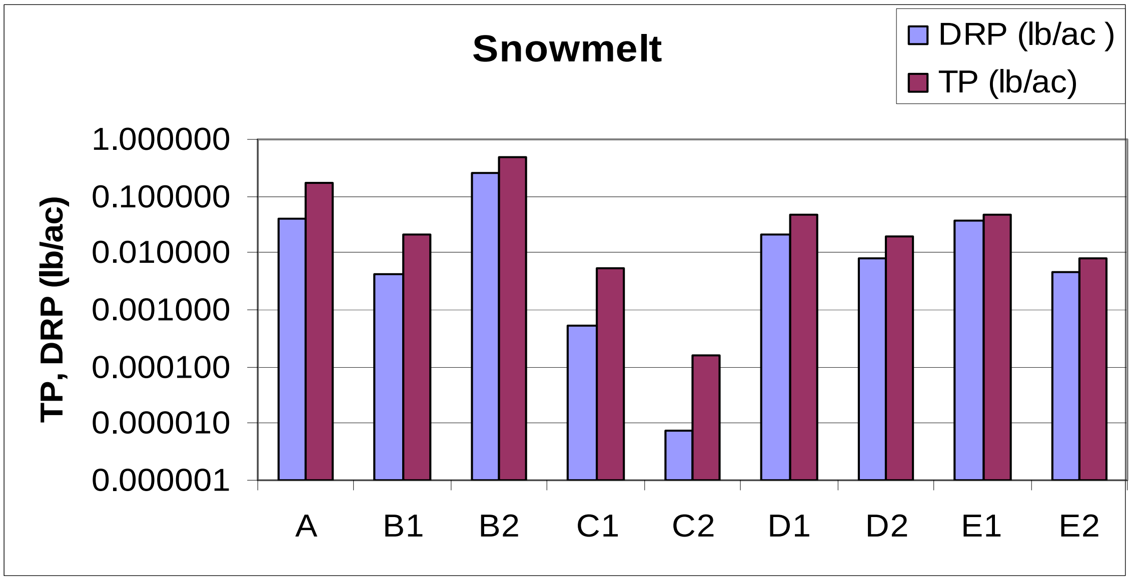

Figure 4. Phosphorus loss during snowmelt events, per unit contributing area. Light bars are dissolved reactive P. Dark bars are total P. Note log scale on y-axis. See text above for site abbreviation key.

Below are some features of the data to note:

In some cases snowmelt can contribute to more runoff at a site than rain-generated runoff. Snowmelt tends to be a larger fraction of runoff at the sites where minimal tillage is used. Of course, the amount of snowpack (not shown) vs. rainfall also plays a deciding role in the split. In general, however, snowmelt contributes much less to sediment and P loss than does rainfall.

Sediment loss is 30 times more variable across fields than runoff. Site conditions (soils, terrain, management) play an important role in controlling erosion.

While 2003-2004 was a year containing large rainfall events, erosion in general was less than “T” (tolerable soil loss) for all but one site. In only one site, Opitz, was the sediment loss greater than “T”. Half of the erosive events at Opitz occurred within one month of tilling the soil in preparation for planting – a worst case scenario. Even with this large sediment loss, the buffer was able to retain enough sediment to bring total contributing area sediment loss under “T”.

In snowmelt, sediment concentrations (mass per unit runoff volume) and P losses (mass per unit area) are an order of magnitude smaller than in storm runoff.

In sites with edge-of-field vegetated buffers (Knigge and Opitz), the buffer removed 13-20% of runoff, 90% of snowmelt sediment, 57-90% of storm sediment, 90-95% of snowmelt P, and 50% of storm P.

Comparisons with RUSLE2

RUSLE2 is a commonly used model that estimates annual mean sediment loss for use in conservation planning. As one of the goals of this study is to calibrate RUSLE2 to observations in Wisconsin, we compared estimated and observed sediment loss on two of our study sites.

At the Optiz site, "T" is estimated to be 5 T/ac/yr. We measured 5.5 T/ac/yr for 2003-2004, which had an erosivity index of 116. RUSLE2 uses an average erosivity of 120, and estimates sediment loss of 13 T/ac/yr.

At the Knigge site, "T" is estimated to be 3 T/ac/yr. We measured 0.67 T/ac/yr for 2003-2004, which had an erosivity index of 230. RUSLE2 uses an average erosivity of 110, and estimates sediment loss of 7.1 T/ac/yr.

RUSLE2 appears to greatly overestimate erosion for these sites. This may be due to the difficulty in scaling up observations on uniform "unit plots" (0.01 ha) to the field scale. More comparisons are needed before any tuning of RUSLE2 can occur.

Conclusions

In the first year of this study, we have measured runoff, sediment, and P losses from four Wisconsin Discovery Farms and one university research farm. We have measured more than 100 site-events including runoff generated by rainfall and snowmelt.

Sediment loss is 30 times more variable across the sites than is runoff. In all cases but one, sediment loss was less than "T". When vegetated buffers are considered, all losses were below "T". P losses varied from 0.01-10.0 lb/ac/yr.

Buffers removed from 50-90% of sediment, DRP, and TP.

RUSLE2 estimates of sediment loss are greater than observed.

Future Work

We will continue to collect runoff samples at these sites. We will use these observations to validate a precision-scale model, called PALMS, which can produce maps of runoff, sediment, and P losses on an event basis. This model produces output that can be compared directly to observations.

Because PALMS has extensive data needs, and runs slowly, we will use PALMS to calibrate SNAP+. SNAP+ uses RUSLE2 and the Wisconsin P Index top produce annual average estimates of sediment and P loss over multiple-year rotations. SNAP+ runs rapidly and uses readily available data. While SNAP+ can't be compared directly to observations, we will use PALMS simulations over several years and rotations to calibrate SNAP+ to observed data.

We will use PALMS and SNAP+ to design a package of management changes for each site in an effort to reduce sediment and P loss. We will continue to collect runoff at the sites to measure the impact of the management changes.

SNAP+ will also be relied on in the Wisconsin Buffer Initiative as a tool to guide the placement and design of vegetative buffers across the state.

PRECIPITATION AND RUNOFF FROM TWO WATERSHEDS

Dennis R. Frame[1]

Introduction

Soil conservation and nutrient management have taken center stage as the major management practices that producers and consultants need to adopt to reduce agricultural non-point pollution. For some producers the implementation of these recommendations will require only minor changes in their farming systems, while others will need to make major changes in practices ranging from feed management, manure storage and handling, nutrient applications, and tillage to potentially their entire cropping system. Two key questions must be considered as we move forward on the requirement that producers adopt these systems:

- Will the adoption of nutrient management plans and soil conservation plans to tolerable soil loss levels achieve the state and federal water quality goals?
- How much money and time will it take before society knows if the adoption of these practices will achieve the water quality goals?

The UW – Discovery Farms Program is working with state agencies, producers and policy makers to determine if the adoption of these management practices will achieve our water quality goals. We are also working with producers to identify how different farming systems affect our environment and how the entire farming system can be changed to reduce sources of non-point source pollution.

To encourage the adoption of best management practices (BMPs), both state and federal governments have established cost share programs that provide payments to producers who implement these practices. The practices have been identified through research on experimental farms and watersheds throughout the country. This research has concluded that a specific practice can reduce nutrient or sediment loss under specific field and weather conditions. But, the questions posed by many farmers are:

- Is my farming system contributing a detrimental load of sediment and nutrients to the waters of our state,
- How will the adoption of this BMP affect my farms profitability,
- Can I adopt these practices without making a major investment in equipment, labor or management, and
- Will the adoption of these BMPs make any difference in the water quality of our lakes and streams?

When we started the Discovery Farms Program we knew farmers felt strongly that their farming system was having little negative affect on the environment. This has been proven many times through on-farm visits and group meetings. What we didn't know going into this program was how many producers feel that their farming system was not losing soil or nutrients; and that the concerns about non-point source pollution was caused by their neighbors and others who were not using the same farming system. This presents a tremendous challenge to university and agency personnel in that if producers don't believe they are causing any of the non-point source pollution, then cost sharing must be at a high enough level to encourage changes strictly from an economic perspective.

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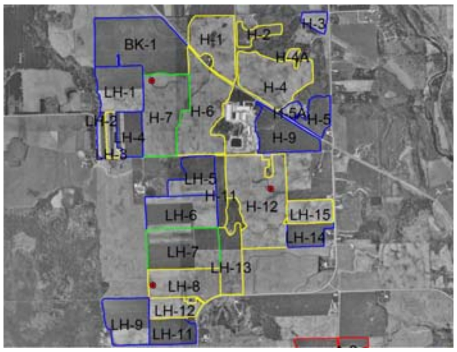
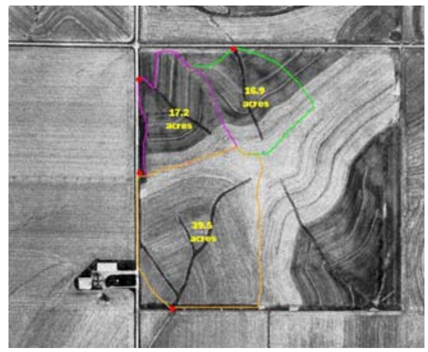
Determining Nutrient and Sediment Losses

An alternative to developing excessively high cost share programs is to work with producers at a field and watershed scale to determine how their farming system is affecting water quality. The following is first year of data from two operations in Wisconsin. These operations have very different farming systems and soils, but both have tremendously high levels of management.



Farm A



Farm B

Table 1. Soil Information on Farms A & B

	Crop 2004	***Soil Texture***	***Slope %***	***OM %***	***Bray P mg/kg***	***Cont. Area acre***
Farm A	alfalfa	silt loam	4	3.5	66	22.3
Farm A	alfalfa	silt loam	4	2.8	28	22.8
Farm A	alfalfa	silt loam	4	2.9	48	13.8
Farm B	corn	silt loam	6	3.5	63	16.9
Farm B	corn	silt loam	6	3.5	63	17.2
Farm B	soybeans	silt loam	6	n/a	n/a	39.5

As indicated in Table 1, our six watersheds are on silt loam soils (though Farm A's soil has a higher clay content) with slopes ranging from 4 - 6 percent. Farm A has all of the watersheds in hay (field H – 7 was seeded in 2003), while Farm B has two basins in corn and the other in soybeans. Each of these operations surfaced applied manure to these basins either in the fall or during the 2004 crop season.

As indicated in Figure 1 (below), both farms received significant rainfall from November of 2003 through July of 2004. Farm A had on average 8% rainfall runoff from the fields, while Farm B had on average 4% rainfall runoff. Figure 2 provides a closer examination of the number of runoff events. As indicated, half of the rainfall events on Farm A produced runoff, while 20% of the rainfall events on Farm B produced runoff events (even though Farm B had slopes greater than Farm A). Closer examination of the data reveals that of the seven runoff events on Farm B, one occurred in March, three in May and three in June. Figures 3 and 4 provide a summary of the rainfall and runoff that occurred on Farm B during the months of May and June. As indicated in the graphs, each runoff event was preceded by significant rainfall.

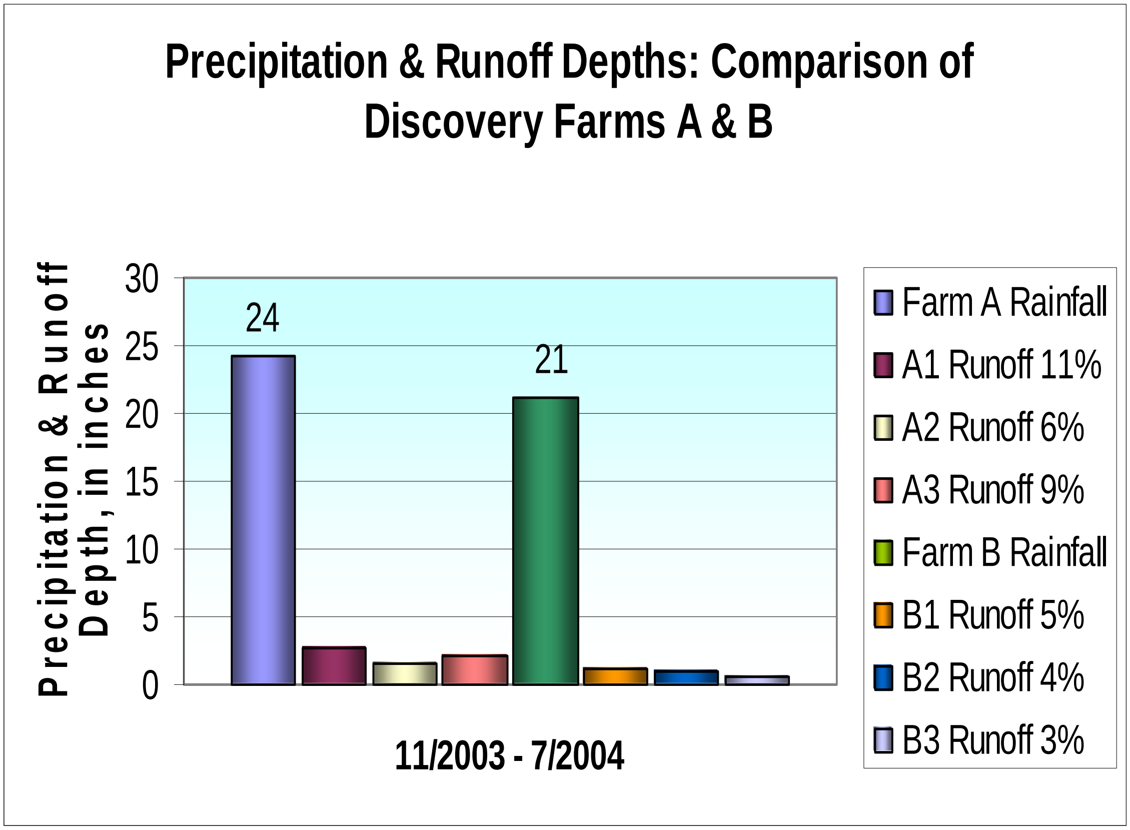


Figure 1 Precipitation and runoff events

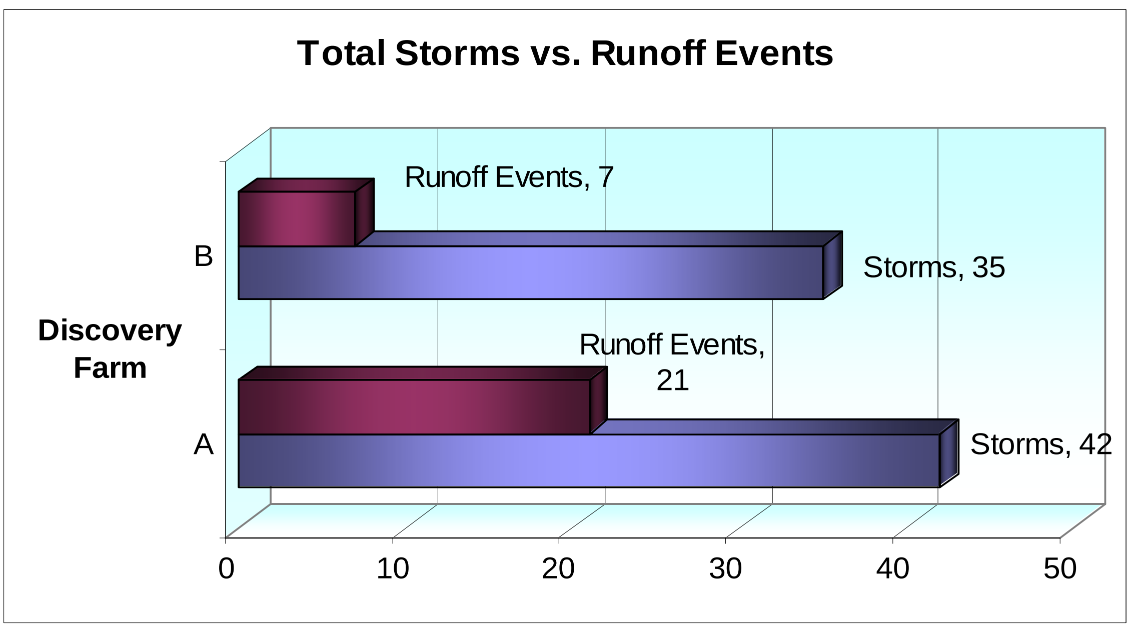


Figure 2 Total Storms and Runoff Events

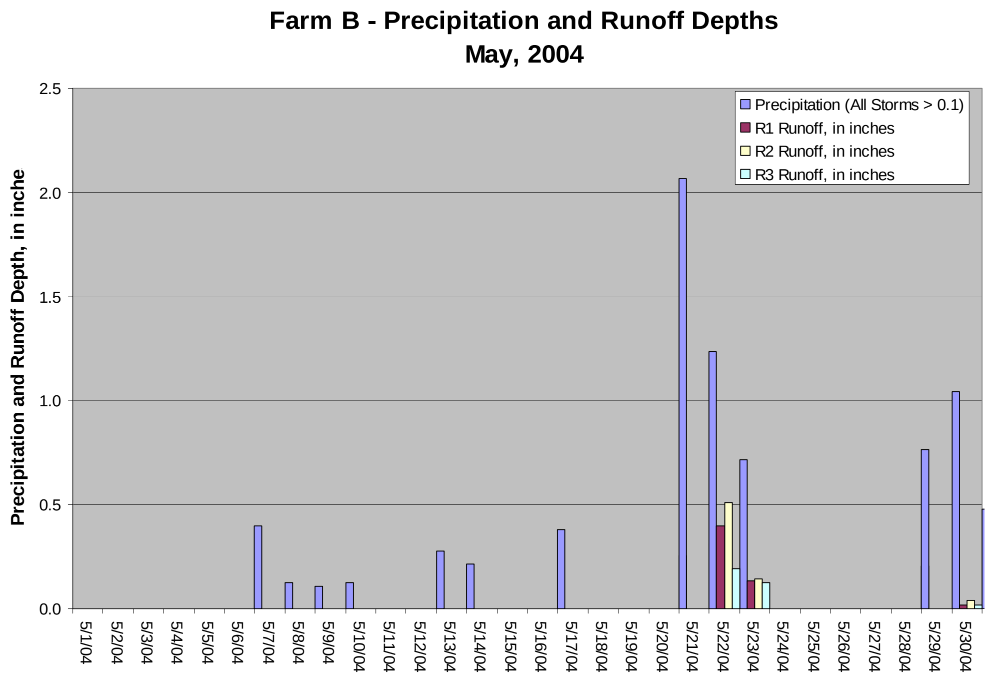


Figure 3 May Rainfall versus Runoff

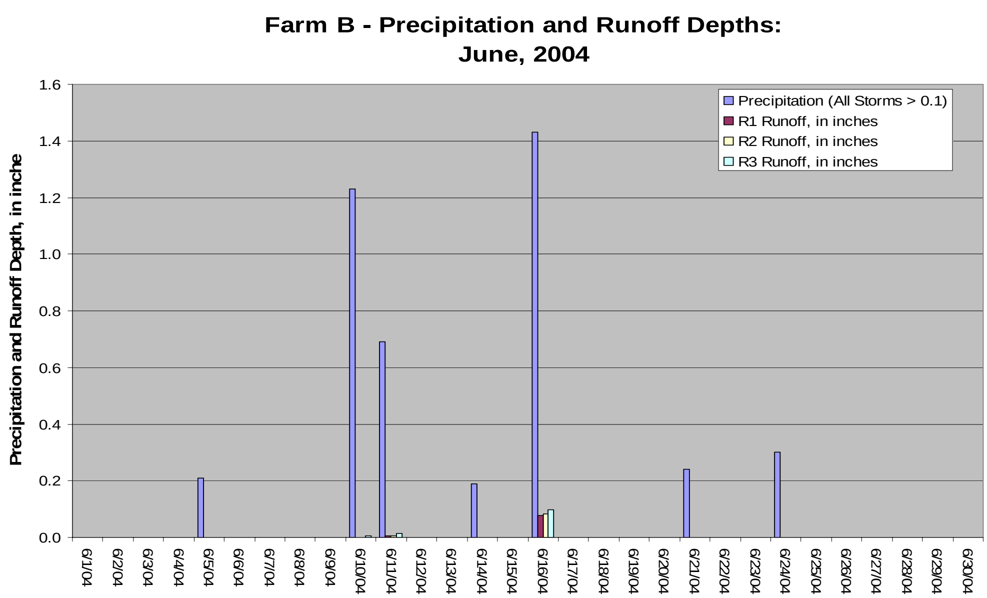


Figure 4 June Rainfall versus Runoff

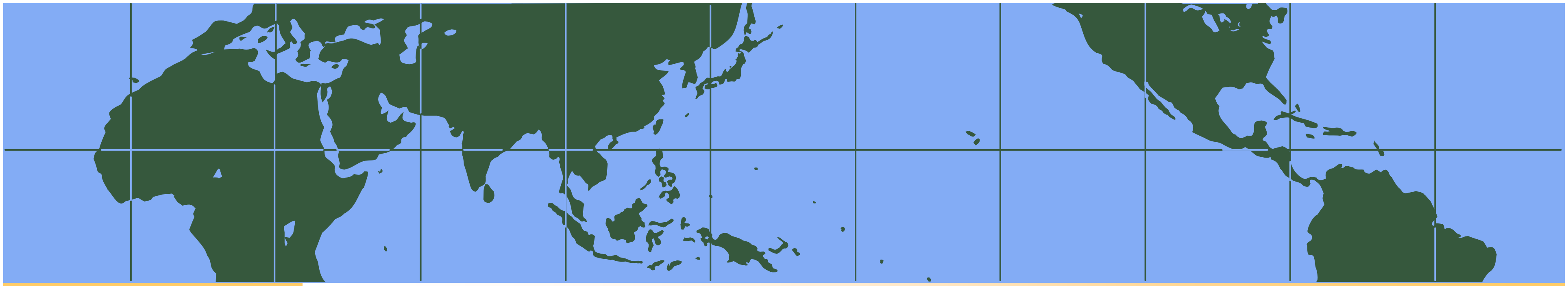
As indicated in the figures above, these two farming systems produce significant differences in volume of runoff compared to rainfall. This may be due to soil types as well as farming practices. Farm A uses a minimum tillage system to plant crops and incorporate their manure. Farm B uses a direct plant system and does not use tillage throughout the rotation.

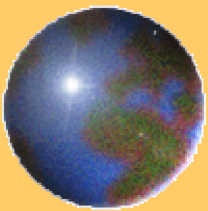
Conclusions

It is much too early to draw conclusions from these data, but the assertion that no-till farming systems reduce nutrient and soil loss can be inferred from these data. It is clear that the direct plant farming system decreases runoff events. However, just because there were fewer events, does this mean that these events produced less nutrient and sediment losses? The presentation at this conference will evaluate not only the runoff events, but also the loss of nutrients and sediments throughout the cropping season.

This project is providing valuable information in terms of runoff events, nutrient concentration and loading rates under differing farming systems. It has also identified other research needs including:

- Better understanding of the water budget for these fields including the water leaving each field through tile drainage systems,
- Would incorporation of manure decrease the nutrient loading rates,
- Would incorporation of manure increase sediment losses and therefore increase nutrient losses,
- Is it necessary for either of these producers to adopt any best management practices or are the nutrient and sediment losses from these farms at an acceptable level?





Agricultural Retailers Association

Jack Eberspacher

President & CEO

Agricultural Retailers Association

Agricultural Retailers Association

- ARA's mission is to increase the value of our retail member's business for the benefit of their customers and the local areas they serve through legislative and regulatory policy.

- ARA aggregates the power of the industry through State and National leadership, providing a strong voice for their interests on Capitol Hill and with Federal agencies.

Retail and On Farm Bulk Storage State Comparisons

States Requiring Secondary Containment

Eastern = Liquid Fertilizer		
STATE	RETAIL/DIST	FARMERS
Delaware	Yes	Yes
Maryland	No	No
Pennsylvania	Yes	Yes
Arkansas	No	No
Florida	Yes	No
Mississippi	No	No
S. Carolina	No	No

States Requiring Secondary Containment

Midwest = Liquid Fertilizer		
STATE	RETAIL/DIST	FARMERS
Illinois	Yes	Yes
Indiana	Yes	Yes
Kentucky	Yes	No
Minnesota	Yes	Yes
Missouri	Yes	Yes
Ohio	Yes	Yes
Tennessee	No	No
Wisconsin	Yes	No

States Requiring Secondary Containment

Plains = Liquid Fertilizer		
STATE	RETAIL/DIST	FARMERS
Iowa	Yes	Yes
Kansas	Yes	Yes
Montana	Yes	Yes
Nebraska	Yes	Yes
Oklahoma	Yes	No
S. Dakota	Yes	No
Texas	No	No
Wyoming	No	No

States Requiring Secondary Containment

Western = Liquid Fertilizer		
STATE	RETAIL/DIST	FARMERS
California	No	No
Idaho	No	No
Oregon	No	No
Utah	No	No
Washington	Yes	Yes

States Requiring Secondary Containment

Eastern = Dry Fertilizer		
STATE	RETAIL/DIST	FARMERS
Delaware	No	No
Maryland	No	No
Pennsylvania	Yes	Yes
Arkansas	No	No
Florida	No	No
Mississippi	No	No
S. Carolina	Yes	No

States Requiring Secondary Containment

Midwest = Dry Fertilizer		
STATE	RETAIL/DIST	FARMERS
Illinois	Yes	Yes
Indiana	Yes	Yes
Kentucky	No	No
Minnesota	Yes	Yes
Missouri	Yes	Yes
Ohio	No	No
Tennessee	No	No
Wisconsin	Yes	No

States Requiring Secondary Containment

Plains = Dry Fertilizer		
STATE	RETAIL/DIST	FARMERS
Iowa	Yes	Yes
Kansas	No	No
Montana	No	No
Nebraska	No	No
Oklahoma	Under Roof	No
S. Dakota	Yes	No
Texas	No	No
Wyoming	No	No

States Requiring Secondary Containment

Western = Dry Fertilizer		
STATE	RETAIL/DIST	FARMERS
California	No	No
Idaho	No	No
Oregon	No	No
Utah	No	No
Washington	Yes	Yes

States Requiring Secondary Containment

Eastern = Pesticides		
STATE	RETAIL/DIST	FARMERS
Delaware	No	No
Maryland	No	No
Pennsylvania	Yes	Yes
Arkansas	No	No
Florida	Yes	No
Mississippi	No	No
S. Carolina	Yes	No

States Requiring Secondary Containment

Midwest = Pesticides		
STATE	RETAIL/DIST	FARMERS
Illinois	Yes	Yes
Indiana	Yes	Yes
Kentucky	Yes	No
Minnesota	Yes	Yes
Missouri	Yes	Yes
Ohio	Yes	Yes
Tennessee	No	No
Wisconsin	Yes	No

States Requiring Secondary Containment

Plains = Pesticides		
STATE	RETAIL/DIST	FARMERS
Iowa	Yes	Yes
Kansas	Yes	Yes
Montana	No	No
Nebraska	Yes	Yes
Oklahoma	No	No
S. Dakota	Yes	No
Texas	No	No
Wyoming	No	No

States Requiring Secondary Containment

Western = Pesticides		
STATE	RETAIL/DIST	FARMERS
California	Yes	No
Idaho	No	No
Oregon	No	No
Utah	No	No
Washington	Yes	Yes

States Requiring Secondary Containment

- Pesticide quantity varies greatly from a minimum of 55 gallons to a minimum of 500 gallons.
- Liquid Fertilizer varies from a minimum of 250 gallons to a minimum of 5000 gallons.
- Other state triggers

  - diking required if stored for more than 30 days

  -in season exemptions for liquid fertilizer 6,000 gallons at application site and pesticide exemption for 275 gallons or less in mini-bulk

States Requiring Secondary Containment

- Other state triggers

-Michigan has bulk liquid fertilizer triggers for commercial facilities and the **same for on farm**.

-Pesticides inventories for 55 gallons or 100 lbs, including mini-bulks.

-Fertilizer inventories for containers larger than 2500 gallons or 2000 lbs or having a combined total greater than 7500 gallons.

-Containment for mobile storage on site more than 15 days for pesticides and 30 days for fertilizer.

End User Bulk Storage Regulations

- ARA is supporting the policy that container and containment standards should follow the product.

- The grower groups have been very reluctant to talk about this issue.

Spill Prevention Control & Countermeasures (SPCC)

- EPA is considering regulations on any combination of petroleum products over 1320 gallons to require
  - Security Plan
  - Containment
  - Professional Engineer Inspection
  - Every three years integrity testing

Spill Prevention Control & Countermeasures (SPCC)

- ARA has been one of the leading organizations for the ag industry on this issue

- Working with a broad industry coalition both in ag and outside of ag

Spill Prevention Control & Countermeasures (SPCC)

- ARA has proposed to EPA a tiered system

  -Up to 5000 gallons doesn't require a security plan or professional engineer inspection

  -Up to 10,000 gallons requires security plan but no professional engineer inspection

- Diking required for anything over 1320

Current Chemical Site Security Laws & Regs.

- **The Patriot Act of 2001:** Requires finger printing and CDL background checks.

- **2003 DOT Security Regulations:** Agriculture is included in a DOT regulatory program that calls for security assessments, plans and training for personnel, facility access and en-route transport security.

Patriot Act of 2001

- Department of Homeland Security now oversees Transportation Security Administration (TSA).

  -Require CDL background checks

  -Finger printing

  TSA estimate 20% loss of drivers

  January 31-05 new applicants

  Renewals & transfers May 31-05

  Fees estimated $83-$100 or higher

Chemical Site Security - Proposed Legislation

- Chairman Inhofe's "Chemical Facilities Security Act of 2003" (S. 994) was approved by the Senate EPW committee on Oct. 23, 2003
- Supported by the Bush Administration
- Opposed by Environmental Groups and most Senate Democrats

Inhofe's Bill (S. 994):

- No Inherently Safer Technology (ISTs) provision, but includes "Alternative Approaches"
- Employee background checks
- Federal List of Risky Facilities
- Response Plan, Vulnerability Assessment, Security Plan
- Allows for Third Party Audits
- DHS designated agency in charge, given emergency powers
- Still Very Tough on Dealers

Ag Business Security Grant Program

- Senator Wayne Allard (R-CO) sponsored this ARA sponsored amendment to S. 994 during EPW Committee vote
- Designed to provide financial assistance to eligible ag retailers and producers
- Eligibility criteria established by DHS in consultation with USDA and the Small Business Administration
- Supported by other ag organizations such as American Farm Bureau and The Fertilizer Institute.

Agricultural Business Security Tax Credit Act of 2004

- **House Sponsor of HR 4718:**
  Representative Ron Lewis (R-KY-2nd)

  Senate Sponsors of S. 2872:
  Senators Jim Bunning (R-KY) / Ben Nelson (D-NE)

Ag Security Tax Credit Act

- **Eligible Businesses:** Ag retailers as well as manufacturers, formulators or distributors of pesticides would be eligible. There is no restriction on the size of the operation.

- **Facility Limitation:** $50,000 per facility in a given taxable year. Once a facility reaches the $50,000 tax credit limit, an eligible business must wait 5 years before that specific facility is eligible to receive an additional security tax credit.

- **Company Annual Limit:** No eligible business can receive more than $2 million in security tax credits in any given taxable year. Tax Credit covers 50% of the aggregate amount paid or incurred at a facility.

Ag Security Tax Credit Act

- **No carry backs**: The bill does not allow carry backs of a tax credit before date of enactment (i.e. A business can only receive a tax credit for security costs incurred after this proposal becomes law). Customary with most tax proposals

- **Effective Date:** Once the bill is signed into law.

Security Vulnerability Assessment (SVA)

- Web based model
- Ranks and weighs security factors specific to a retail facility
- Allows the retailer to answer questions online
- Final report with recommended countermeasures
- Utilization of layers of protection
  - Ways to improve site security in an incremental fashion
  - More informed decisions
  - Effective implementation

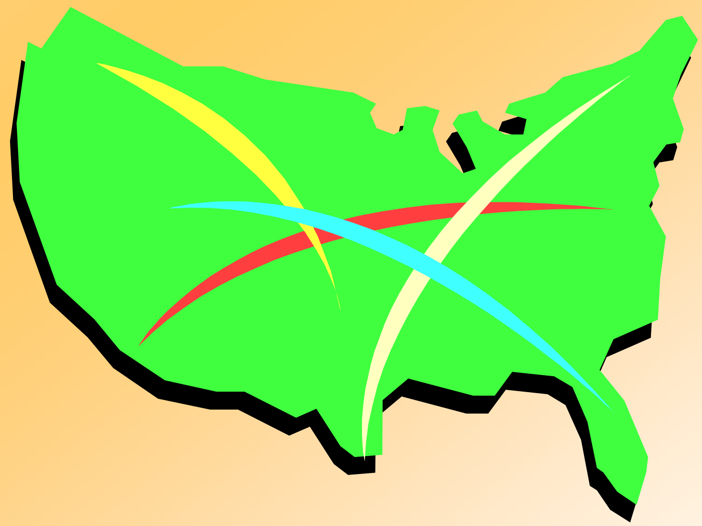
Agribusiness Security Working Group

The Fertilizer Institute | ARA Agricultural Retailers Association | CropLife America

The Security Vulnerability Assessment (SVA) is sponsored by the Agricultural Retailers Association in cooperation with CropLife America and The Fertilizer Institute working together on behalf of industry as the Agribusiness Security Working Group.

How It Works

• Retailers nationwide contact their State Association to register



• The State Association:

 • registers each location

 • assigns a login

 • forwards instructions

• Retailers logon to Agricultural Retailers Association's website to perform SVA by providing answers to 85 questions

•Retailers receive the final report upon submission


ARA - Microsoft Internet Explorer
File Edit View Favorites Tools Help
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Address http://www.aradc.org/
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Agricultural Retailers Association
The National Voice of Ag Retailers
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SVA
Members Only
Retailer Facts
Legislative Guide
Regulatory Policy
News Archives
About ARA
Member Benefits
How To Join ARA
News Releases
Calendar of Events
CCA
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The Agricultural Retailers Association (ARA) is a non-profit trade association representing the interests of retailers across the United States on legislative and regulatory issues on Capitol Hill. As the political voice of agricultural retailers, ARA not only represents its membership but also educates members on the political process and important issues affecting the industry.
ARA Headline News
Revised Hours-of-Service Rule Fact Sheet - May 13, 2003 (Members Only)
Non-Road Diesel Emissions Proposed Rule Fact Sheet - April 17, 2003 (Members Only)
ARA endorses U.S. Representative
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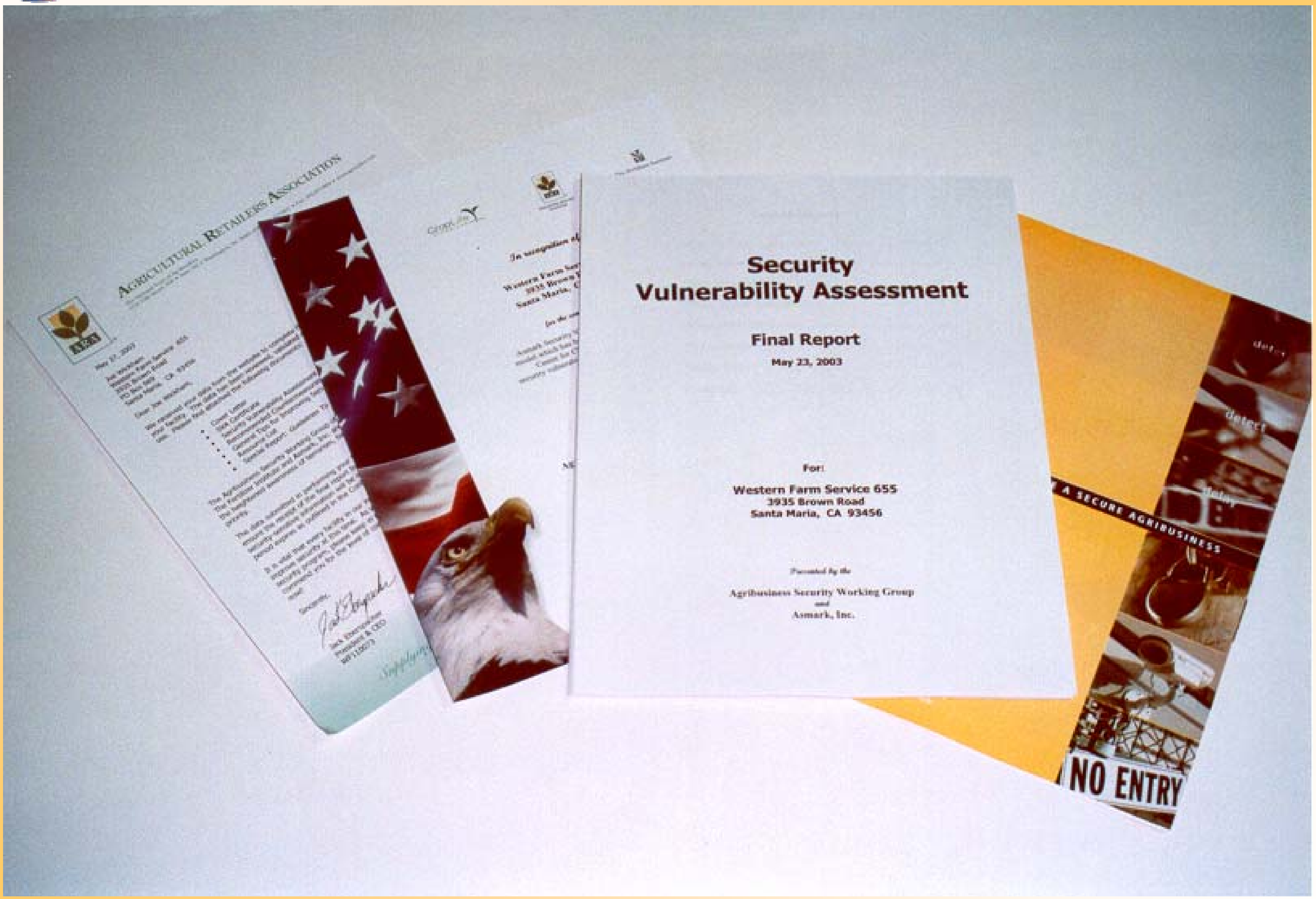
Department of Transportation Hazardous Material Transportation Regulations

The last 10 questions of the survey meet the requirements of the DOT rule published March 25, 2003.

U.S. Department of Transportation



AGRICULTURAL RETAILERS ASSOCIATION
Security
Vulnerability Assessment
Final Report
May 23, 2003
For:
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Santa Maria, CA 93456
Agribusiness Security Working Group
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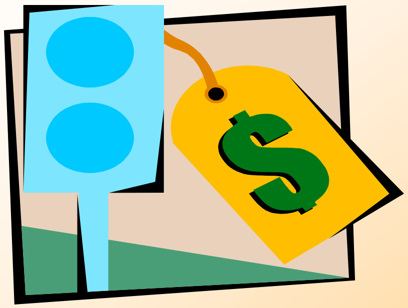

Establishing the Right Price

The price the member pays is determined when the registration is made by answering the membership questions. Example shown:

Price	Holds Current Membership with:
$87.50	State Assoc. **AND** ARA,CLA or TFI
$162.50	State Assoc. **OR** ARA,CLA or TFI
$312.50	Not a member of any of the above

BEATING THE APHANOMYCES RACE GAME IN ALFALFA

Daniel Wiersma [1/]

With the introduction of new Aphanomyces root rot (*Aphanomyces eutieches* Drechs.) resistance alfalfa varieties, it is important to know how best to position these products for dairy and alfalfa producers. To help understand the extent and range of soils infested with the Aphanomyces root rot organism, we conducted a survey of soils in the dominant forage producing counties of Wisconsin and Sutheastern Minnesota. Our goals included testing for the presence of Aphanomyces root rot race 1 and/or race 2. This test also detects the presence of Phytophthora root rot (*Phytophthora medicaginis*). We collected cropping history data to determine if the disease is more likely expressed in fields with a high frequency of alfalfa in the rotation. Survey results will be summarized and presented in this summary presentation.

[1/] Field Sales Agronomist, Pioneer Hi-Bred Intl.

INTRODUCTION OF ROUNDUP READY® ALFALFA

Jennifer Ralston [1/]

In 1997, Monsanto and Forage Genetics International began a joint project to develop Roundup Ready alfalfa. Forage Genetics, in collaboration with Montana State University, produced the first transgenic Roundup Ready alfalfa plants in 1998, using the same gene that was used for other Roundup Ready crops. Roundup Ready alfalfa is currently being evaluated for the necessary regulatory approvals. We anticipate that Roundup Ready alfalfa will be deregulated by the USDA and commercialized sometime in 2005.

Roundup Ready alfalfa will offer growers numerous benefits in comparison to conventional alfalfa. The system provides unsurpassed control of broadleaf and grass weeds, as well as, suppression/control of most persistent, parasitic or poisonous weeds. The use of Roundup® agricultural herbicides in alfalfa will greatly increase the grower's flexibility for weed control in alfalfa by providing: a broad application window for the crop and weeds, excellent crop safety and minimal waiting before grazing or feeding. In addition, Roundup agricultural herbicides work without soil incorporation and have no carryover problems or rotation restrictions. Monsanto research trials conducted in 2003 demonstrate that improved weed control in alfalfa can result in: higher percent purity of alfalfa hay and haylage, more alfalfa yield per acre and improved hay quality.

Upon commercialization, Roundup Ready alfalfa will be available from several different seed companies. The varieties will range from FD3 to FD8 types, with two to three varieties adapted to each alfalfa producing region of the U.S. All new Roundup Ready alfalfa varieties are required to meet high performance standards for yield and quality. In 2003 and 2004, extensive field trials were conducted to compare forage yield and quality of Roundup Ready alfalfa experimental varieties to a set of commercial check cultivars. All varieties received the same conventional herbicide treatment program. In these trials the Roundup Ready experimental varieties were competitive with commercial check cultivars for both forage yield and relative feed quality (RFQ) (Figure1).

Roundup Ready alfalfa is not approved for sale or distribution in the U.S. Roundup brand herbicides are not registered for this use. It is a violation of federal law to promote any unregistered herbicide use. Roundup® and Roundup Ready® are registered trademarks of Monsanto Company.

[1/] Technology Development Manager, Roundup Ready Alfalfa, Monsanto Company, 800 North Lindbergh Blvd., St. Louis, MO 63167.

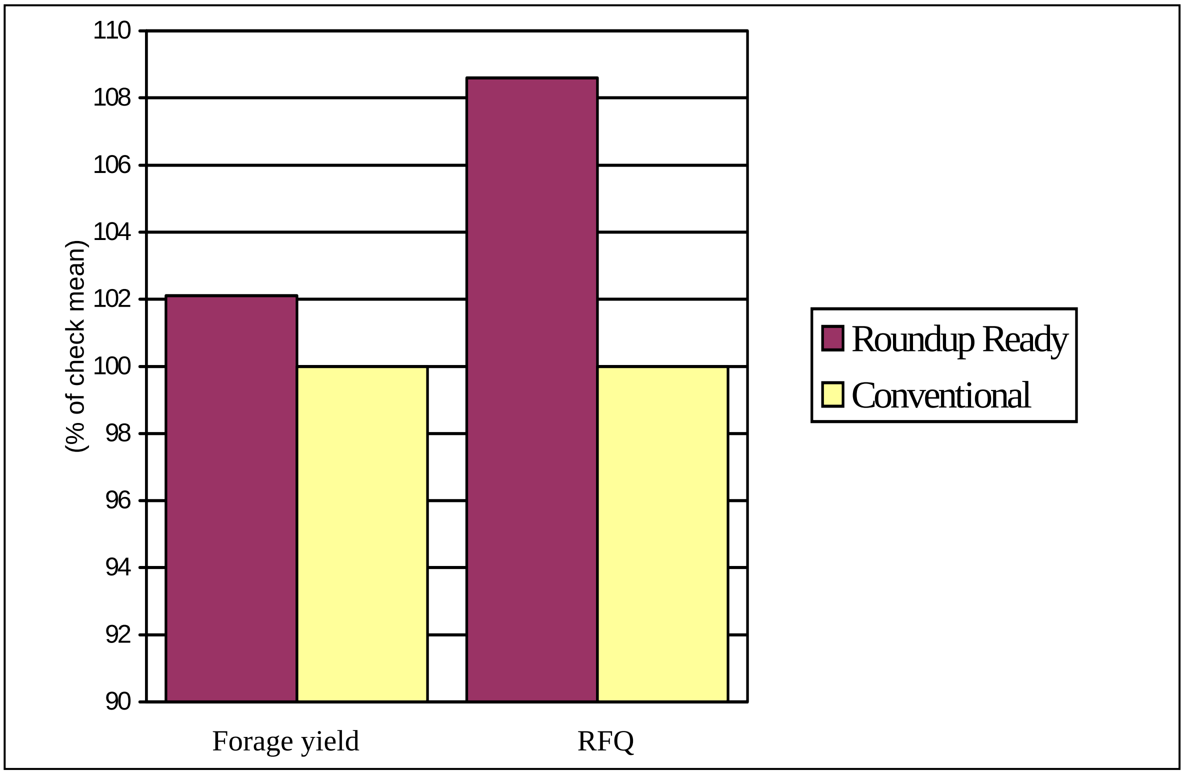

Figure 1. Performance of Roundup Ready and conventional alfalfa cultivars in agronomic trials.

CAN FOLIAR FERTILIZATION IMPROVE CROP YIELD?

Carrie A.M. Laboski [1]

Can foliar fertilization improve crop yield where no signs of nutrient deficiency can be seen? This is an oft asked question which unfortunately does not have a black and white answer. The objective of this paper is to briefly highlight what is known about leaf functions and provide an overview of the performance of foliar fertilizers.

Supplying nutrients to plants is a primary function of roots and not leaves. Though not a primary function, nutrients may enter a plant through leaves. Nutrient uptake by leaves is much less than roots, but like roots, many factors impact the uptake of nutrients from leaves. Marschner (1994) provides a list of concerns related to foliar application of nutrients: (1) Low nutrient penetration rates, particularly in plants with thick cuticles; (2) Runoff from hydrophobic leaf surfaces; (3) Washing off by rain; (4) Rapid drying of spray solutions; (5) Limited rates of translocation of some nutrients; (6) Limited amounts of macronutrients that can be supplied by one foliar application; and (7) Leaf damage. Marschner (1994) also provides some guidance on where foliar nutrient applications may be beneficial. They include: (1) Soils where nutrient availability is low. This is particularly true for micronutrients on soils with a high pH and high organic matter content. (2) Conditions where dry topsoil limit nutrient availability. (3) At the onset of reproduction when root activity decreases and nutrient uptake is reduced.

Of most interest recently is foliar application of nutrients at the reproductive growth stages. In 1976, Garcia and Hanway sparked this question when they reported significant soybean yield increases that ranged from 1.2 to 8.0 bu/acre when N-P-K-S fertilizer was applied two times at R4 and R5, R5 and R6, or R6 and R6.5. Subsequent research results have been disappointing compared to Garcia and Hanway's work. Gray and Akin (1984) report on a study conducted in 28 states and found that on average soybean yield decreased 5.2% with the foliar application of nutrients. Parker and Boswell (1980) reported a 10.9 and 17.6% soybean yield decrease with application of foliar fertilizers. In corn, foliar applications of N-P-K-S after silking were reported to temporarily reduce photosynthesis and subsequently yield was reduced by 6.4% (Harder et al., 1982).

In more recent work in Minnesota, Rehm (2003) reported that one to three applications of N-P-K-S applied after silking resulted in corn yield increases and decreases on the order of -5.8 to +4.7 bu/acre. In Iowa, Sawyer and Barker (1999) found that foliar application of urea and mono-potassium phosphate at V6-V8, V12-V14, or 50% VT had minimal impact on corn grain yield.

With regard to soybeans, Rehm et al. (1997) showed no yield benefit when soybeans were sprayed with repeated applications of N-P-K-S at pod filling. DiFonzo and Laboski (unpublished data, 2004) found that application of N-P-K + micros at R3 and R5

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resulted in yield decreases and increases that ranged from -3.3 to +0.8 bu/acre. At the current price of soybeans ($5.50/bu) and the fertilizer used, a minimum yield increase of 3.1 bu/acre would have been required for this practice to be economical. Additionally, locations where the greatest yield decreases from foliar fertilization occurred coincided with the most evenly distributed rainfall throughout the growing season.

While it is possible for foliar fertilization to increase yields, it appears that the conditions under which a yield increase is assured are unknown. The variability in positive and negative yield responses and the lack of economical yield responses are such that widespread practice of foliar fertilization to boost yields is not recommended.

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A BRIGHT FUTURE FOR GRASSES

Michael Casler and Dan Undersander[1]

Introduction

The grazing movement is, both literally and figuratively, a grass-roots movement. Many livestock producers in the northern USA have recently moved from predominantly confinement feeding systems to grazing systems. Most of them use some form of management-intensive rotational grazing in which livestock are periodically rotated from one paddock to another, allowing the plants in each paddock a rest period to recover from grazing.

The beginnings of the grazing movement originated with livestock producers and support groups, adapting routine methods and technology (Voisin, 1959) to their personal situations and needs. Once the movement became more visible and gained momentum, research interests grew and several research institutions, including the University of Wisconsin, began to support the movement.

Management-intensive rotational grazing systems in the northern USA are grass-based systems. They can be based on naturalized grasses, those that naturally appear if crop fields are allowed to revert to pastures. The most dominant grasses in these systems are Kentucky bluegrass (*Poa pratensis*), quackgrass (*Elytrigia repens*), and smooth bromegrass (*Bromus inermis*). Cropland can also be converted into productive pasture by renovation and reseeding. Orchardgrass (*Dactylis glomerata*), reed canarygrass (*Phalaris arundinacea*), tall fescue (*Festuca arundinacea*), meadow fescue (*Festuca pratensis*), festulolium (*Festulolium braunii*), perennial ryegrass (*Lolium perenne*), Italian ryegrass (*Lolium multiflorum*), timothy (*Phleum pratense*), are commonly used grasses in improved pastures.

The best grass species for a pasture will vary with location, climate, soil type, moisture conditions, and grazing regime. Some of the grasses above are very long-lived perennials that can last forever in the proper environment and with proper management. Others can only be considered to be short-term components to pastures, particularly for locations with relatively cold winters. For some species, there is a huge amount of variability among varieties, with some varieties being more suitable for grazing than others. The purpose of this paper is to describe some recent research aimed at developing better grasses for management-intensive rotational grazing systems.

Results and Discussion

We began working on the ryegrasses in the early 1980s, quickly realizing that winter survival under Wisconsin conditions was the biggest issue in the promotion and use of any ryegrasses. The big European companies would routinely send their most recent and best varieties and lines for testing, indicating that these were the most winter-hardy lines for northern Europe. It didn't matter–none of them would survive our worst Wisconsin winters, characterized

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by intermittent or lack of snow cover, strong winds that dried out the plant crowns, and extreme shifts between warm and cold spells during late winter and early spring.

In the late 1980s, we began selecting ryegrasses and festuloliums for winter survival. We dug surviving plants from old research plots and on-farm pastures at several locations, crossing the survivors to produce new seed populations and testing those populations and their parent varieties in plot trials to determine the amount of improvement that we had made.

The first variety to be developed and released from this selection program was 'Spring Green' festulolium. This variety is a selection from hybrids of meadow fescue with perennial ryegrass or Italian ryegrass. We collaborated with Peter Pitts, a livestock producer and entrepreneur near Spring Green, WI and with Pure Seed Testing, Inc. in Hubbard, OR to develop this variety. Spring Green has improved freezing tolerance, measured as plant or tiller survival at -12°F (Table 1). This resulted in improved survival under field conditions. The improvement in survival was greatest at the locations with the most severe winter conditions (USDA hardiness zones 2 through 5). Over 1 million pounds of seed have been sold during the past 5 years, marking the success of this variety. Over 200,000 pounds of certified organic seed was produced in 2004 for the 2005 planting season.

Table 1 Performance of Spring Green festulolium relative to its two commercial parent varieties. Data adapted from Casler et al. (2002).

Variety	Plant survival at -12°F	Tiller survival at -12°F	Forage yield	Survival in the field†	
				14 locations	6 locations
	%	%	Tons DM/acre	%	%
Spring Green	56	48	1.74	65	52
Tandem	33	41	1.78	56	37
Kemal	3	25	1.67	61	43
LSD(0.01)	19	15	0.04	3	4

† Survival was measured at 14 field locations. Six of these locations were classified in USDA hardiness zones 2 through 5, with the most severe winter conditions.

Our first grazing research effort was an on-farm trial of several pasture grass varieties (Casler et al., 1998). This study identified meadow fescue has having untapped potential as a pasture grass for the northern USA. It has forage yields lower than tall fescue, but because its acceptance by dairy cows was considerably higher than tall fescue, consumption was equal for the two species. Meadow fescue comes from the colder regions of northern and eastern Europe, while tall fescue comes from the Mediterranean region. Due to its greater cold tolerance and palatability, meadow fescue is a better choice than tall fescue for the northern USA. Both grasses are highly adapted and tolerant of grazing.

We began breeding meadow fescue in the late 1990s, and have developed one new variety that has yet to be named, still going by its experimental name WMF1. We conducted more extensive evaluations of meadow fescue germplasm from all over northern and eastern Europe, selecting a small number of parents for WMF1. This variety has 8% higher forage yield, 34% higher forage intake, and 20% higher preference under rotational grazing than tall fescue (Table 2). It has crown rust resistance comparable to the best tall fescue varieties. This variety is currently in the seed multiplication phase and will be named and released in 2005 or 2006.

Table 2. Performance of WMF1 meadow fescue in comparison to eight tall fescue varieties in a management-intensive rotational grazing trial with dry cows and heifers at Arlington, WI in 1997 and 1998. Data adapted from Casler and van Santen (2001).

Variety	Forage yield	Forage intake	Preference	Crown rust†
	------ Tons DM/acre	------	%	
WMF1 meadow fescue	4.15	1.89	38	2.7
KY31 tall fescue	3.93	1.39	31	3.4
GA5 tall fescue	3.80	1.36	32	2.9
Malik tall fescue	3.91	1.43	32	3.3
Johnstone tall fescue	4.02	1.51	33	3.8
Elfina tall fescue	3.75	1.33	32	3.3
Dovey tall fescue	3.89	1.39	31	3.5
Barcel tall fescue	3.69	1.35	31	2.3
Advance tall fescue	3.68	1.45	34	2.5
LSD(0.01)	0.12	0.22	3	0.4

† Low values indicate more resistant varieties.

Reed canarygrass is a potentially valuable pasture grass that suffers from poor seedling vigor, increasing the length of time required for successful establishment (Casler et al., 1999; Undersander et al., 2001). In 1993, we began a breeding program to improve seedling establishment capacity in reed canarygrass. Our approach was to plant seeds in areas with heavy infestations of annual weeds, allowing the weeds to compete with the reed canarygrass seedlings, but managing the stands as normally recommended for new seedings (occasional clipping to open the canopy to sunlight).

Table 3. Performance of six reed canarygrass varieties in a four-location field test of establishment, a two-location test of forage yield, and a greenhouse test of seedling shoot and root weights. Unpublished data (2004).

Variety	Ground cover†	No. of tillers‡	Forage yield	Shoot weight§	Root weight¶
	%	No./ft^2	Tons/acre	grams	grams
Bellevue	20	7.7	4.33	26.2	3.8
Palaton	15	6.2	4.20	18.5	2.0
Rival	22	8.7	4.48	29.4	4.1
Vantage	20	7.9	4.48	24.3	3.4
Venture	13	3.8	4.24	17.0	2.2
WR00	31	11.1	4.55	36.1	4.2
LSD(0.05)	5	21	0.43	6.1	0.9

† Percentage of ground covered by reed canarygrass in October of the establishment year.
‡ Number of tillers per square foot in May, one year after seeding.
§ Weight of shoots 30 days after emergence.
¶ Weight of roots 16 days after emergence.

We developed a new variety, with the temporary experimental name WR00. This variety had 41% higher ground cover and 28% more tillers than Rival, the best of the commercial varieties (Table 3). We studies many characteristics of these seedlings in greenhouse studies and found that this improvement could be explained by increased seedling vigor, as measured by seedling shoot weight after 30 days. Part of this improvement could also be explained by increased root weight after 16 days, but the difference in root weight was only observed at this early date, not at the later dates. Therefore, the improvement in establishment capacity of WR00 appears to be due to improved seedling vigor, which occurs largely through increased shoot weights and partly through increased root weights of young seedlings. This variety is currently in the seed multiplication phase and will be named and released in 2005 or 2006.

Orchardgrass is a valuable pasture grass in many parts of the northern USA, but it is very difficult to manage in the spring due to early and profuse heading. Some livestock producers have had some success with late-maturing varieties, but seed is not always readily available for all of these varieties. Breeding non-heading orchardgrass varieties would be an alternative that would make orchardgrass more valuable and popular for pastures. A non-heading orchardgrass variety would also have the benefit of fitting better into multiple-species mixtures, which are advantageous for many livestock producers with a range of diverse soil and environmental conditions on the farm.

Breeding a non-heading orchardgrass is complicated by the need to produce seed. By definition, lack of heads, means lack of seed. Because there is no other way to propagate orchardgrass economically, we must be able to produce seed. We have found some orchardgrass plants with heading genes that are controlled by winter temperatures–they don't head following cold winters, but head-out normally after warm winters. We have selected the best of these plants and have sent them to four mild-winter locations in the western USA to check for seed production. If we are able to produce seed on these plants, we will bring them back to Wisconsin and neighboring states to determine the reliability of the non-heading characteristic and identify the environmental conditions that lead to non-heading plants. We are still a few years from variety development, but a 2005 seed crop will go a long way toward determining feasibility of this idea.

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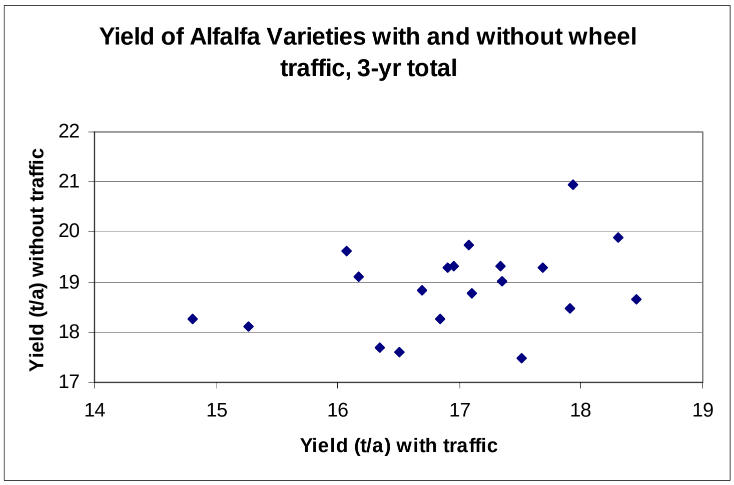
EFFECTS OF WHEEL TRAFFIC ON FORAGE STANDS

Dan Undersander [1/]

In response to farmer concerns about the effect of wheel traffic on alfalfa yields, we began a study to look at these effects. Studies were established at the UW Arlington Research Station and ABI Research Station (Napier, IA) during the spring of 2000. In a Second study started in 2001, plots were established in Iowa, New York, Wisconsin, Minnesota, New York, Nebraska, Oklahoma, Kentucky and South Dakota. Wheel traffic was applied 5 days after cutting by driving approximately a 100-Hp tractor across the plots covering the entire plots with both wheel tracts. This was an attempt to simulate driving over the field with tractor, chopper, and wagons, or tractor baler, and wagon. In the 2001 study, wheel traffic conditions were the same except that treatments were no wheel traffic, wheel traffic 2 days after cutting, and wheel traffic 5 days after cutting.



The yield for the first study conducted at Arlington, Wisconsin and summed over 3 years for each entry comparing wheel traffic to no wheel traffic is presented in the graph at the end of this article. While all varieties showed some yield reduction due to wheel traffic, some entries were less affected than others. A number of varieties yielded up to 1.0 t/acre/year less with wheel traffic than the same variety without wheel traffic.

Based on the data from this study and the consistency of ranking across years, we have begun a variety trial with and without wheel traffic. Data are reported on my website (www.uwex.edu/ces/forage).

Yield reductions due to wheel traffic can be related to physical damage to the soil and plant. Deep soil compaction is related to axel weight and surface soil compaction is related to contact weight (weight per surface area of wheel contact with soil). Wheel compaction usually only occurs on heavier soils. Wheel traffic damage to alfalfa crowns may result in cracking or breakage of the crown which will reduce the shoots produced and may allow entry of disease. In five days, shoots will have begun to regrow and if they are broken by wheel traffic this will result in a yield reduction.

To the extent that the yield loss is due to damaged regrowth, the sooner the wheel traffic occurs after cutting, the less the damage will likely be. Chopping for silage at 1 day after mowing may cause less yield reduction than baling 4 to 5 days after mowing. We set up a multi-state

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[1/] Professor, Department of Agronomy, Univ. of Wisconsin-Madison.

study to see if yield reductions occurred across a wide variety of soil types and environments. We also include an additional 2-day-after-cutting wheel traffic treatment to compare silage making to hay making effects.

Data (in the table) show that, in all cases except Nebraska, wheel traffic caused a reduction in average yield. There was a variation among the varieties generally ranging from 0% to 15 to 20% reduction. (Data from South Dakota and Kentucky are not presented due to drought.) In all cases, the wheel traffic at 2 days caused significantly less yield reduction than wheel traffic at 5 days. This indicates that, while some of the yield reduction due to wheel traffic is likely soil compaction, a significant portion of the yield reduction is due to plant factors. Harvesting as soon after cutting as possible will reduce the yield loss due to wheel traffic.

% REDUCTION IN 2002 DUE TO TRAFFIC

		VARIETY AVG.	VARIETY AVG.	RANGE of % AMONG VARIETIES	
STATE	**SEED YEAR**	**2 DAY**	**5 DAY**	**2 DAY**	**5 DAY**
IA	2000		30		18 to 41
	2001		22		14 to 34
WI	2000		9		0 to 19
	2001	2	9	0 to 15	2 to 22
MN	2001	11	29	0 to 21	**12 to 52**
NY	2001	3	25	0 to 7	14 to 29
NE	2001	0	0	0 to 13	0 to 14
OK	2002		9		4 to 12

We believe the following management recommendations will reduce yield loss due to wheel traffic. These are as follows:

1) Plant traffic tolerant varieties (check www.uwex.edu/ces/forage for test results).

2) Use small tractors when possible on established stands, i.e. don't use larger tractor than necessary for raking, or leave loader on tractor when harvesting

3) Avoid unnecessary trips across the field when harvesting
   – Mowing and conditioning in a single operation
   – Do full wagons have to be hauled the length of the field?
   – If bales are dropped and collected can this be done with less driving?
   – Do not drive on alfalfa field when harvesting crop of adjacent field.

4) Consider using larger harvesting equipment (there is some question about this because while less area is affected by wheel traffic, the affected area has greater weight applied to it). This could be another benefit of contract harvesting.

5) Drive on field as soon after cutting as possible (e.g. make silage from higher yielding fields, hay from lower yielding fields).

Fertilizer, AgLime and Pest Management Conference. 2005. Vol. 44.

RYE: THE ALL-PURPOSE INTEGRATED WEED MANAGEMENT CROP

Jerry Doll and Dwight Mueller[1]

Introduction

Rye has long been known for its weed suppressing abilities. Part of this effect comes from the natural herbicides found in rye. This phenomenon is known as allelopathy which was first documented in the 1800s (Rice, 1974). Allelopathy was initially studied by ecologists who observed that it is often helps explain species succession, and it sometimes accounts for the reason a climax species dominates other plants. We have known for years that many weed species have chemicals that inhibit (and occasionally stimulate) various physiological processes in plants. However, the use of these plant interactions in agriculture is a relatively recent development. The most notable one is the development of a commercial corn herbicide, mesotrione, from the callistemon plant, a shrub native to Australia.

The initial report on this aspect of rye appeared in the early 1940s (Faulkner, 1943) and more recent research by Barnes et al. (1986) identified the specific chemicals involved (allelochemicals in the benzoxazinone chemical family referred to as BOA and DIMBOA). Researchers at Michigan State University developed systems of vegetable production that use rye to suppress weeds (Barnes and Putnam, 1983) and similar studies in agronomic crops have also been done.

A summary of research with rye in corn and soybeans in the midwest and the results of our work in Wisconsin in soybean production systems are found in the articles by Doll and Bauer (1991) and Ateh and Doll (1996). The key findings are as follows:

- rye can provide nearly full season weed suppression if:
  - the rye is chemically killed
  - when in the boot stage of growth
  - at least 1.5 ton/acre dry wt of rye is present
  - and soybean is no-till planted
- rye fails to control weeds if:
  - tillage is done to kill rye
  - mowing is done before rye pollinates (rye regrows and is a weed itself)
  - the rye is killed in the vegetative growth stage
- rye biomass declines as the planting date is delayed

We concluded our 1991 Fertilizer, AgLime and Pest Management Conf. paper with this statement:

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> "Since the potential for success has been shown, on-farm testing of the system seems appropriate. This may be especially appropriate on dairy farms where rye can be established easily in old hay fields in late summer, the rye can be used as silage next spring, and the soybeans can be used to replace purchased protein supplement."

Time has proven this to be a realistic assessment of the future. Interest in rye as a cover crop has steadily grown, particularly because Wisconsin producers harvest nearly 1,000,000 acres of corn for silage annually and these fields have little if any crop residue remaining to protect the soil from the erosive action of wind and water. Some of these fields are being seeded with rye in the fall to both protect against soil losses and to also graze or harvest rye as a forage the following spring (after forage harvest, there is still time to plant soybeans or corn). In addition to these benefits, rye can be part of a weed management plan due to its rapid growth and the mulch and allelopathic effects it offers.

Building on our previous research, we have done large-plot research with rye prior to planting corn and soybeans at the Arlington Agricultural Research Station for three years. A summary of our findings is presented below.

Methods Used

All trials were done at the University of Wisconsin Arlington Agricultural Research Station. Rye was planted in the fall of 2001, 2002 and 2003, following corn silage harvest. Table 1 gives the background information on when specific activities occurred in the trials. Tillage was done in the non-rye plots but not in the rye system. An adapted Roundup Ready corn hybrid and soybean variety was planted each year. Plots were no less than 0.75 acre in size which allowed using field-size equipment for all operations.

Table 1. Background on rye, corn and soybean planting dates and dates when rye was killed or harvested as a forage.

	2001/2002	**2002/2003**	**2003/2004**
Previous crop	corn silage	corn silage	corn silage
Rye planted	Sept. 27	Sept. 18	Sept. 26
Rye killed	Apr. 30	May 17 & June 11	Apr. 30 & May 18
Corn planted	May 8	Apr. 24	May 6
Soybean planted	May 15	May 23	May 20
Rye forage harvest	--	--	May 20
Soybean after rye	--	--	May 27
Corn after rye	--	--	June 1
Rye regrowth killed	--	--	July 8

Glyphosate at 0.56 to 0.75 lb ae/acre was used to kill rye. When and in-crop application of glyphosate was part of the treatment plan, the rate was always 0.75 lb ae/acre. The specific treatments each year were as follows:

2002: rye was killed in the tillering stage on Apr. 30. Rain prevented planting corn until May 8 and soybean until May 15. Corn and soybean in the rye system either did or did not receive a subsequent application of glyphosate after crop and weed emergence. Corn and soybean without rye received glyphosate as an in-crop treatment.

2003. We learned in 2002 that we needed to wait longer to kill the rye. We planted corn on Apr. 24 and killed rye on May 17 in this system and ahead of the soybean planting on May 23. Some soybean plots were not treated until June 11 at which time rye was in the pollination stage. As in 2002, we either did or did not apply glyphosate in-crop for the rye system and planted corn and soybean with tillage and without rye as a comparison system.

2004. The primary change this year was to include rye harvested as a forage in the treatments. We also had two times of rye kill to coincide with the difference in corn and soybean planting dates. Rye harvested for forage in the boot stage was not treated with glyphosate until it regrew after corn and soybean planting.

Weed control assessments and crop yields were taken each year. Some years, weed and crop height and populations and soil moisture were also measured.

Results and Discussion

The rye-based system provided adequate weed suppression every year. The only time we saw a yield benefit to applying glyphosate in-crop was in the rye and no-till corn system in 2002. Rye was killed on April 30 and the biomass at this time was insufficient to give full season weed suppression (Tables 2 and 3). Crop densities were generally lower in the rye-based system, not due to the rye but rather because we used a no-till system. The lower population did not affect crop yields, except perhaps for corn in 2002. Yields of both crops in all systems were low in 2003 due to very dry conditions in the mid and late summer and to high levels of soybean aphid.

Table 2. Crop population and height and weed population on June 18 in the 2002 trial.

System	Crop population (1000s/acre)		Crop height (inches)		Weed population (no./100ft^2)	
	corn	soyb	corn	soyb	corn	soyb
chisel plow no rye	28.0	196	13.0	8.0	939	527
no-till rye	24.5	127	7.5	6.0	57	62

Table 3. Weed pressure on July 20, 2002 and weed biomass and crop yield at harvest in the rye and no rye systems.

System	Weed pressure, July 20 (%)		Weed biomass, Oct. (fr lb/acre)		Crop yield (bu/a)	
	corn	soyb	corn	soyb	corn	soyb
chisel plow no rye	0	0	2	0	153	57
no-till rye no gly post	20	11	2495	840	110	57
no-till rye + gly post	1	0	25	0	134	55

We calculated the variable costs and returns in the 2002 trial and found that soybean in the rye system gave returns equal to the non-rye system when glyphosate was no used in the growing crop (Table 4). As seen in table 3, this was an unnecessary application in soybean as it did not increase yield. The rye system with corn was unprofitable because yields were lower than in the conventional non-rye system.

Table 4. Variable costs and returns in the rye and no rye systems, 2002.

System	Variable costs ($/acre)		Return ($/acre)		Rye vs. conventional ($)	
	corn	soyb	corn	soyb	corn	soyb
chisel plow no rye	112	108	194	177	--	--
no-till rye no gly post	108	105	109	180	-85	+3
no-till rye + gly post	124	120	144	155	-50	-22

In 2003, we killed rye later so that there would be more biomass and indeed there was. When rye was killed in the boot stage, 2 ton/acre of dry rye biomass was present and when killed in the pollination stage, the dry biomass was 3.9 ton/acre. Our earlier work with rye found that weed suppression with rye alone was successful if we had 1.7 ton/acre biomass or more. This quantity of biomass often coincides with rye in the boot stage. Weed control was excellent in all systems and there was never a benefit of using glyphosate in the growing soybean crop (Table 5). The corn system included the in-crop application because corn provides a much later canopy over the soil, especially in no-till, rye-based systems. Crop yields were reduced by drought and soybean aphid. Corn yields were higher without rye but soybean yields were similar in all systems and actually slightly higher in the rye system. We did not calculate economic returns but it is clear that corn in the rye system would again be less profitable while returns for soybean would be comparable in both systems.

Table 5. Weed control on July 22, 2003 and weed biomass and crop yield at harvest in the rye and no rye systems.

system	Weed control, July 22 (%)		Crop population (1000s/acre)		Crop yield (bu/a)	
	corn	**soyb**	**corn**	**soyb**	**corn**	**soyb**
chisel plow no rye	93	94	30.4	141	115	23
no-till rye no gly post	99	97 early kill 100 late kill	27.9	196 early 163 late	98	25 early kill 21 late
no-till rye + gly post	97	99 early kill 100 late kill	26.5	207 early kill 152 late kill	100	26 early 26 late

In 2004, we compared using rye only as a mulch or as a forage followed by planting corn and soybean. The wet spring and early summer provided challenges to timely field operations but we achieved our goal of harvesting rye as a forage and then establishing a competitive corn or soybean crop. Production data from this season are still being analyzed but the weed control obtained was excellent (Table 6).

Table 6. Weed evaluations in 2004 rye systems trial.

System	Weed pressure, July 7 (%)		Weed control Sept. 9 (%)
	grass	**broadleaf**	
rye killed early corn	16	13	99
rye killed boot soybean	0	1	94
rye for forage then corn	8	12	99
rye for forage then soybean	4	3	100

Summary

The use of the biological (fall planted, fast early season growth), physical and allelochemical properties of rye as a weed management approach in Wisconsin cropping systems offers great promise to both conserve soil and nutrients and help manage weeds. It does require extra effort to plant rye and this system will not fit everyone's situation. The most profit would seem to be in systems that use rye as a forage before planting soybean or corn.

The following table is based on our earlier and current rye research and summarizes how rye can be used in Wisconsin cropping systems. It attempts to address the most common questions asked by those who want to try rye, especially that of what crops can be planted after rye is killed or harvested.

Table 7. The impact of how and when winter rye is killed on weeds and the crops safe to plant into dead or dying winter rye residues.

Method used to kill rye	Growth stage when rye is killed	Level of weed suppression from rye	Crops that can be planted

chemical	tillering (8 to 12")	poor	alfalfa, corn, soybean
chemical	boot (20-30") mid May	fair to very good (30 to 60 days)	soybean corn for silage
chemical	pollination (32-44")	very good to excellent	short season soybean
tillage	can be killed at all stages	none to poor	alfalfa, corn, soybean
forage harvest followed by planting a RR	harvested at boot stage (mid May); rye will regrow; can be killed	poor (7 to 15 days)	soybean corn for silage

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NITROGEN AVAILABILITY FROM DAIRY MANURE[1/]

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Introduction

Dairy manure is a valuable source of N for crop production in Wisconsin. Accurate estimates of dairy manure N availability in the first- and subsequent residual-years after application are needed to maximize crop N uptake and reduce N losses to the environment. This study examined dairy manure N availability and mineralization of dairy manure components using various methods. A 6-year field trial estimated the first-, second-, and third-year dairy manure N availability using (1) the apparent recovery method (difference method) (2) the fertilizer N equivalence method and (3) recovery of ^{15}N labeled manure. Manure N release was also studied in the field trial using a mesh litterbag. A laboratory incubation study was conducted in which ^{15}N-labeled or unlabeled feces, urine, and oat straw bedding were incubated in soil for 168 days.

Materials and Methods

Experiment 1

The field experiment, located at West Madison Agricultural Research Station, Madison, WI was conducted on a Plano silt loam (fine-silty, mixed, mesic, Typic Argiudoll) during the 1998 to 2003 cropping seasons. Corn (*Zea mays L.*, c v Lemke 6063) was planted all years of the study. Treatments include five fertilizer treatments (40, 80,120,160, and 200 lb acre^{-1}, applied as NH_4NO_3) applied every year; two manure rates (estimated to provide approximately 80 and 160 lb available N acre^{-1} in the first year) applied at various intervals (every 1, 2, or 3 years) and a no fertilizer or manure control. In addition to the treatments, a starter fertilizer, (9-23-30) was applied to all plots at a rate of 150 lbs acre^{-1} at time of planting. Inorganic fertilizer was broadcast on plots 5 days prior to planting. Manure was hand spread using pitchforks and was disked within 24 hours. Micro plots using manure labeled with ^{15}N were incorporated within the larger unlabeled plots in order to be exposed to the same spatial field elements as the larger plots, but provide the ability to directly measure manure N uptake by corn.

Nitrogen availability was determined in this study using the apparent recovery, fertilizer equivalence, and ^{15}N isotope methods. The apparent recovery method compares treatment whole-plant N uptake from the manure treatments to the amount taken up by the un-manured control plots. This can be seen in Equation 1 (Motavalli et al., 1989):

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$$\text{Apparent N recovery \%} = \frac{\text{Treatment N Uptake} - \text{Control N Uptake}}{\text{Amount of Total Applied N}} * 100$$

The fertilizer equivalence method compares manurial N yield or uptake responses from where a similar response is obtained from a fertilizer N treatment. The derived value divides the fertilizer N rate by the total manurial N rate expressed as a percentage. The percentage is the worth of the manure in terms of fertilizer, which is deemed 100% available in this case. Equation 2 (Motavalli et al., 1989):

$$\text{Nutrient Availability} = \frac{\text{Estimated equivalent fertilizer N rate}}{\text{Total N from manure applied}} * 100$$

The apparent recovery and fertilizer equivalence methods are commonly used for predicting the availability of nitrogen in manures in first year studies. Using the labeled nitrogen method we may be able to obtain better estimates over a longer period of time (Powell et al., 2005).

Nitrogen tracer techniques involve enriching the manure above the natural levels of the ^{15}N isotope and monitoring the movement of this tracer through the soil and crop (Hauck and Bremner, 1976; Powell et al., 2004). This technique is similar to the apparent recovery method as it based on the uptake of isotopic nitrogen rather than a total N uptake. The ^{15}N uptake calculation, Equation 3 (Hauck and Bremner, 1976):

$$\%\ ^{15}\text{N recovered} = \frac{100\ \text{P}(c - b)}{f\ (a - b)}$$

P is amount N in corn silage (manure-amended plots);
f is the amount of manure N applied;
a is the atom % ^{15}N in the manure;
b is natural abundance of ^{15}N in corn silage (control plots);
c is atom% ^{15}N in corn silage (manure-amended plots).

Experiment 2

Litterbag studies have investigated organic matter decomposition and N release from sheep manure (Powell et al., 2004; Rixon and Zorin, 1978) and dried cattle manure (Lupwayi and Haque, 1999). This experiment was conducted inside of the larger field study. In 2000 and 2002, 3.7 x 7.1 inch nylon bags (38 µm mesh) were filled with 21, 31, and 6 g wet weight urine, feces, and bedding, respectively. This represented a typical barn scrape ratio where 42, 36, and 22% of the total manure N came from urine, feces, and bedding, respectively. In 2000, the urine and feces were labeled with ^{15}N using the procedure described in Powell et al. (2004) where dairy cattle were fed ^{15}N labeled forage. Bags were prepared 1 week before burial, closed with a nylon string, placed in individual plastic bags and kept frozen to preserve mineralization characteristics (Van Kessel et al., 1999). On May 15, 2000 and May 22, 2002 bags were randomly buried horizontally (3 inch depth) at 6 inches to the side of the cornrow, spaced 9.8 inches apart. Three bags were not buried and kept frozen to determine N losses before the experiment started. Also, three random bags were buried and sampled approximately 1 hr after burial. The remaining bags were excavated (3 per date) at 7, 14, 21, 28, 35 (2000 only), 42, 56, 84, 98, 126 days after burial and at whole plant harvest at 142 (2002) and 154 (2000) days after placement. Four bags were taken on day 154 in 2000. Sampled bags were placed into individual clear plastic bags and frozen until analysis. The whole sample was thawed, dried at 131°F for 48 hours to determine dry mass and then split for N analysis. The portion of sample to be analyzed for chemical content was ground to 0.5 mm in an Udy mill to achieve homogeneity.

At the time of bag sampling in 2002, corn plants from a non-adjacent row were sampled. Starting June 11, four plants were sampled and starting July 16, only two plants were sampled. Plants were dried at 131°F to a constant mass, ground to 2 mm in a Wiley mill and sub sampled for total N analysis.

Corn samples were digested using the semi-micro Kjeldahl digestion described in Liegel et al. (1980), diluted, filtered and analyzed for total N (QuickChem Method 13-107-06-02D) in an automated colorimeter (Lachat Instruments, Mequon, WI). Mass and N losses were adjusted by subtracting ash content contributions.

Samples of urine, feces, and straw bedding put into litter bags, and litter bag contents after excavation were analyzed for organic matter, NH_4^+(only feces), and total N at the University of Wisconsin- Soil and Plant Analysis Lab at Marshfield using the procedures outlined in Combs et al. (2001). Total ^{15}N of these components was analyzed using a Carlo Erba (Milan, Italy) elemental analyzer coupled with a Europa 20/20 mass spectrometer at the University of California-Davis, Stable Isotope Facility.

Experiment 3

An incubation trial utilized a Plano silt loam (26% sand) with the following initial chemical characteristics: 3.55% total C, 2.56% total organic C, 72 mg kg^{-1} Bray P1, 2220 mg kg^{-1} total Kjeldahl N, and 7.6 pH. Soils were amended with ^{15}N labeled and unlabeled dairy manure components in the following treatments and incubated at 52, 64, and 77°F for 168 days at 60% water filled pore space:

- Treatment 1: ^{15}N-labeled feces; urine and bedding at natural abundance.
- Treatment 2: ^{15}N-labeled urine; feces and bedding at natural abundance.
- Treatment 3: ^{15}N-labeled bedding; feces and urine at natural abundance.
- Treatment 4: ^{15}N-labeled feces; urine and bedding.
- Treatment 5: control (no amendments).

Samples taken at day 168 were analyzed for total and inorganic (NH_4^+ and NO_3^-) ^{15}N.

Results and Discussion

Experiment 1

Manure N availability estimates from this study are shown in Table 1. The apparent recovery and ^{15}N methods had the lowest estimates of manure N availability and the fertilizer equivalence method had the highest estimates. The difference method relies heavily on manure N uptake by corn in the control plots. In this study the control plots had high yields throughout all study years causing low estimates of apparent manure N availability. The recovery of ^{15}N had the lowest variability of all the methods.

This study estimated first-year nitrogen availability from dairy manure to be 19% when averaged across all methods. Currently, the University of Wisconsin Extension recommends that dairy manure N availability (based on total N) during the first year to be 30% when surface applied and 40% when incorporated within 72 hours (Kelling et al., 1998). A review and summary conducted by Beegle et al. (in review) that included 37 studies found that dairy manure N availability during the first year after application averaged 37%. Our estimates appear to be lower than these other sources. One explanation for this may be the use of the 15N isotope where others (Bergström and Kirchmann, 1999; Paul and Beauchamp, 1995) have also found estimates to be lower as result of a phenomena inherent to the method and can be explained by "pool substitution" (Hauck and Bremner, 1976; Jenkinson et al., 1985) whereby soil microorganisms immobilize applied ^{15}N and add ^{14}N to the total N pool.

This study found second- and third-year nitrogen availability to average 9 and 2%, respectively when averaged across all methods. The University of Wisconsin Extension recommends dairy manure residual N availability to be 10 and 5% for the second- and third-year after application. The fertilizer equivalent method produced results that were comparable to University of Wisconsin Extension recommendations for residual dairy manure N availability (Kelling et al., 1998). Estimates using ^{15}N were lower than those obtained using the fertilizer equivalent method and may be considered a minimum residual manure N availability. Based on this and other studies (Kelling and Wolkowski, 1993; Klausner et al., 1994; Paul and Beauchamp, 1993), it is suggested that second and third year residual N availability from a single application of semi-solid dairy manure would be 9 to 12%, and 3 to 5%, of the original manure N application, respectively. Based on our first-year and residual availability estimates for semi-solid dairy manure, producers can be confident in University of Wisconsin recommendations for dairy manure N availability.

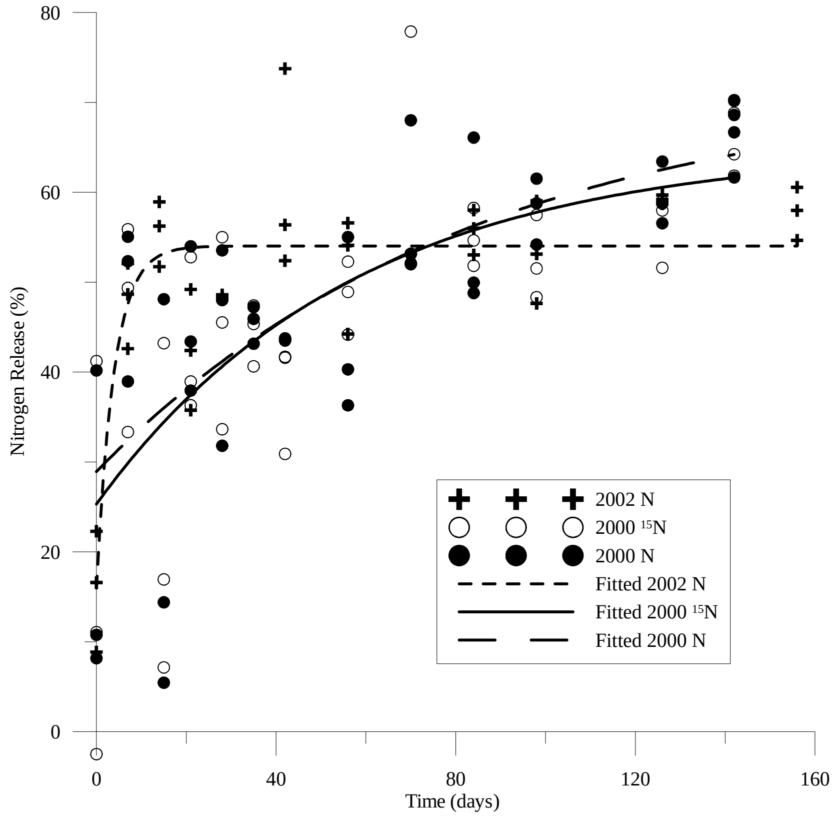
Table 1. Estimates of first-, second-, and third-year manure N availability using various methods.

		Method		
Manure N availability	n†	^{15}N Recovery	Apparent recovery	Fertilizer equivalence
		---%--------------------------------------		
1st year	6	17 (3.1) ‡	14 (4.7)	25 (10.5)§
2nd year	5	6 (1.1)	8 (6.6)	12 (7.9)§
3rd year	4	2 (0.4)	1 (5.8)	3 (9.4) §
† no. of measurement years in parentheses; 4 reps/year				
‡ Average (standard error)				
§ Data from 2002 excluded.				

Experiment 2

Of the total manure N added to the litterbags, an annual average of 67% apparently mineralized (Figure 1). The litterbag released 53 and 86% of the mineralizable N pool by day 21 in 2000 and 2002, respectively. Much of this mineralized N may be attributed to urine, which comprised about 42% of the total manure N. Although, a large majority of the manure N is released in the first year of application, a study conducted by Muñoz et al. (2003) found that 46% of ^{15}N labeled dairy manure N to remain in the soil after 3 years of application, the majority (82%) remaining in the top 12 inches. This may suggest that the 45% of N remaining in litterbags from our study may remain in soil organic pool for some time. This indicates that the manure N during the first year of application may be entering soil N organic pools.

Figure 1. Measured and fitted data for N release from litterbags, 2000 and 2002.



A comparison of ^{15}N and N data from 2000 showed the use of either N form resulted in statistically similar N mineralization rates of release. This suggests that the measured amounts of ^{15}N lost from litterbags were apparently unaffected by an unbalanced dilution of ^{15}N with unlabeled soil N, as has been found in other studies (Bergström and Kirchmann, 1999; Paul and Beauchamp, 1995). The similar results also suggest that expensive ^{15}N is not required for computing N balances in litterbag studies, such as ours.

Experiment 3

In the incubation trial, soil samples taken on day 168 from all temperatures and treatments were analyzed for inorganic ^{15}N to determine individual manure component contributions to mineralized N (Table 2). Net urine mineralization was unaffected ($p<0.05$) by temperature and averaged 55% at the end of the 168 day observation period. Because total ^{15}N recoveries averaged 115% (data not shown), providing evidence that manure N was not lost in this experiment, it is likely that the remaining 45% urine ^{15}N was exchanged with unlabeled N or may have been mineralized and subsequently immobilized. Soil samples taken in 2000 from the larger field experiment showed that a large portion of applied ^{15}N remained in soil 2 to 3 years after application (Muñoz et al., 2003; Powell et al., 2005).

Approximately 19% of applied fecal ^{15}N was mineralized over the 168 d observation period. Fecal ^{15}N mineralization increased significantly with increasing temperature. Other studies have also shown a positive relationship between temperature and manure N mineralization for temperatures 0 to 95ºF (Stanford et al., 1973) and 50 to 75ºF (Griffin and Honeycutt, 2000). Similarly, temperature had a significant effect on bedding N mineralization with N mineralization being lowest (15%) at 52ºC and highest (25%) at 64 and 77ºF. In vessels where all applied manure components were labeled, N mineralization averaged 30% and was unaffected by temperature likely dominated by high N mineralization of urine. This is relatively close to the 35% mineralized N derived by summing the proportionate contribution of individual labeled manure N components.

Table 2. Mineralized ^{15}N recovered from various labeled manure components over all temperatures at day 168.

Temp (ºC)	Urine	Feces	Bedding	All components
	------------------------------% of applied ^{15}N--------------------------			
52	44	13	15	24
64	60	18	24	30
77	63	26	25	36
P_t>F	0.054	0.003	<0.001	0.088
LSD, 0.05	16.2	5.7	3.5	10.4

Conclusion

The use of the stable isotope ^{15}N provided direct, and therefore more precise estimates of dairy manure N availability to corn the first, second and third year after manure application. Use of ^{15}N labeled dairy manure confirmed current University of Wisconsin Extension recommendation on dairy manure N availability. Conservation of dairy urine N is key to manure N availability to crops. Most urine N apparently mineralizes during the first few weeks after manure application. A large portion of applied manure N that is not taken up by a crop remains in the soil, and may be available to crops over the long term.

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SEASONAL VARIABILTY IN SOIL TEST POTASSIUM

Carrie A.M. Laboski [1]

There has been increased interest in understanding the variability one sees in soil test potassium (K) levels within a field. Of particular interest is why after 3 or 4 years the soil test K (STK) levels are less than or greater than expected based on prior STK levels and nutrient budgets for K additions (fertilizer and/or manure) and removals (crop removal of K). It must be remembered that K availability is assessed by chemical extractions (soil tests). And any soil test only measures a fraction of the K in soil, specifically soil solution K and exchangeable K. This paper will highlight factors that affect exchangeable K and subsequently STK levels.

Drying/Wetting

Exchangeable K can either increase or decrease upon drying and is dependent upon the clay minerals present. Potassium fixation (K becomes non-exchangeable) can occur from drying soils with high exchangeable K or recent K fertilizer applications. Fixation is a result of K becoming trapped within clay sheets as they dry and collapse. While K release (K becomes exchangeable) can occur when soils low in exchangeable K are dried because the clay sheets roll back and release K (McLean and Watson, 1985). The net effect is dependent upon whether fixation or release dominates and is dependent upon the types of clays and the amount of weathering they have undergone. Thus, the time of soil sampling in relation to field wetting and drying cycles may influence soil test K levels.

In Ap horizon soils of Ohio, Large (1969) found that air-drying on average increased exchangeable K by 14.3% compared to field moist soils. However, it must be noted that this was an average, and release and fixation were both observed. Past research in Iowa found STK increased on average about 25% when soil samples were dried at 35 to 40ºC (95 to 104ºF) (as reported by Mallarino et al., 2004). Mallarino et al. (2004) explain that their research "suggests that the effect of sample drying (and the temperature used) on extracted K varies greatly across soil series, with the soil moisture content when the sample is collected, and with other unknown factors." These differences in STK brought on by drying soil highlight the point that it is important for all soil testing laboratories to follow the same protocol for sample handling. Following a uniform protocol, with regard to drying, will minimize using soil test data that are not valid because they deviate from conditions that were used to obtain a correlation between STK and crop yield response to fertilizer K application.

Freeze/Thaw

In soils with considerable amounts of mica clays, freezing and thawing cycles will release fixed clay. Whereas, in soils containing smaller amounts of mica and having greater amounts of exchangeable K, freezing and thawing have no effect on K fixation/release. Thus, depending on clay mineralogy present in a soil and type of winter weather pattern, STK from samples in the spring may be different than STK from samples taken in the fall.

Oxidation State of Iron

Iron (Fe) is a component in the structural lattice of clay minerals. Iron can be either reduced (Fe^{2+}) or oxidized (Fe^{3+}) depending upon the oxidation/reduction (redox) status of the soil. Low oxygen conditions, which may result from saturated soil, cause a change in the

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biochemical pathway of soil organisms such that Fe^{3+} is reduced to Fe^{2+}. Shen and Stucki (1994) explain results of several studies that indicate that when the Fe in smectites (a type of clay mineral) is reduced, K fixation is increased and likely results in reduced K availability. They also showed that reduction of Fe in illites (another type of clay mineral) results in K release and increases in exchangeable K. In soils containing both smectitic and illitic clays the net effect of K fixation or release when Fe is reduced would depend upon the relative amount of each clay in the soil (Shen and Stucki, 1994).

Clay Minerals in Wisconsin

If one were to know the dominate clay minerals in a given soil, predictions about how STK may change under different environmental conditions might be possible. However, knowing which types of clay minerals dominate in soils of different regions of Wisconsin is not straightforward because of various glacial activities throughout the state. Thus, we might expect that environmental impacts on STK may vary differently depending upon region (e.g., driftless region, eastern red soils, northern soils, and central soils) (C.A. Stiles, 2004; personal communication).

Soil Sampling

Soil sampling must be done correctly to obtain soil test results that are representative of a field. The most intensive soil sampling recommendation is to take one sample per five acres and each sample should be comprised of 10 to 20 soil cores that are thoroughly mixed. Less intensive sampling may be done in some situations, see UWEX A2100 for details. Mallarino and Wittry (1999) reported high small scale variability in STK across fields of Iowa. Depth of sampling can also cause large differences in STK results for example if a field is sampled to seven inches one time and only five inches another time. Thus, one must recognize that if a field is soil sampled once every 3 or 4 years, the expected STK value may differ from what was actually measured, solely because of inconsistent sampling. Inconsistent sampling may include: different number of cores composited per sample, different number or location of samples within a given field, or different depth of sampling.

It must also be remembered that estimating changes in STK over time using nutrient budgets for a given field is not an exact calculation either (e.g., actual crop removal of K may be more or less than predicted). This is exactly why continued soil testing is essential to determining crop nutrient needs.

Seasonal Variability in STK

Ebelhar and Varsa (1996) reported seasonal variation in STK over a 1-year period (Fig. 1). In 1994, the reduction in STK from June through September was attributed to crop uptake of K and possible K fixation because of drier soil conditions in August. The rebounding of STK levels after September 1994 was attributed to increased soil moisture and decomposition of crop residues releasing K to the soil (Ebelhar and Varsa, 1996). At Belleville, April 1995 was very dry and Ebelhar and Varsa (1996) felt that the reduction in STK that month was a result of K fixation brought on by dry conditions. The data shown by Ebelhar and Varsa (1996) highlight the variability in STK that could potentially be seen over the course of a year. Similar variation may be expected in Wisconsin.

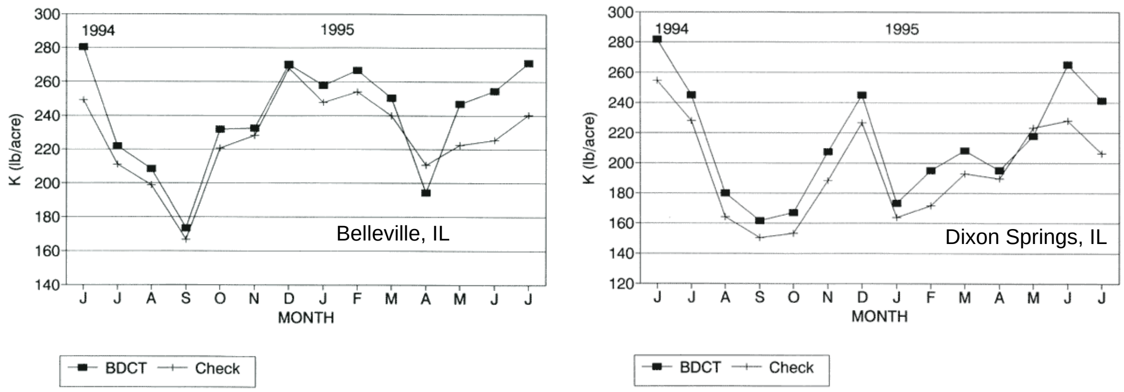

Figure 1. Soil test K levels for soils sampled monthly at Belleville, IL (left) and Dixon Springs, IL (right). On a given date at a given location, samples were composited across corn and soybean plots with the same treatment (thus, the same plots were sampled and composited each time). Treatments include: BDCT is 120 lb K_2O/acre broadcast prior to planting in the spring of each year; and Check is no potassium fertilization. (From Ebelhar and Varsa, 1996).

Summary

Environmental conditions such as wetting and drying along with periodic or repeated saturation, in addition to soil clay mineral composition impact STK levels. Because seasonal variation in STK is known to exist, it is recommended that soil sampling occur at about the same time of year such that seasonal variation of STK within a field will be minimized.

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CAN WE BRIDLE HORSEWEED'S RACE?

Ed Luschei [1/]

Horseweed is a common winter/spring annual weed of no-till production fields and waste areas. Also known as Marestail or *Conyza Canadensis*, horseweed has demonstrated "nature's abhorrence of a vacuum" once again. First documented in the Delaware, horseweed biotypes displaying resistance to the popular herbicidal chemical glyphosate have appeared in at least three different geographic regions. These source populations, or foci, are spreading quickly. Both the rapid adoption of glyphosate resistance crops over large portions of the landscape and the capacity of the weed to produce large numbers (50,000 to 200,000 seeds/plant) of aerially dispersed seed have allowed horseweed to capitalize quickly on its genetic innovation. Currently there are no known resistant biotypes in Wisconsin. To the best of our current knowledge, no state bordering Wisconsin has detected the problem. However, researchers in Indiana have performed widespread surveys throughout the state and approximately 350 miles from Madison are populations capable of surviving four times the typical use rate.

Using geographical data compiled by researchers at Penn State University and analyzing the historical distribution and rate of spread across the landscape, I will address the question of when we are likely to have the problem reach Wisconsin. I will also report on investigations into our capacity to avoid or slow down the problem by employing 'resistance management' strategies that effectively lower the selection pressure responsible for the problem in the first place.

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VARIATION AMONG WISCONSIN SCN POPULATIONS[1]

Ann MacGuidwin[2]

The soybean cyst nematode (SCN), *Heterodera glycines*, is a chronic problem for soybean production in Wisconsin. The distribution of SCN expands every year. This nematode rarely disappears from a field once an infestation is detected, even if SCN-resistant soybean varieties are incorporated into the rotation. Host resistance is the most effective and economical management strategy available for this soybean pest, but even this tactic must be thoughtfully deployed to achieve full yield potential. The most serious threat to SCN-resistant varieties is the tremendous genetic variation among the individual nematodes that comprise a SCN population. Somewhere "in the crowd" lurks nematodes not affected by the host chemistry that confers resistance to nematode reproduction. The fact that the majority of nematodes are affected explains why host resistance is successful in boosting yields; the fact that some are not explains why it is difficult to maintain high yields if the same soybean genotype is planted season after season.

Planting resistant varieties does not eliminate a SCN problem and in some cases may increase SCN levels. Our research showed that SCN populations significantly ($P \leq 0.05$) decreased in four fields, increased in six fields, and remained statistically unchanged in seven fields planted with an SCN-resistant variety during 1999-2001. Our experience is not unique; similar findings have been reported for Iowa, Illinois, and other North Central states.

Almost all SCN-resistant varieties sold in Wisconsin derive their resistance from P.I. 88788. This source of resistance is effective for most, but not all populations of SCN. The accepted means of describing genetic variation among SCN populations is the Hg (*Heterodera glycines*) Type Test. The Hg Type Test compares the growth of SCN on seven different soybean indicator lines to that achieved on a standard susceptible variety. We tested nematodes from some of our research sites as well as from other fields across the state for their Hg Type designation.

Procedures

The Hg Type Test involves planting soybean seed of seven indicator lines that represent the resistance genes currently used in soybean breeding programs: "Peking", PI 88788, PI 90763, PI 437654, PI 209332, PI 89772, and PI 548316. New indicator lines are added to the HG Type Test once the germplasm is available in commercial seed. Five replicate pots were planted for each line as well as a standard susceptible variety 'Lee 74'. The plants were maintained in a growth chamber at 27 C for 30 days. Cysts were dislodged from roots, collected, and counted. The number of cysts recovered was averaged for each soybean line and then divided by the average number of cysts collected on the susceptible variety to compute a FI (female index) value. If the FI was greater than 10%, the soybean line was considered to be susceptible to SCN.

Results and Implications

To date, we've conducted Hg tests on fourteen populations of SCN from 13 counties. The FI {(average number of females produced on the test variety/average number of females produced on the susceptible variety) x 100} for 10 populations is presented in Table 1. Four populations infected and matured ($FI > 10$) on P.I. 88788, the source of resistance in most commercial

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infected and matured (FI > 10) on P.I. 88788, the source of resistance in most commercial varieties developed for Wisconsin. Based on the Hg Type Test results, we predict that the Grant population would diminish the yield potential of soybean varieties with PI 88788-derived resistance only slightly. The yield benefit of using PI 88788-derived resistance could be substantially compromised by the Juneau, Sauk, and Buffalo populations.

County	FI on P.I. 88788	Hg type
Waushara	1	0
Waupaca	5	1
Racine	7	0
Columbia	7	7
Shawano	7	7
Dunn	9	5.7
Grant	14	2.7
Juneau	30	2.5.7
Sauk	35	2.5.7
Buffalo	43	2.5.7

Table 1. Results of Hg Type tests on SCN populations collected from 10 counties in Wisconsin.

Knowing the Hg Type of a SCN population is important, but it may not provide all the information that produces need. The indicator lines used in the Hg Type Test are in the linage of commercial varieties, but are not the varieties themselves. This is an important distinction because even two varieties that share the same source of resistance, such as PI 88788, may support quite different levels of SCN reproduction. The reason is that the two varieties have many other genes that may contribute to the success of SCN (e.g., root architecture) or because not all the resistance genes in PI 88788 are present. Some companies provide resistance rankings (i.e. high, moderate, slight) and producers can take advantage of this information by planting varieties with only the highest level of resistance into fields with populations known to have a FI value greater than 10.

Results of these tests underscore the inherent variability among SCN populations and the importance of this fact to soybean variety selection. None of the populations we tested had ever been exposed to an SCN-resistant variety, yet some nematodes in the population were not affected by soybean defense responses. Planting a resistant variety will eliminate all but these nematodes and they will produce offspring that inherit the same successful characteristics.

The “CystX” source of resistance is now available to Wisconsin producers. Varieties carrying these resistance genes, derived from PI 437654, are reported to be effective against most populations of SCN. Hopefully, this source of resistance will be effective for a long time, but almost certainly not forever. The existence of “Cyst X” can be attributed to the incredible range of genetic variability that exists within populations of soybeans. It is inconceivable that SCN, which depend on soybean plants for food, are any less diverse. No single host genotype is likely to provide the “magic bullet” to eliminate SCN; so Wisconsin producers should continue to monitor what is happening in their fields. Our recommendation is to plant a variety with PI 88788 resistance once SCN is detected in a field. There are many high-yielding varieties available with a range of resistance to other diseases. The soil should be tested every two soybean crops and alternative sources of resistance, such as ‘CystX’ should be planted if SCN population densities have increased. Practicing crop rotation and managing resistant soybean varieties will enable producers to maintain high yields in SCN-infested fields.

SOYBEAN RUST MANAGEMENT IN WISCONSIN

Nancy C. Koval and Craig R. Grau

Asian soybean rust is caused by the fungus *Phakospora pachyrhizi*. The soybean rust pathogen has been moving progressively westward from its center of origin in China and has now reach North America. Soybean rust has gained considerable attention in the US since its discovery in nine Southern states this fall. Currently, there is much speculation and apprehension on how soybean rust will develop and impact soybean production in the U.S. The reality of the situation is that soybean rust has been a devastating disease in many parts of the world. Thus, it is prudent that we must respect its potential to reduce yield, and be prepared to manage it starting in 2005. This publication was developed as a resource to acquaint crop advisors and soybean growers with the soybean rust pathogen, soybean rust epidemiology and how this disease can be managed to limit yield loss.

Description of Soybean Rust

Asian soybean rust is a disease caused by the fungus *Phakopsora pachyrhizi*. Like all other fungi that cause rust diseases, the soybean rust pathogen must have a living host to grow and reproduce. Unlike many of the rust pathogens that infect cereal crops, the soybean rust pathogen does not have a spore stage that is dormant during the winter and can resume growth in the spring and infect a living host. *Phakopsora pachyrhizi* infects the foliage of a soybean plant and causes lowered photosynthetic activity and premature defoliation. Infection of foliage can result in reduced pod set and grain development ultimately leading to reduced soybean yield. Symptom severity and yield reduction is dependent on growth stage of host when initial infection occurs, susceptibility of soybean variety and climatic conditions during the growing season. Symptom severity and yield loss will decline as infection is delayed with growth stage.

Identification of Soybean Rust

Symptoms and Signs

Symptoms of soybean rust appear as plants approach the R1 (early flower) growth stage and appear on leaves in the lower canopy (Fig. 1). Accurate and timely diagnosis of soybean rust is critical to achieve control of soybean rust, especially if fungicides are involved in the management plan. Initial symptoms of soybean rust begin on lower leaves, but symptoms and signs can also occur on petioles, stems and pods. Initial symptoms are chlorotic (yellow) areas that that develop into tan or brown angular lesions. Lesions increase in size over time and change color from gray, to tan or reddish-brown. Tan lesions mature to form small pimple-like structures (called pustules) on the lower leaf surface. Pustules contain powdery tan spores that give the leaves the appearance that they have dandruff and are surrounded by slightly discolored necrotic (i.e., dead) tissues. Leaves lower in the canopy are infected first and are difficult to detect. Furthermore, early symptoms are not unique to soybean rust and are easily either missed or confused with symptoms caused by other pathogens. The inexperienced person will likely miss symptoms of soybean rust until infected tissues support sporulation, the formation of pustules. Initially, a hand lens is needed to identify pustules. In time, pustules become abundant and are apparent macroscopically. Early identification is mandatory for successful control with fungicides.

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For a more accurate identification symptoms can be viewed with a hand lens. In the early stages of infection the emerging pustules look like miniature volcanoes topped with a pore. There is no yellow halo surrounding the pustule. Later, the pustules "burst" releasing masses of rust-colored spores. Reddish-brown lesions are composed of primarily necrotic tissue and typically have only a limited number of pustules. As plant canopies close and pods begin to set, the soybean rust pathogen

Figure 1. Symptoms and signs of soybean rust. Signs of the pathogen (A) are gray tufts of spore masses (pustules) that appear on both sides of a leaf. Symptoms are various degrees of chlorosis (yellow) or necrotic (dead) tissues. Symptoms of soybean rust at canopy level may appear as a nutrient or disease caused by several other pathogens of soybean.

can rapidly spread from lower to upper foliage of plants. If not controlled, soybean rust results in premature chlorosis and total defoliation of plants by the R4-6 growth stages. Other diseases of soybean including brown spot, bacterial pustule and particularly downy mildew could potentially be confused with soybean rust. Soybean rust could also be confused with nutrient deficiency problems.

<u>Submission of Leaf Samples for Rust Diagnosis</u>

If you believe you have found soybean rust, getting a high quality, intact leaf sample to the Plant Disease Diagnostic Clinic is critical for verification.

- Select a representative group of leaves (or other plant parts) that exhibit the range of symptoms that you have observed in the field;
- Be sure to collect detailed information on the location where the sample was collected so that the site can be revisited if necessary. If you know the GPS coordinates of the site, please provide these;
- If possible, place the leaves between layers of cardboard and paper towels to keep them flat (i.e., layer the materials as follows – cardboard, paper towel, leaves, paper towel, cardboard, paper towel, leaves, paper towel, cardboard, etc.);
- Place the leaves in a self-sealing plastic bag and seal the bag shut;
- Place this bag inside a second self-sealing plastic bag, being particularly careful that the outside of this second bag does not become contaminated;
- Keep the leaves cool (e.g., by placing them in a cooler or refrigerator) between the time of collection and the time when they are shipped to the PDDC;
- Ship samples to the PDDC by overnight mail whenever possible.
- The PDDC address: Plant Disease Diagnostics Clinic, Department of Plant Pathology, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706-1598

Epidemiology and Soybean Rust Disease Cycle

Distribution of Soybean Rust Pathogen in the North America

Prior to 2004, the soybean rust pathogen was confined to regions south of the equator in South America not accessible to North Hemisphere weather systems. However, the pathogen moved north of equator in 2004 into Columbia. Thus, the wind transported spores of the pathogen were reached by winds originating in the Caribbean and moved northward by low pressure weather systems. Soybean rust was detected near Baton Rouge, LA on a university research station on November 10, 2004. Spores of the soybean rust pathogen are believed to have been transported into the Southern US on the winds of hurricane Ivan (Fig. 2). This detection activated a general alert and soybean rust was detected soybean plants in eight additional states, plus on kudzu in Florida (Fig. 3).

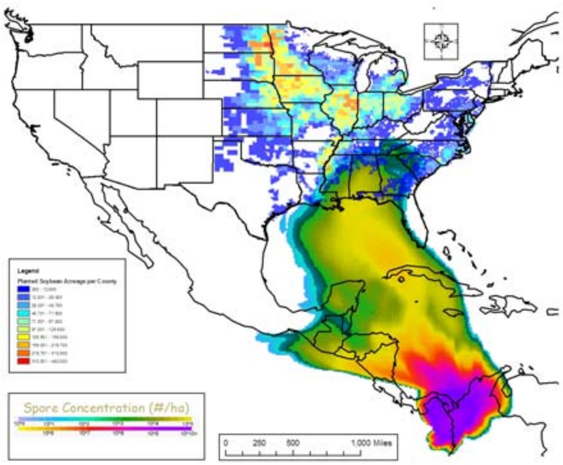


Figure 2. Computer model for the hypothesized transport of the soybean rust pathogen on the winds of hurricane Ivan during September 15-17, 2004. Spores of the pathogen originated in Columbia and were transported northward into North America.

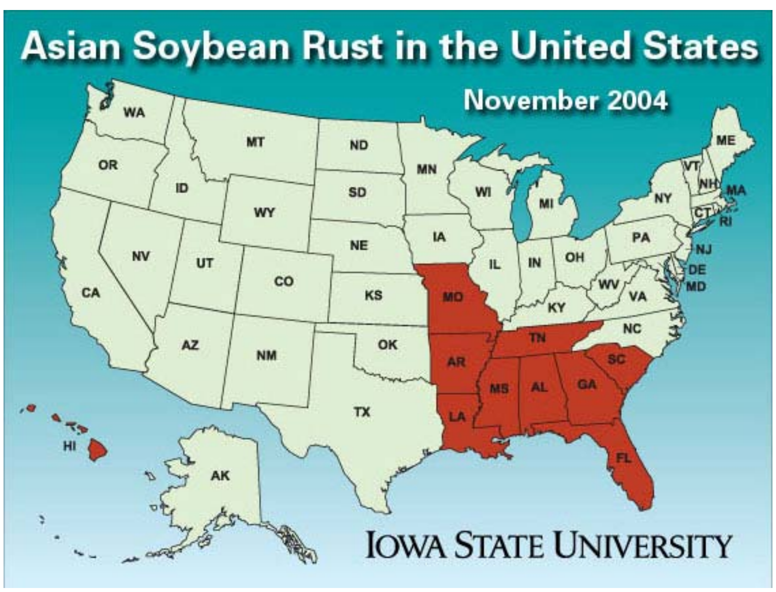


Figure 3. Distribution of soybean rust in the United States as of November 2004. The pathogen was

identified on soybean and on kudzu in Florida.

Sources of Inoculum

Phakospora pachyrhizi is reported to infect 95 plant species of which most are in the legume family. Hosts of most economic importance are soybean and all types of common bean including snap bean and dry edible beans. Host range will play an important role in the epidemiology and economic importance of the soybean rust pathogen in North America. In Wisconsin, other potential hosts are soybean, snap and kidney bean (*Phaseolus vulgaris*), American birdsfoot trefoil (*Lotus unifoliolatus*), crimson clover (*Trifolium incarnatum*), Korean clover (*Kummerowia stipulacea*), white clover (*Trifolium repens*), purple crownvetch (*Coronilla varia*), Chinese lespedeza (*Lespedeza cuneata*), lupine (*Lupinus spp.*), pea (*Pisum sativum*), rattlebox (*Crotalaria spp.*), yellow sweetclover (*Melilotus officinalis*), ticktrefoil (*Desmodium spp.*), and winter vetch (*Vicia villosa*).

In order to survive winter in the absence of a soybean crop, the soybean rust pathogen requires an alternative host that retains living foliage (Fig. 4). Thus, the soybean rust pathogen will only survive in regions of the U.S. in which freezing temperatures do not occur. Kudzu, a widespread perennial leguminous plant in many parts of the U.S., meets these requirements and could serve as an overwintering host for the soybean rust pathogen. It is an alternative host to the soybean rust pathogen, is widespread in the southern U.S. and escapes freezing temperatures and remains green all year regions bordering the Gulf of Mexico (Fig. 5). Yellow sweetclover is a candidate for an overwintering host of the soybean rust pathogen in Wisconsin. However, foliage of perennial host species in Wisconsin are usually killed by freezing temperatures, thus the rust fungus will perish. Unless winter temperatures increase dramatically, the soybean rust pathogen is not expected to survive in Wisconsin during the absence of soybean or bean production.

The lack of an overwintering source of inoculum means the soybean rust pathogen must be reintroduced to Wisconsin each growing season. Spores of the soybean rust pathogen are transported readily by air currents and can be disseminated rapidly hundreds of miles in 2 to 3 days. The severity of soybean rust will be influenced by where the soybean rust pathogen survives during the winter months. Lack of inoculum survival in Wisconsin should contribute to lesser severity of soybean rust. However, the explosive nature of the soybean rust pathogen can overcome factors such as distant sources of primary inoculum if weather conditions are favorable for rust development.

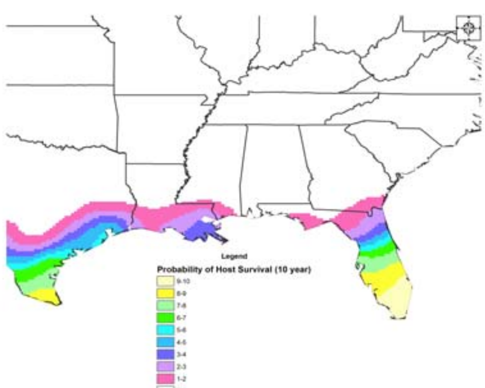


Figure 4. The soybean rust pathogen will survive on leguminous in the southern U.S. Shaded areas represent a range of probability for survival of overwintering hosts based on occurrence of temperatures greater than 28° F in a given year using 10-year daily climate data.

The soybean rust pathogen has not been shown to be moved with soybean seed. Thus, growers should not be reluctant to purchase seed grown in regions where soybean rust developed the previous growing season.

Infection and Disease Development

Soybean rust will develop across a broad range of temperatures common to Wisconsin, but moisture conditions required for spore germination and infection are more restrictive and precise. Key to moisture conditions is the duration of continuous moisture on the leaf surface. Rust spores will germinate between 46°F to 97°F with an optimal range of 61°F and 75°F, but more restrictive is the requirement of 8 hours or more of continuous leaf wetness made possible by relative humidity of >75 to 80% or precipitation. Temperature above 86°F may stop or slow disease development, especially with moisture conditions are limiting. The infection will proceed between 52-82° F with an optimum temperature range of 66-75°F and a minimum of 6 hr of leaf wetness. Spores are produced 10 days after infection and are continually released from lesions if favorable environmental conditions remain.

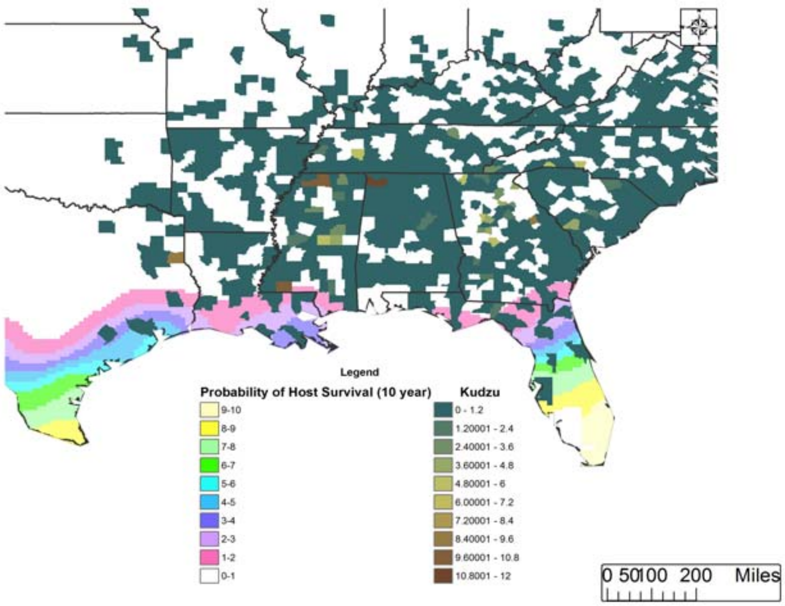


Figure 5. Probability for survival of overwintering hosts based on occurrence of temperatures greater than 28°F in a given year, overlaid with the estimated percentage of kudzu coverage by county.

The environment plays a major role in the incidence and severity of disease. For spore germination and infection to occur the leaf must be wet for an extended period of time. Temperatures need to be between 59° and 86°F, and humidity levels should be in the range of 75-80%. Under these environmental conditions spores are produced within 10-21 days, but in 6-7 days after infection in 72-81°F. An initial infection site normally produces spores for 10-14 days. Within optimal conditions, a plant can go from the first signs of infection to severe defoliation in 1-2 weeks. Knowledge of conditions required for infection and spore production can be applied to the application of fungicides for rust control.

There are three key factors in determining the risk of soybean rust movement into northern soybean production regions: (1) the occurrence of soybean rust during the spring and early summer in the Gulf coast areas. This determines the amount of spores available to blow northward; (2) the July-August climate conditions, which establish where in the U.S. conditions favor soybean rust development, and (3) northward movement of soybean rust spores in weather systems and by “green-bridging”. Producers in more northern production areas may be able to assess the risk of seasonal outbreaks using the following steps throughout the year.

Yield Loss

Yield loss from soybean rust will depend on crop stage infected, environmental conditions, amount of inoculum (spores) produced during growing season, soybean variety planted, and whether implemented control tactics were appropriate and correctly implemented during the growing season. Yield loss in other countries has ranged from 10-90%. However, it is difficult to predict yield loss potential in Wisconsin. Soybeans are susceptible to rust infection at all growth stages, however, amount of yield loss will depend on crop stage infected. The most susceptible crop stages are between early flower stage (R1) and mid-seed development stages (R5).

The occurrence of soybean rust declines in regions of China that correspond to latitudes found in Wisconsin (Fig. 6). Although many factors may render this comparison invalid, this information is the best available to make predictions on soybean rust activity in Wisconsin.

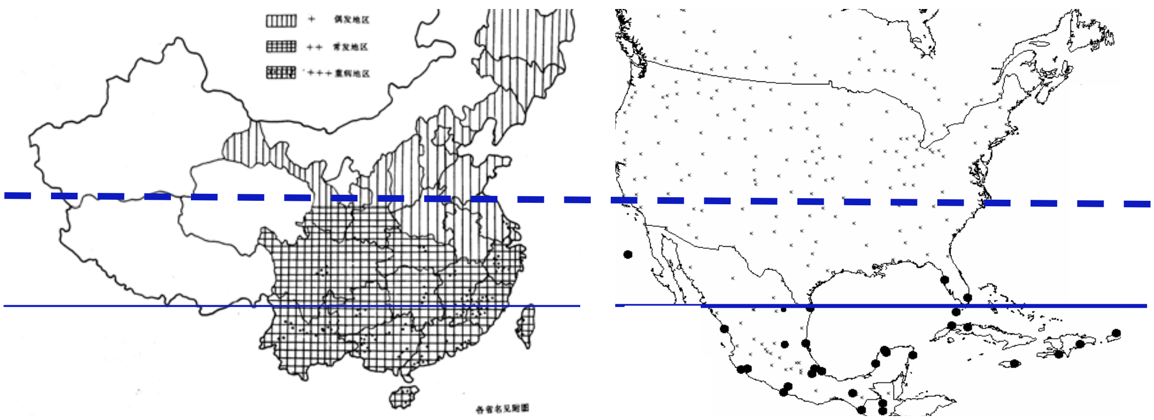


Figure 6. Soybean rust decreases in frequency of occurrence and severity from south to north in China. The map illustrates the intensity of soybean rust in China by latitudes comparable to regions of the United States.

Management of Soybean Rust

Variety Selection

Currently there are no known varieties which are resistant to soybean rust in the Midwest. However, it is likely that varieties will vary in their susceptibility. There are indications that early maturity varieties for a geographic region will escape some degree of the yield-limiting effects of soybean rust. However, early maturity varieties generally have lower potential compared to full-season varieties.

Cultural Practices

Early planting may allow plants to reach advanced growth stages before the arrival of rust inoculum. Other cultural control practices like wider row width and reduced plant populations may reduce the length of time that leaves remain wet and potentially decrease the severity of rust. However, it is not known how big of an impact these methods may have, if at all. The impact of all diseases should be considered before changes in cultural practices are made with the goal of rust suppression. For example, early planting increases the potential of white mold throughout Wisconsin, for yield-limiting levels of *Bean pod mottle virus* due to intense bean beetle activity in early planted soybean fields.

Fungicides

Fungicides are the only in-season pest management practice that is effective against soybean rust. Several fungicides are registered (Section 3) for soybean rust and more are likely to be granted Section 18 emergency use labels in the future. Always check label instruction before using any pesticides.

Fungicides for Soybean Rust

Formulations of chlorothalonil (Echo 720 and Bravo Weather Stik), azoxystrobin (Quadris) and pyraclostrobin (Headline) have full registrations (Section 3) for use on soybeans to control soybean rust (Table 1).

Additional fungicides will be available through Emergency Exemption (Section 18) labels for propiconazole (Tilt, Propimax, Bumper), myclobutanil (Laredo), and/or tebuconazole (Folicur). Up to date information will be available at www.ipmcenters.org/newsalerts/soybeanrust/quarantine.cfm. These labels will not be in effect until the Wisconsin Department of Agriculture, Trade and Consumer Protection determines that implementation of one or all of these Section 18s is appropriate.

Predicting the Need for Fungicides

A major decision will be whether the potential for rust merits the application of a fungicide. There are several factors to consider in making a spray decision to manage soybean rust. It is expected that although soybean rust will affect soybean production throughout the continental U.S., it will be endemic in some areas, and seasonal in others. Disease epidemics are also likely to vary from season to season. Thus, decisions will focus on the need to spray, timing of application, and the number of applications required for a specific field. The need for fungicides will likely be different from region to region and season to season.

Growers and advisors have several starting points for the decision making process. The first is to monitor rust activity to the south of Wisconsin. A second approach is to monitor sentinel plots in Wisconsin. Usually sentinel plots involve planting early-maturing soybean varieties about 3 weeks before the commercial crops are planted. Spray warnings are given once soybean rust is found in the sentinel plots. Since soybean rust is usually first observed on plants of more advanced growth (beginning flowering (R1) or later), the sentinel plantings provide an opportunity to observe the first signs of the disease before the disease gets a foothold in production fields.

Timing of Fungicide Applications

Fungicides of all types will provide greater control if applied before rust spores are deposited soybean leaves. Once rust symptoms are visible, fungicides with protectant activity will not be effective, and protectant/curative types will have limited activity. Early detection and proper identi-

Table 1. Fungicides registered (Section 3) for control of soybean rust.

Fungicide Brand Name and Company	Active ingredient,	Chemistry Class	Soybean Diseases	Resistance management
Bravo® (Syngenta)	chlorothalonil	Chloronitrile (substituted benzene)	Soybean rust, Anthracnose, Diaporthe pod and stem blight, frogeye leaf spot, purple seed stain, Septoria brown spot	See guidelines for chlorothalonil
Echo 720 Sipcam Agro Inc	chlorothalonil	chloronitrile	Soybean rust, Anthracnose, Diaporthe pod and stem blight, frogeye leaf spot, purple seed stain, Cercospora seed blight, Septoria brown spot	See guidelines for chlorothalonil
Quadris® (Syngenta)	azoxystrobin	strobilurin (quinone outside inhibitors or QUI)	Soybean rust, Aerial blight, frogeye leaf spot, Anthracnose, Alteraria leaf spot, Septoria leaf spot, Cercospora blight and leaf spot, Pod and stem blight).	See guidelines for strobilurin fungicides
Headline® (BASF)	pyraclostrobin	strobilurin	Not registered for soybean	See guidelines for strobilurin fungicides.

As useful listing of fungicide chemistry classes is at http://www.avcare.org.au – go to “resistance strategies” for the PDF files.

fication of soybean rust will be key to successful management of soybean rust. Reports from Brazil indicate that infections exceeding 20-30% of the soybean canopy cannot be controlled with fungicide applications. At that point fungicides are no longer able protect plants sufficiently from additional infections, or yield reduction is already so great that fungicide application cannot recover treatment cost. Because of the differences in efficacy and activity, it is critical for producers to have access to products with multiple modes of action, which provide for different disease control strategies.

When it comes to timing of application, there are two obvious mistakes, both of which can be costly. Soybean rust spreads quickly and poor timing of a fungicide spray will significantly increase the risk of failure. Spray too early and the effects of the fungicide may dissipate by the time spores arrive and infect plants. Conversely, delayed applications will result in applications after initial infection has occurred and the disease may have progressed beyond the point where effective control is possible with fungicides.

Coverage of Foliage and Canopy Penetration

For fungicides to be most effective, choose application techniques which promote through coverage of the leaves, stems and pods. Select nozzles that promote smaller droplets size and deeper penetration. Also increase pressure and carrier rate. Application techniques used for weed control are generally not compatible with fungicide application.

Because soybean rust tends to initially develop in the lower and mid canopy, thorough coverage of foliage, including penetration of spray into the canopy, is essential to achieving a successful soybean rust spray program. Fungicides are best applied at higher gallons per acre, higher pressures and with different nozzles than herbicides. Thus, improvements in spray technology for fungicide effectiveness are being researched and data will also help with delivery of insecticides to soybean.

Websites for Soybean Rust

There are many websites with information on soybean rust.

www.ncpmc.org/soybeanrust/
www.planthealth.info/rust/rust.htm
www.csrees.usda.gov/Extension/index.html
www.plantpath.iastate.edu/soybeanrust.html
www.plantpath.wisc.edu/pdd
www.uwex.edu/ces/ag/
www.oardc.ohio-state.edu/ohiofieldcropdisease/soybeans/soybean_rust.htm
www.ppdl.purdue.edu/ppdl/soybean_rust.html
http://www.ppdl.purdue.edu/ppdl/SBR/SBR_fungicide.htm

REGISTRATION PLANS FOR FUNGICIDES FOR CONTROL OF SOYBEAN RUST

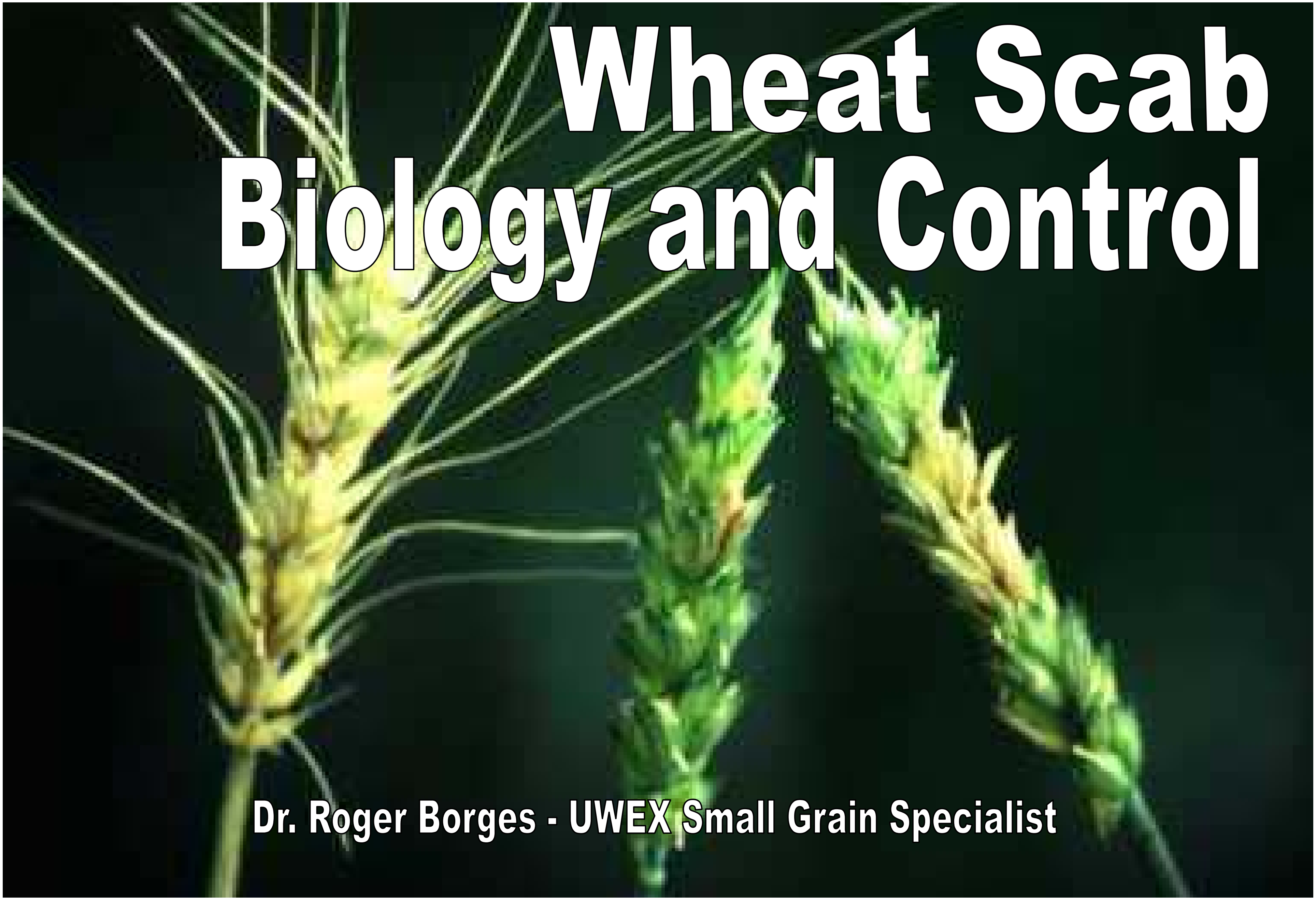
Patricia Kandziora [1/]

Abstract: Wisconsin's Quarantine Exemption Petition for Special Pesticide Products to control Asian soybean rust (*Phakopsora pachyrhizi)*

Federal law allows the US Environmental Protection Agency (EPA) to waive conventional registration of a pesticide product and allow States to petition EPA for a food-use of an unregistered product to control pest emergencies in the target crop. This presentation will provide information about Wisconsin's request to obtain special approval for use of fungicides that are needed to control Asian Soybean Rust.

The presentation will give an overview of the chemical products being requested under Section 18 of the Federal Insecticide, Fungicide and Rodenticide Act, the timeline for label approval by EPA and how applicators will obtain the emergency-use labels when they are made available in Wisconsin.

[1/] Wisconsin Department of Agriculture, Trade and Consumer Protection, Madison, WI.


Wheat Scab
Biology and Control
Dr. Roger Borges - UWEX Small Grain Specialist

SCAB (HEAD BLIGHT)

Pathogen: *Fusarium* spp. Mostly *Fusarium graminearum*

Symptoms:

- ✓ Usually first detected soon after flowering
- ✓ White head, while leaves and stems may remain green
- ✓ Often, only part of the head is attacked
- ✓ Bleached Spikelets often with a salmon-pink tint
- ✓ Stem directly below the head may turn to chocolate brown color
- ✓ Kernels above the infected spikelets may be shriveled
- ✓ Kernels are shrunken and chalky or pink in color
- ✓ Tombstone or light weight kernels
- ✓ Barren spikelets
- ✓ Mycotoxin

SCAB SEVERITY AND FREQUENCY

- ✓Very erratic
- ✓Depends on wet weather conditions at flowering
- ✓Happened once every six or seven years in Wisconsin

ALTERNATIVE HOSTS

- ✓Corn, oats, barley, sorghum, and other grasses
- ✓On corn, it causes root, stalk, and ear rot (giberela)
- ✓On sorghum, it causes stalk rot
- ✓May cause root rot in small grains

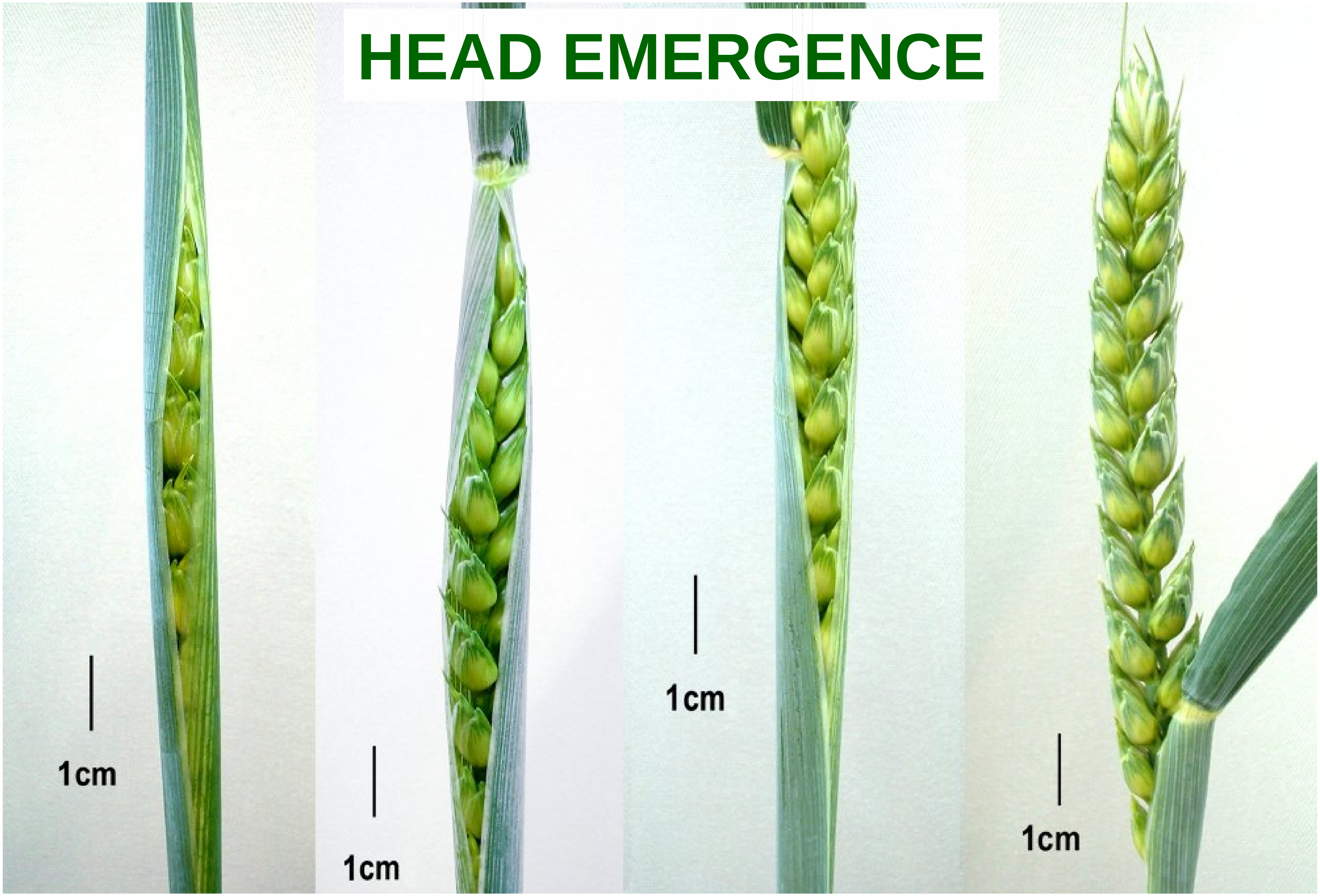
ALTERNATIVE HOSTS

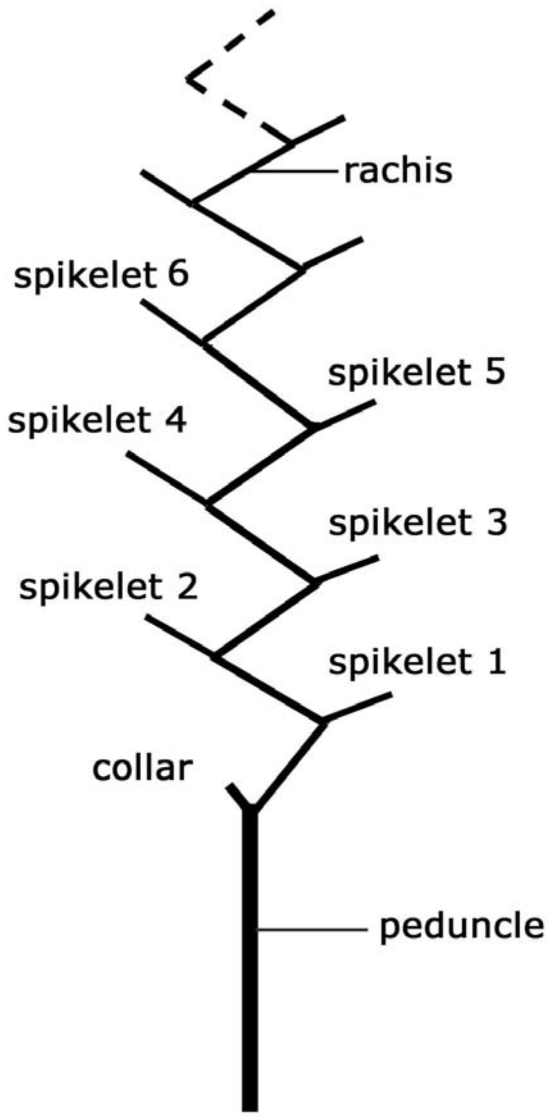
- ✓Mainly crop residue of small grains and corn
- ✓During moist weather, spores of the fungi are windblown or splashed onto the heads
- ✓Seed borne Fusarium spp may cause seedling blight

INFECTION

- ✓From flowering to soft dough stage.
- ✓Mainly through anthers (flowers). Then grow into the kernels, glumes, or other parts of the head.
- ✓Favored by prolonged periods (48-72 hs) of high humidity and warm temperatures of 75-85 ^{0}F.

HEAD EMERGENCE

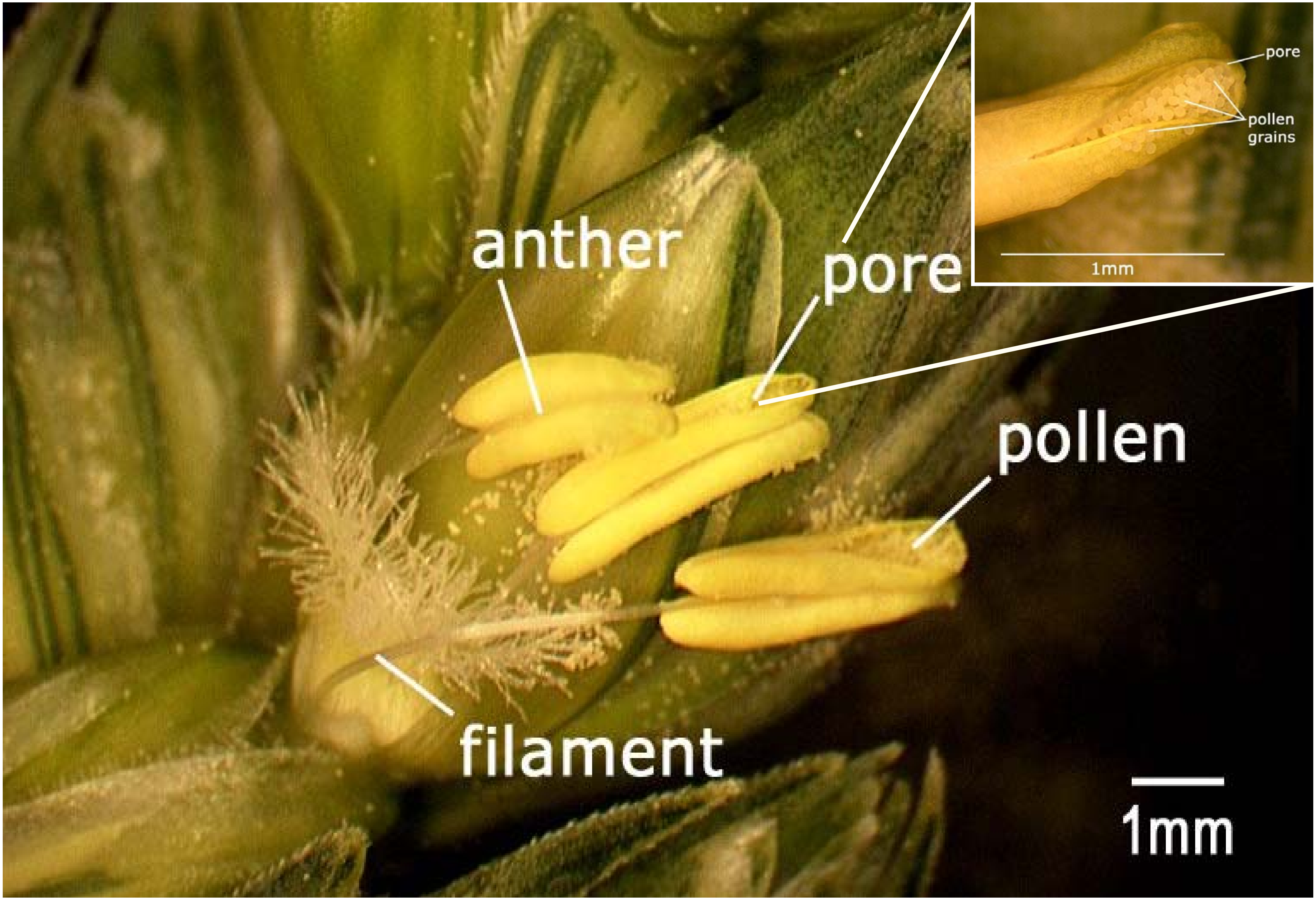



rachis
spikelet 6
spikelet 5
spikelet 4
spikelet 3
spikelet 2
spikelet 1
collar
peduncle


1cm
1cm


Spikelets, row, or mesh
Flower


5mm


anther
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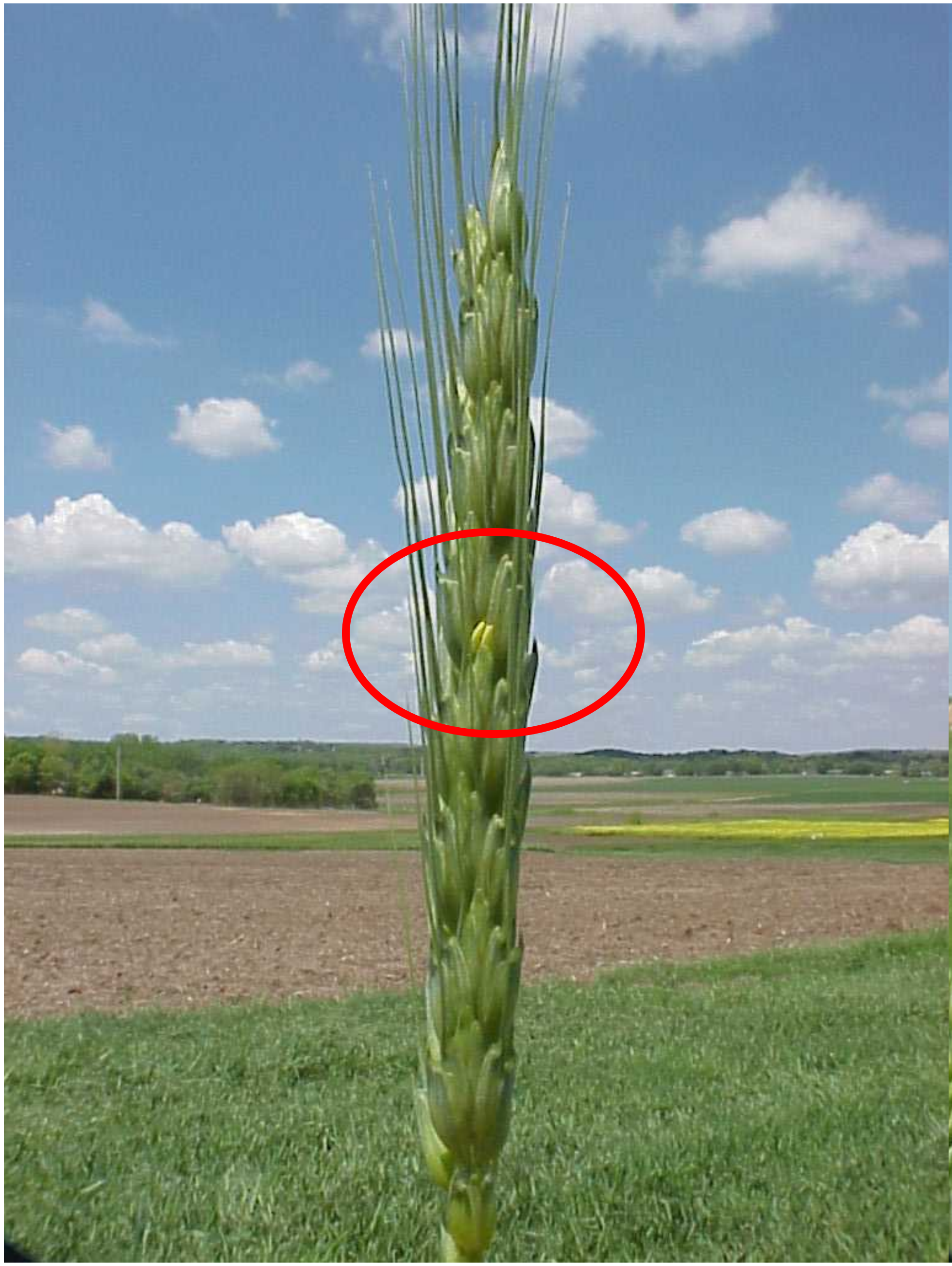
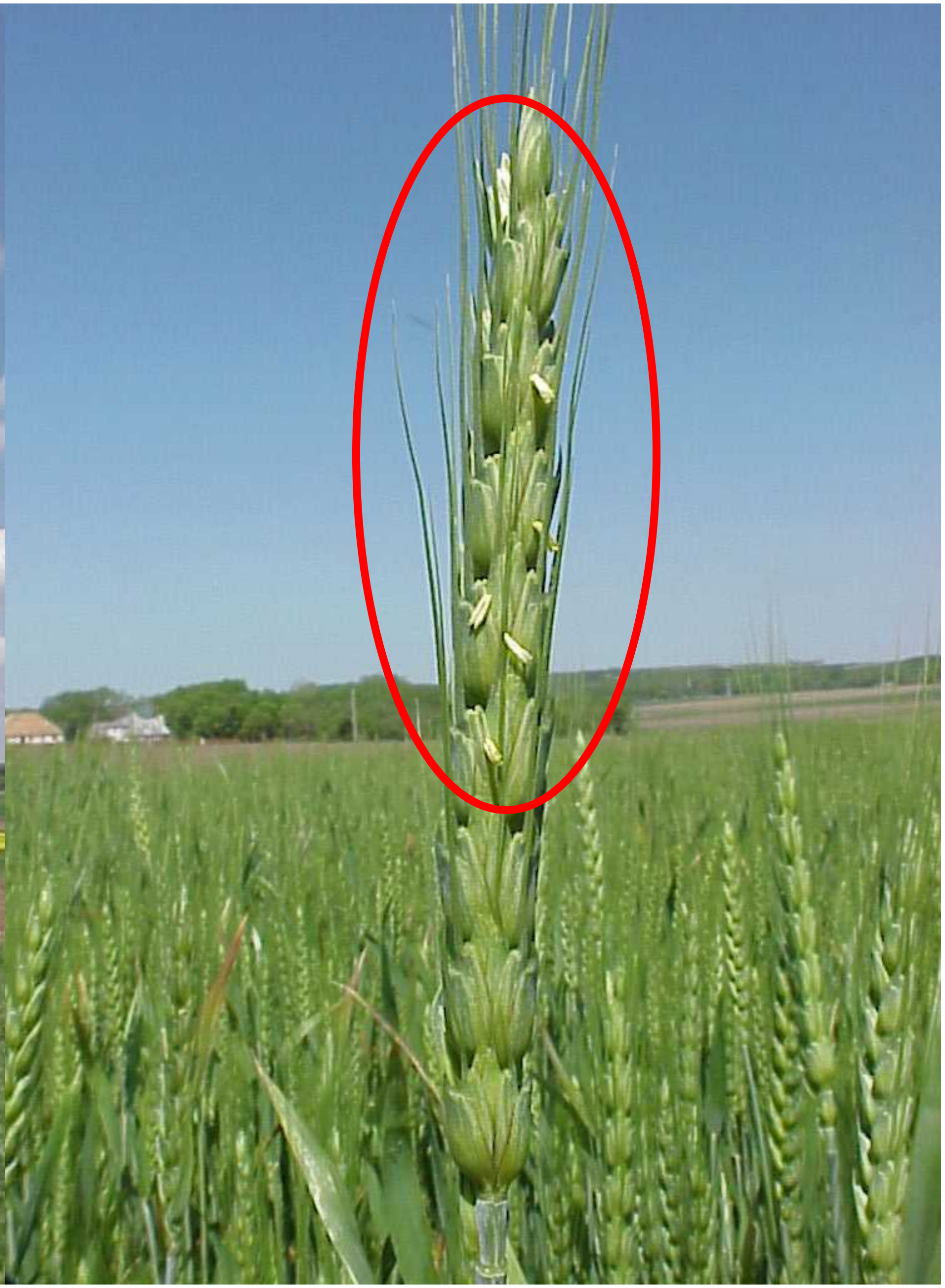




SCAB MANAGEMENT

✓Variety selection:

- Some varieties are extremely susceptible
- No variety is considered highly resistant
- Choose varieties based on scab ratings from multi-location!
- Spread risk by choosing varieties with different maturities.

✓Crop rotation with non-host crops (i.e. soybeans)

✓Chop, bury, or remove crop residue

SCAB MANAGEMENT

✓Seed treatments:
- Help raise seed germination
- May prevent or reduce seedling blight
- DO NOT CONTROL HEAD BLIGHT

✓Seed cleaning
- Set combine fans higher during harvest

✓Foliar fungicides
- Not cost effective in Wisconsin

THANK YOU!

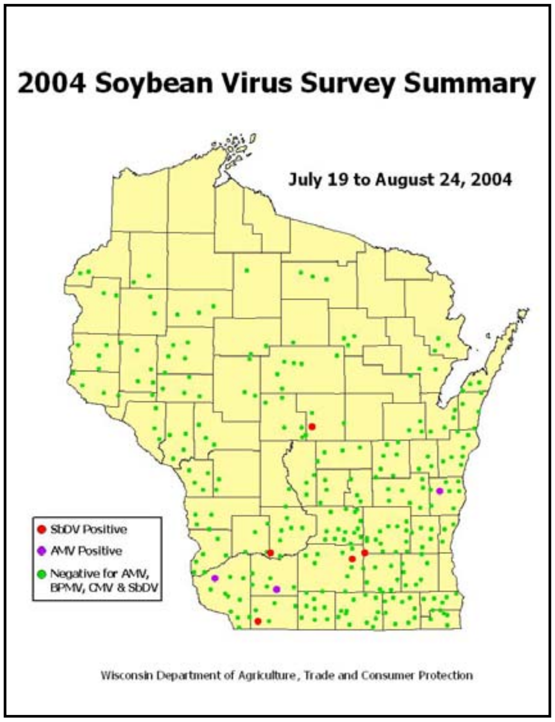
QUESTIONS?
COMMENTS?

WI DATCP's 2004 DISEASE SURVEY HIGHLIGHTS

Adrian Barta and Anette Phibbs[1]

Soybean virus survey

The 2004 soybean virus survey found a surprising lack of viruses. The survey was conducted from July 19 to August 24, targeting fields in the R2-R4 stage of growth. At each field, the topmost fully expanded trifoliate was collected from 10 plants at four sites in the field. Aphid counts were conducted, an estimate of bean leaf beetle defoliation was made, and apparent virus symptoms were noted. Samples were kept on ice until frozen at -80° deg. C. Leaves were ground and assayed for virus presence using DAS-ELISA (reagents from Agdia, Elkhart, Indiana). Of the 293 fields sampled, three had detectable alfalfa mosaic virus, while five had soybean dwarf virus. No cucumber mosaic virus (CMV) was detected in any field sampled. No bean pod mottle virus (BPMV) was detected either, despite a May-June survey of the bean leaf beetle that indicated the presence of BPMV in beetles in six counties in southern Wisconsin.



Soybean Dwarf Virus

Soybean dwarf virus (SbDV) was first detected on Wisconsin soybeans in 2003, when two of 286 soybean fields tested were positive by ELISA and RT-PCR. In the 2004 survey, five of 293 fields were positive. Several strains of SbDV are known to occur throughout the world; the strain found in Wisconsin has been determined by RT-PCR to be the Yellowing (SbDV-Y) strain. The virus is vectored by aphids in a non-persistent fashion. Under laboratory conditions, the soybean aphid (*Aphis glycines*) has not been shown to be a vector, and none of the reported aphid vectors of SbDV-Y are known to occur in Wisconsin. However, it may be that the sheer large numbers of *A. glycines* and associated host probing may be causing the observed small percentage of soybeans infected with SbDV.

SbDV Clover survey

To determine if an overwintering reservoir of SbDV exists, DATCP conducted a spring survey of clovers. Red clover (*Trifolium pretense)* is reported to be a host of SbDV-Y; white clover (*Trifolium repens*) is not. Leaves were collected from clover plants and kept on ice until frozen at -80° C. Leaves were ground and sap extracts were tested using DAS-ELISA. Thirty-one of 53 red clover samples were positive for SbDV. Two samples of white clovers tested positive out of 24 sites sampled; however, it is possible that the host plant in these samples was misidentified. The results show that SbDV is widespread in clover in Wisconsin. The relative low incidence of SbDV on soybeans may be due to the lack of an efficient aphid vector, though relations between the virus, the two hosts and aphids are still unclear. Plans are to repeat the clover survey in 2005, with attention to aphid species present.

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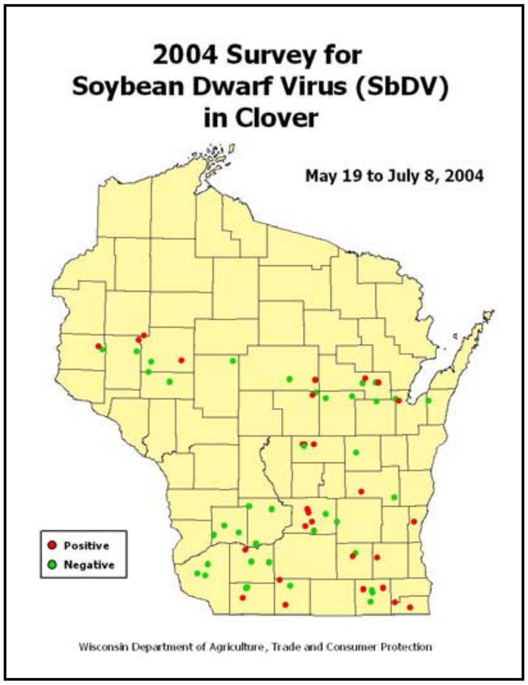
[1] Plant Pest and Disease Specialists, WI Department of Agriculture, Trade and Consumer Protection, P.O. Box 8911, Madison, WI 53708 and WI Department of Agriculture, Trade and Consumer Protection, Plant Industry Laboratory, 4702 University Ave., Madison, WI 53705, respectively



Powdery scab of potato

Powdery scab (caused by *Spongospora subterranea* f. sp. *subterranea)* was detected in the state for the second year in a row. In 2003, this disease was found in three fields in two counties, out of 65 fields in eight counties surveyed. All the positive fields were in the Central Sands region, and all fields were within about 20 miles of one another.

In 2004, the known range of *S. subterranea* in Wisconsin was expanded considerably, with positive fields detected in Oconto and Langlade counties by observant growers and crop consultants. Powdery scab has been common in western states for a number of years, where in some areas it has reportedly caused a shift to less-susceptible cultivars. Infection can increase dessication and increase decay in storage. It is also the vector for potato mop top virus (PMTV), a virus not known to occur in Wisconsin, or in the United States outside of the state of Maine.

Ralstonia

For the second year in a row, geraniums infected with *Ralstonia solanacearum* race 3 biovar 2 were imported into the United States from Guatemala. *R. solanacearum*, a bacteria, is the causal agent of southern wilt of geraniums—and of brown rot of potatoes. The disease is present in tropical areas of the world and in Europe. *R. solanacearum* is divided into races based upon host range and into biovars based upon carbohydrate utilization. Race 1 of the organism is present in the southern U.S., where it infects tomatoes. Race 3 biovar 2 is not known to occur in the United States. As an aside, R3B2 is listed as a Select Agent in the Agricultural Bioterrorism Prevention Act of 2002, making it a felony punishable by a fine of up to $250,000 and imprisonment of not more than 5 years for "whoever transfers a biological agent or toxin to a person who the transferor knows or has reasonable cause to believe is not registered" or "whoever knowingly possesses a biological agent or toxin without registering under the regulations…."

For the past several years, the disease has occurred in asymptomatic geranium cuttings propagated in Guatemala and imported into the U.S. for rooting and potted plant production. Geraniums at a number of greenhouses in Wisconsin were quarantined and ordered destroyed in a joint DATCP-USDA effort, and the facilities disinfected. In 2003, seven WI greenhouses were issued Emergency Action Notifications. In 2004, 24 greenhouses in the state participated in destroying geraniums, with many of those facilities taking action voluntarily.

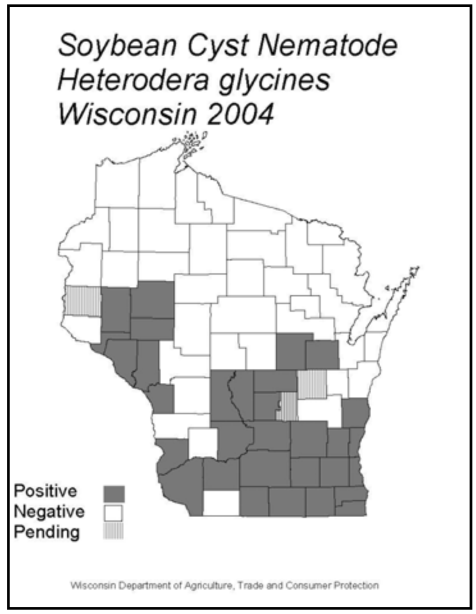
Inspections of propagating facilities in Central America and in Africa by industry plant pathologists and USDA personnel, and the adoption of Best Management Practices for preventing infection by the geranium industry (as well as the costs to the industry associated with continuing quarantine and destruction) should reduce the likelihood of importing infected plant material in the future.

Brown root rot of alfalfa

Another recent disease concern for the state is brown root rot of alfalfa, caused by *Phoma sclerotioides*. Reports from Minnesota (Samac, et. al., 2004) suggest that this disease has been spreading south from Canada. Dr. Samac's work, in cooperation with Dr. Craig Grau of UW-Madison, determined that the disease has been found as far south as Columbia County in Wisconsin. Brown root rot infection may contribute to stand decline, yield loss and increased susceptibility to winter kill. A survey was undertaken to determine the incidence of the disease in the southern part of the state. Survey protocol required the collection of whole symptomatic alfalfa plants for testing. Samples were tested with PCR to detect the fungus. Twenty-three fields were sampled in the southern third of the state, in an attempt to determine the southern range of the disease. No *P. sclerotioides* was detected in any of the samples collected.

Soybean cyst nematode

Soybean cyst nematode (*Heterodera glycines*) has been present in Wisconsin since at least 1981. Nematode infestation often goes undetected, and is believed to cost soybean growers a considerable amount of lost yield every year. Soybean cyst nematode may also infest soil contained in pots or in the root ball of trees, and so is a concern for nursery growers in the state. In accordance with plant protection conventions, DATCP maintains a record of Wisconsin counties in which SCN has been detected. Despite sampling several hundred fields in uninfested counties, and sharing results with UW researchers testing soil samples from growers, no new counties have been added to the official SCN map since 2002.



Samac, D. A. and C. R. Hollingsworth. 2004. Identification of Phoma sclerotioides, the Causal Agent of Brown Root Rot, in Wisconsin and Minnesota. [abstract] North American Alfalfa Improvement Conference, July 19-21, 2004, Ste. Foy, Quebec, Canada. Abstract No. 50.

THE NATIONAL PLANT DIAGNOSTIC NETWORK:
RESPONDING TO NEW AND EMERGING DISEASES

Brian Hudelson [1/]

In wake of the events of September 11, 2001, as well as subsequent federal legislation known as the Agbioterrorism Act of 2002, efforts have been undertaken to network the nation's land grant plant disease and insect diagnostic facilities under a model that would mimic the network that is currently available for detection and tracking of human diseases coordinated by the Center for Disease Control (CDC). The goals of the new National Plant Diagnostic Network (NPDN) are to link and foster communication between diagnostic clinics, and enhance their ability to quickly detect and respond to new and emerging agriculture plant pathogens that might be accidentally or intentionally introduced in the United States.

Diagnostic facilities in the NPDN are divided into five regions and the UW-Madison/Extension Plant Disease Diagnostics Clinic (PDDC) and Insect Diagnostic Lab are members of the north central region, also known as the North Central Plant Diagnostic Network (NCPDN). Efforts in this region are coordinated through Michigan State University. Current activities of the NCPDN include development of an informational website that can be accessed at www.ncpdn.org. This site provides general information for the public and professionals about the NCPDN, as well as alerts on current "hot" insect and disease pests. The NCPDN, in coordination with other regional PDN's, is also developing a centralized database for tracking of samples from member diagnostic facilities. This website allows for easy consultations between member diagnosticians and includes an electronic photo database.

NPDN diagnosticians have already been instrumental in the detection of exotic pathogens. Members of the network were the initial detectors of *Ralstonia solanacearum* race 3 biovar 2, the bacterium that causes Ralstonia wilt (see University of Wisconsin Pest Alert XHT1011 at www.plantpath.wisc.edu/pddc). This bacterium was introduced into the United States on geraniums in 2003, and is of concern because it causes a serious disease of potatoes called brown rot. In addition, *Ralstonia solanacearum* race 3 biovar 2 is listed as a select agent in the Agbioterrorism Act of 2002, and is considered a plant pathogen that might be weaponized by terrorists and deployed against US agriculture. Because of *Ralstonia*'s select agent status, the detection of this bacterium in 2003 was considered a national security issue and led to a federal investigation that concluded that the bacterium was accidentally introduced.

[1/] Senior Outreach Specialist and Director, Plant Disease Diagnostics Clinic, Department of Plant Pathology, University of Wisconsin-Madison/Extension, 1630 Linden Drive, Madison, WI 53706-1598.

NPDN diagnosticians also participated in 2004 in efforts to monitor for the sudden oak death pathogen (*Phytophthora ramorum*). This serious pathogen of woody ornamentals (see Univ. of Wisconsin Pest Alert XHT1024 at www.plantpath.wisc.edu/pddc) had been limited in distribution to California and Oregon until this past year when it was detected at a large commercial nursery, as well as several other smaller nurseries, in California that had been shipping potentially contaminated plants throughout the country. Subsequent testing by NPDN diagnosticians identified the pathogen at 176 sites in 22 states (fortunately not including Wisconsin).

In 2005, NPDN diagnosticians will be spearheading efforts to monitor for *Phakopsora pachyrhizi*, the soybean rust pathogen. This pathogen was confirmed for the first time in the continental US in November, 2004 and currently has been detected in 10 states (including Alabama, Arkansas, Florida, Georgia, Hawaii, Louisiana, Mississippi, Missouri, South Carolina and Tennessee). *P. pachyrhizi*, like *R. solonacearum*, is listed as a select agent in the Agbioterrorism Act of 2002 and has national security ramifications. Because of the seriousness of this disease and pathogen, and the importance of early detection, soybean growers and other agriculture professionals are encouraged to submit any sample that they believe might have soybean rust to the PDDC for diagnosis. Soybean rust samples will be processed free of charge in 2005. For more information on soybean rust and instructions for submitting samples to the PDDC, check out the soybean rust fact sheet and soybean rust submission form (see University of Wisconsin Pest Alert XGT1001 XGT1002) at www.plantpath.wisc.edu/pddc. Fact sheets and submission forms are also available through your county UW-Extension office.

For more information on the PDDC's participation the NCPDN and NPDN, as well as additional information on new and emerging diseases, including soybean rust, contact Brian Hudelson, Plant Disease Diagnostics Clinic, Department of Plant Pathology, University of Wisconsin-Madison/Extension, 1630 Linden Drive, Madison, WI 53706-1598; phone: (608) 262-2863; email: bdh@plantpath.wisc.edu.

GIANT RAGWEED AND HORSEWEED MANAGEMENT

Chris Boerboom [1/]

Giant Ragweed

Giant ragweed is a problem weed in Wisconsin because of its early emergence, rapid growth, and highly competitive nature. Some previous research might suggest that giant ragweed should not be a long-term problem for the following reasons. Giant ragweed often produces less than 5,000 seeds per plant compared to other weeds that can produce 10,000 to 100,000 seeds per plant or more. Furthermore, studies have found that 35 to 86% of the seed produced by giant ragweed is damaged by insects or is not viable even before it is shed from the plant. Other research suggests that up to 90% of the giant ragweed seed will not survive in the soil past one year. Considering all these facts, it would appear that giant ragweed should not be a persistent weed problem. However, we know it is not easy to quickly reduce giant ragweed populations.

Several factors make giant ragweed difficult to control. First, it is difficult to obtain complete control of this large seeded broadleaf weed with current preemergence herbicides, in part because it can emerge from deeper in the soil, below the herbicide treated soil. Fortunately, large seeded weeds like ragweed are also at a disadvantage in no-till systems where their seed is not "tilled" into the soil. When left on the soil surface, it is more difficult for the seed to germinate and establish or it may be eaten by predators. As a result, giant ragweed is less of a problem in long-term no-till. A second problem for controlling giant ragweed is its apparent change in emergence patterns. Giant ragweed was historically one of the earliest emerging annual weeds. In the past, seedbed tillage often controlled the emerged seedlings. However, more giant ragweed is germinating later into the season, which requires later treatments. A third problem is the rapid growth of giant ragweed. This is probably related to its large seed size, which produces a large seedling that can support continued rapid growth. This rapid growth makes it difficult to correctly time postemergence herbicide applications. Giant ragweed may need to be treated before other annual weeds have reached the size that they are normally treated. As a consequence, giant ragweed may become too large for effective control when it is treated. This may lead to a fourth problem. Several species of tunneling insects have been found in giant ragweed stems and it is likely that their tunneling may interfere with herbicide translocation in larger plants and cause reduced control by herbicides. Finally, many populations of giant ragweed across the Midwest are resistant to the ALS herbicides (Classic, FirstRate, Raptor, Beacon, etc.), which limits some of the herbicide options, especially in soybeans.

Given these obstacles, management options should focus on treating giant ragweed early in the season to obtain the highest level of control. Early treatment should also lessen the risk of yield loss as the early emerging ragweed plants are the most competitive. The risk with early treatment is that additional giant ragweed may emerge. If these late escapes are at a low density, they may not warrant treatment. For example, studies have measured 60% corn yield loss from giant ragweed at a density of 13 plants/100 ft^2 when it emerged with the corn. However, when the same density emerged 4 weeks later, the corn yield loss was only 8 to 14%. While this level of yield loss would justify treatment, it illustrates that late emerging ragweed are much less competitive. These late emerging ragweed also produced about 90% less seed and only about half of the seed is viable.

[1/] Extension Weed Scientist, Agronomy Dept., Univ. of Wisconsin-Madison, 1575 Linden Drive, Madison, WI, 53706.

In corn, the most consistent giant ragweed control will be obtained by a 2-pass program (preemergence herbicide followed by a postemergence herbicides). A single preemergence herbicide application often does not provide consistent or full season control, especially at our reduced atrazine rates. Preemergence herbicides that may be adequate with lower densities of ragweed are atrazine, atrazine plus Hornet, or Lumax. A follow up postemergence treatment will still be necessary in areas with high densities of giant ragweed.. Most postemergence corn herbicides will control giant ragweed, especially if they contain atrazine or a growth regulator herbicide. The key with postemergence herbicides is to apply them while the ragweed is still within the labeled growth stage. In no-till corn, 2,4-D ester (0.5 lb ae/a) plus atrazine provides excellent burndown control of giant ragweed seedlings. For larger plants, the addition of glyphosate may be necessary.

In soybeans, preemergence applications of FirstRate (0.6 to 0.75 oz/a) or Gangster, which contains FirstRate, can provide adequate control of light to moderate infestations of giant ragweed if they are not ALS resistant. In heavy infestations, a preemergence FirstRate application is beneficial because it 1) removes early emerging ragweed, 2) allows postemergence herbicides to be applied to smaller ragweed, and 3) eliminates the need for a second postemergence application.

In no-till soybeans, FirstRate plus 2,4-D ester (0.5 lb ae/a) or glyphosate plus 2,4-D ester are burndown options. These herbicides alone generally will not provide adequate control of heavy infestations and should be followed with a postemergence herbicide to control late emerging plants. Glyphosate can be somewhat variable for burndown of large giant ragweed plants; use of the appropriate glyphosate rate based on plant size. The addition of 2,4-D ester to glyphosate is recommended to increase the consistency of control.

The most effective postemergence herbicide options in soybeans are glyphosate, Extreme, Cobra, and Flexstar, FirstRate, and Raptor. As Cobra and Flexstar are contact herbicides, be sure to apply these herbicides early. FirstRate and Raptor will be ineffective on ALS resistant ragweed. Even glyphosate should be applied early (e.g., 8 to 12 inch ragweed) to get the best control. It is frequently seen that all of these herbicides can kill the upper shoots of larger giant ragweed, but the plants recover by growing branches from lower axillary buds on the stem. Proper application timing is critical for successful ragweed control.

Early postemergence applications where giant ragweed infestations are heavy may need to be followed by a second application to control late emerging plants. A slightly later initial application may reduce the need for a sequential treatment with lighter infestations, but the application must be made before the plants exceed the maximum labeled size. Where a split postemergence application is planned, applying one-half the labeled rate when giant ragweed are small (around 2 to 3 inches), and following with a second application at the same rate 2 to 3 weeks later can be very effective. Any of these herbicide treatments will perform best when applied to young, actively growing plants under hot, humid conditions and adequate soil moisture.

Horseweed

Horseweed (also known as marestail) is a frequent winter annual weed of no-till fields. It is easily identified in the spring as a rosette of bright green leaves, which are narrow, covered with scattered hairs, and have slightly toothed margins. Horseweed often grows to a height of up to 5 feet as a single main stem that is densely covered with narrow leaves. It produces short flower bearing branches in the upper third of the main stem. The flowers are small, yellowish and less than 1/4 inch in diameter. Horseweed is in the composite (sunflower) family so each “flower” is actually a flower head that contains 25 to 50 flowers. At maturity, a small bristly pappus is attach to each seed, which aids its dispersal in the wind.

Although horseweed is often considered a winter annual, it may also germinate in the spring and act as a summer annual. In studies conducted in Minnesota and Iowa, 68 to 95% of horseweed seed germinated and emerged in the fall. Of the fall germinated seedlings, 59 to 91% survived winter. Seedlings with 7 to 9 leaves survived better (81 to 91% survival) than small seedlings with only 3 or 4 leaves (59 to 62% survival). Unlike most winter annual weeds (e.g. shepherd's purse) that mature in late spring, horseweed matures in late summer, which makes it more competitive against crops and even a harvest problem.

Horseweed is a native to the Midwest and is common in waste areas, fence lines, and roadsides. These plants provide a ready seed source to easily infest corn and soybean fields with its wind disseminated seed. Horseweed plants may produce up to 200,000 seeds. The seed has little or no dormancy so it is able to germinate whenever conditions are favorable. Horseweed flowers are self-compatible, which means that a single plant can pollinate itself to produce seed. Horseweed flowers can also cross pollinate, although the reported rates are generally rather low and range from 1 to 14%.

Horseweed management has gained considerable interest in recent years because of the selection of glyphosate-resistant horseweed and its dominance as a no-till weed. Horseweed has evolved resistance to several herbicides. This high frequency of herbicide resistance may be because of either natural characteristics such as outcrossing or a high degree of genetic diversity or because it occurs at high densities in so many fields, which results in a high level of selection pressure for resistance. Regardless, glyphosate-resistant horseweed is reported in 12 states in the US; paraquat-resistance (Gramoxone) is reported in Mississippi in addition to other countries; ALS-resistance (FirstRate) is reported in Ohio, Indiana, and Michigan; and atrazine-resistance is reported in Michigan. Horseweed with resistance to a single herbicide mode of action can make management more complex. However, horseweed with multiple resistance may become difficult to control. Unfortunately, there are examples that clearly demonstrate that horseweed can develop resistance to more than one herbicide mode of action. For example, horseweed with resistance to glyphosate and ALS herbicides has been confirmed in Ohio. Similarly, Michigan reports horseweed with resistance to atrazine and diuron (Karmex).

Keys for successful horseweed management are to:

1) control horseweed prior to planting,
2) treat horseweed before they are 4 to 6 inches tall (e.g. early spring),
3) add 2,4-D ester to all burndown treatments when possible.

Fields with higher densities of horseweed may benefit from residual herbicides (e.g. Authority, FirstRate, Gangster, Python, Sencor, or Valor) to control seedlings that emerge after planting. Herbicides programs to consider are listed below. These recommendations are based on information from Ohio State University and Purdue University, which have extensive experience with glyphosate-resistant horseweed.

<u>Seedlings or rosette stage in early spring</u>

2,4-D ester (1.0 lb ae/a)
2,4-D (0.5 lb ae/a) + glyphosate, Sencor, or Gramoxone
Gramoxone + Sencor (small seedlings)

Horseweed with elongated stem, but less than 6 inches tall

Glyphosate (0.75 lb ae/a) + 2,4-D (0.5 lb ae/a)
Glyphosate (0.75 lb ae/a) + FirstRate (0.3 oz/a)
Gramoxone (1.7 pt/a) + Sencor + 2,4-D (can be somewhat variable)
Glyphosate + 2,4-D + FirstRate (recommended where resistance has developed)

Horseweed taller than 6 inches

This should be avoided because of the difficulty to control such large plants
Glyphosate (1.5 lb ae/a) + 2,4-D + FirstRate

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