BALANCING SUSTAINABILITY & INNOVATION

in Wisconsin agriculture

NPM

Extension
UNIVERSITY OF WISCONSIN–MADISON

Agricultural production is becoming increasingly complicated in the 21st century. Climate change, social impacts, market demands and economic concerns all influence agroecosystems, whose continued resilience is dependent on incorporating both sustainable and innovative strategies to mitigate these pressures. Balancing these strategies can be challenging, since they have the potential to be at odds with each other. For example, sometimes the short-term need to be profitable may conflict with an innovative strategy that is new and expensive to adopt, but still may be worth investing in if the situation is right. This publication showcases both sustainable and innovative practices in nutrient management, cropping systems and pest management along with a section on how to balance innovative economic ideas with established sustainable practices.

SUSTAINABILITY is when farming is economically profitable, ecologically sound and socially supportive of farmers, their families and communities.

INNOVATION in agriculture is primarily concerned with maximizing productivity as well as enhancing quality by incorporating new ideas or technologies that prove successful in practice.

Soil testing

NUTRIENT MANAGEMENT

Sustainability and innovation in nutrient management utilize basic strategies in soil fertility and manure management, while balancing them with innovative approaches like improving soil health and incorporating continuous cover.

-------- SUSTAINABILITY --------

Sustainability options are linked with best management practices (BMPs) and the 4Rs nutrient stewardship guidelines of right source, right rate, right placement and right time.

- ✓ **Soil sample a given field every 3 to 4 years,** with the exception of sandy soils which should be sampled every 2 years.
  - ✶ Start with soil tests to make profitable soil fertility management decisions. Soil testing costs $0.40 to $1.00 per acre per year or roughly the value of a few pounds of fertilizer!
  - ✶ Soil sample at the same time of the year to compare results accurately and use the same lab provider to minimize confusion between lab test methods.
  - ✶ Compare soil test results and yield data overtime to provide insights on soil differences within a field and help guide management decisions.
  - ✶ Take the time to understand your soil test results! Soil test interpretations are based on actual soil test levels, crop demand and yield potential, and the field's soil type optimum level for phosphorus (P), potassium (K) and pH for the rotation.
- ✓ **Utilize a nutrient management plan** which uses soil and manure test data to allocate nutrients from fertilizer and manure based on crop need to obtain maximum economic return that promotes soil conservation and resiliency while protecting water quality.
- ✓ **Maintain soil pH in an appropriate range for the crop rotation** to improve nutrient availability, enhance nitrogen (N) fixation in legumes and

N mineralization from soil organic matter. Lime can take years to completely react with soil depending on application rate, lime grade and tillage practices; plan pH management strategies accordingly.

Manure crediting

- ✓ **Take nutrient and manure credits** to reduce fertilizer application rates.
  - ✶ Forage legumes may provide substantial N credits to corn but can be dependent on stand longevity and productivity.
  - ✶ Biosolids and manure have significant amounts of N, P and K. A manure analysis that uses correct sampling procedures provides the most accurate nutrient content.
- ✓ **Apply manure at the correct rate** to get a good crop response.
- ✓ **Spread manure in the fall and incorporate** to reduce N loss.
- ✓ **Use manure management technologies** such as solids separation, composting and digesters to help reduce the overall volume of manure being applied.

Consider using a mobile app to keep track of manure applications!

https://ipcm.wisc.edu/apps/tracker/

Fertility planning

- ✓ **Apply nitrogen based on soil type** and consider using an appropriate nitrification inhibitor.
- ✓ **Utilize the maximum return to nitrogen (MRTN) guidelines.** MRTN guidelines along with realistic N:corn (or wheat) price ratios should be used to determine N application rates.
- ✓ **Apply phosphorus and potassium based on soil tests.** P and K fertilizer rates can be lowered for soils testing over the optimum range. In some situations starter fertilizer may be sufficient. If deciding between P and K due to costs, prioritize K. Research has demonstrated little crop yield response to N and P when K is deficient.
- ✓ **Consider starter fertilizer for later established corn and high residue environments.** Do not apply starter on soybeans.
- ✓ **Apply sulfur (S) to corn and alfalfa** if s deficiencies in the past have been determined, or if on low soil organic matter/sandy soils. When S is limiting, applications of 15-25 lb S/acre in sulfate form can be very profitable.
- ✓ **Understand micronutrients are often <u>not</u> deficient in Wisconsin.** Know which crops are sensitive to which micronutrients, know the soil conditions that are more likely to have low availability of micronutrients and before you decide to make an application, verify deficiency.
- ✓ **Tissue testing** is best utilized when combined with recent soil tests while comparing normal and abnormal areas of plant growth in a field. Make sure to collect the proper plant part at the proper growth stage and use caution when interpreting results as nutrient content in plant tissue can be affected by environmental factors.
- ✓ **Use reduced tillage and no-tillage practices if possible** as it can reduce fuel costs, labor needs and equipment overhead. Long-term reduced and no-till improves soil resiliency, providing an advantage in low margin years.

Click or scan the code to watch a video on **tissue testing!**

Click or scan the code to watch a video on **tillage and corn silage!**

-------- INNOVATION --------

Utilizing new technologies can enhance the collection of precision data and improve efficiencies when analyses are done correctly.

- ✓ **Soil sampling at the same time each year** using GPS is best to help identify variability across the field and compare results over time; keeping track of each sampling event can reveal trends that overlay with yield data and soil type to guide management decisions.

Soil resiliency

- ✓ **Use soil health practices to build resilience** and influence environmental aspects of agroecosystems.
  - ✶ Often the best tool to start exploring soil health: scout multiple fields throughout the year and look for soil earthworm activity, root growth and soil structure variability.
  - ✶ Soil health potential for a field can often be assessed by comparing metrics from a neighboring native undisturbed area such as a fence row or forested field edge.
  - ✶ Overall resiliency of the system is heavily influenced by soil organic matter, soil type, field management history and native habitat vegetation.
  - ✶ To begin a soil health assessment, measure the following three factors:
    - ✶ Soil organic matter (SOM) is often one of the most influential soil components that impacts crop yield. Working to improve soil organic matter increases water holding capacity and nutrient cycling.
    - ✶ Aggregate stability impacts water infiltration, plant water availability and can lower the risk of soil compaction. There are multiple methods for measuring aggregate stability, so it's best to choose one method and compare it over time.
    - ✶ Soil respiration helps understand the biological activity happening within the soil. The amount of microbial activity can greatly influence nutrient cycling. Soil respiration is an important component of soil health, but critical values have not been established (more research is necessary).
  - ✶ To maintain and build soil health:
    - ✶ Minimize disturbance (tillage) and removal of crop residue maintain soil cover; maximize living roots and crop diversity with at least 3 or more crops in rotation.
    - ✶ Incorporate manure or organic material into a nutrient management plan; graze livestock when applicable.
    - ✶ Base soil health management practices on specific goals. Understand that some practices may ensure long-term profitable crop production yet may not improve water quality.

Continuous cover

Click or scan the code to watch a video on **tillage and runoff!**

- ✓ **Continuous living cover** can help retain on-farm nutrients, and limit soil erosion and runoff.
  - ✶ Nitrates are a concern to both ground and surface water. Wisconsin groundwater often has nitrates present, sometimes exceeding the health threshold.
  - ✶ Phosphorus losses are associated with soil erosion and runoff. Phosphorus is a major surface water contaminant and contributes to algae blooms.
  - ✶ Potassium losses occur with soil erosion and are mostly economic.
- ✓ **Use cover crops or supplemental forages** to achieve specific objectives in conservation, nutrient or pest management.
  - ✶ Have a plan for managing and terminating the cover crop that favors the subsequent crop.
  - ✶ Grass cover crops provide the best erosion control and water quality benefits as they establish quickly. If planted after a manure application and growth exceeds ½ ton per acre, the N credit from manure will be reduced.
  - ✶ Legume cover crops established via frost seeding following a small grain or summer harvested vegetable crop have the potential to provide N credits. Legume cover crops planted at other timings typically do not provide significant N credits.
    - ✶ Red clover is a popular option, which can either be terminated in the late fall or terminated the following spring to increase the potential N benefit. Berseem and crimson clover are good options to plant in the summer and will winter kill.

Click or scan the code to watch a video on **fall forage!**

Click or scan the code to watch a video about **fall cover crops before soybean or corn!**

- In dairy systems, cover crop establishment following corn silage or winter wheat for straw will likely be more successful than cover crops in corn-soybean grain systems.
- For soybeans, if the planter is set up properly, there is little yield-risk with terminating a cover crop prior to or within a week of planting.
- Overwintering covers like winter rye or winter triticale can be planted after corn silage and terminated early the following spring or harvested as a forage crop near the boot or early heading stages of growth in mid-to late May, allowing enough time for a full season crop to follow. A forage yield of at least 2 tons dry matter (DM) per acre should be the goal for profitability.

CROPPING SYSTEMS

Introducing innovation while balancing sustainability in grain and forage production can be challenging. The first thing is to stay focused on goals. Both experience and the bottom line can help determine sound decisions regarding crop rotation, variety selection and seeding rates. There are also opportunities in current agroecosystems to incorporate alternative forage species and well-managed grazing to diversify and build resilience. Resist the temptation to buy untested products that make unsubstantiated promises and instead search for research-based evidence.

-------- SUSTAINABILITY --------

There are many proven crop management strategies that help maintain and improve sustainable production systems.

Crop rotation

Click or scan the code to watch a video on **corn/soy rotations!**

- ✓ **Irrigate crops based on crop demand** and subsurface moisture availability rather than simply dry weather conditions.
  - For corn the most important stage to irrigate just prior to tasseling through the dent stage (R4) and for soybean, it's seed-fill (R6).
- ✓ **Rotate crops!**
  - Crop rotation can help manage residue without tillage. Fewer passes can save money!
  - Crop rotation increases corn and soybean yields by 6 to 20%.
  - Soybean yield is greater after two years of an "off" or "non-soybean" crop with the rotation effect lasting 2 years at most (planting a winter cover crop does not constitute another crop year).
  - Corn following soybean or small grains in the rotation can reduce the need for N.
  - Management of heavy corn residue is critical for soybean yield.

Variety selection

Just a quick note about new biological inputs. *Historically, biologicals have proven beneficial in cropping systems (like Rhizobium bacteria in legumes), but many new products have not been studied or proven to the extent necessary to be widely adopted on Wisconsin farms.*

If you do decide to try, start with a small amount of acres, leaving untreated test strips before making a larger investment in the product.

- ✓ **Choose a variety or hybrid** that performs well in multi-location performance trials and optimize its management for your farm.
  - Use independent multi-location trial data to pick varieties or hybrids that not only perform well but also have the desired traits (e.g. herbicide tolerance). See University of Wisconsin websites for individual variety/hybrid performance trial results.
  - Every hybrid must stand on its own for performance; it must pull its own weight!
  - Plant multiple varieties or hybrids to diversify plant genetics and lower risk of yield loss to unforeseen stress factors (climate, diseases, insects). Look for consistency of performance over multiple locations and over time.
  - Pay attention to crop maturity ratings and use varieties or hybrids that best match production practices and location. Later maturing corn or soybean often produce greater

Click or scan the code to watch a video on **new biologcal inputs!**

yield, however frost damage or drying costs can offset higher yield potential.

- Buy only needed traits. Most traits in corn or soybean are pest management traits, not yield traits. These traits protect yield, not enhance it.
- Evaluate seed costs. Hybrids/varieties with expensive traits may not be a good return on investment.
- Fungicide and insecticide seed treatments should only be used in fields where there is a risk or history of pest-related issues. They do not need to be used on every acre.

Seeding rates

✓ **Optimize seeding rates** to ensure quality yield and economic return using the following recommendations.

- **For soybean,** the economic optimal seeding rate across ~80% of Wisconsin soils is 140,000–165,000 seeds per acre, with the intent to achieve a final stand of 100,000 plants per acre at harvest to maximize yields. If white mold is an issue in the field, plant 100,000–120,000 seeds per acre in 30 inch rows. In stressed environments, increase soybean seeding rate to achieve a final stand of 140,000 or more in the entire field or problematic areas of a field.
- **For corn,** the harvest plant density that produces the maximum yield on most soils in Wisconsin is between 35,000–38,000 harvested plants per acre. However, the economic optimal plant stand is 4,000–5,000 less plants per acre. Plan to be within 95% of the maximum yield and economic optimum by establishing 26,000–30,000 harvested plants per acre. However, these guidelines vary greatly by field, hybrid choice and production system (no-till vs. tillage).

Alternative forages

Consider incorporating some "emergency forage" species. Forages grown for animal feed but not considered mainstream like alfalfa and corn silage are often referred to as alternative or emergency forages. These forages can range from finding a niche in dairy rations to being planted as an emergency forage, however, they might also have a place in a forage system in typical years.

✓ **Planting annual warm season grasses** (such as sorghum-sudangrass, sudangrass, and pearl millet) once soil temperatures have exceeded 60 degrees F can yield 1-2 cuttings of forage if planted by mid-July.

- These warm season species will tend to yield quite well (5-10 tons DM) especially on more well drained soils. Studies done in Wisconsin have shown that, on the upper end, they can sometimes match corn silage yields. The adaptability of these species to be planted in July provides a great opportunity to establish forages when it has become clear that winter killed stands or drought conditions might significantly be affecting forage inventory.
  - If the primary objective is yield, stick to one cutting around mid- to late October.
  - If the primary objective is quality; two cuttings (one around early August and another in mid-October) is the best practice.
  - One cut brown midrib (BMR) forage sorghum has shown some promise in southern Wisconsin but is less consistent elsewhere in the state. It tends to have high yields and good forage quality.
- Cereal crops can sometimes be a great single-use fall forage source.
  - Manure application timing and method should be considered before planting forages. To avoid planting delays due to manure application, consider applying manure later if adequate equipment resources are available.
  - Early and late maturing oats planted in early to mid-August are a "tried and true" method for harvesting or grazing late fall forages to increase tonnage ahead of winter. Spring wheat or barley are also viable species options for single-cutting fall forage. With any of these, expect yields in the range of ~3 tons DM/acre when conditions are right, and forage is harvested or grazed around November 1st.
  - Avoid cereal crops that require a vernalization/overwintering process to elongate, boot and form a seed head because they will not be high-yielding in the fall, unless the intent is for fall cover and spring harvest.
  - These crops can sometimes be difficult to manage when chopping due to high moisture content.

Click or scan the code to watch a video on **wheel traffic in alfalfa!**

-------- INNOVATION --------

Innovation in cropping systems can be attained through careful utilization of technologies and novel approaches Focus should be placed on those that help build a resilient, efficient and economically beneficial agroecosystem.

Click or scan the code to watch a video about **precision ag!**

- ✓ **Be patient**, your time is also expensive; new technologies usually have a steep learning curve and take time (and lots of mistakes) before you get proficient.

Equipment

- ✓ **Utilize technology that you don't have to own.** Check with your local cooperative for variable rate application (VRA) equipment. If so, hiring them to make VRA may increase profitability given the right conditions.
  - ✶ First, map field variability by collecting soil samples on a 1- to 2-acre grid basis.
  - ✶ Second, determine if at least 25% of a field should have a P, K, or lime recommendation that is different from the field average.

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- ✓ **Use section control on sprayers,** which allows the sprayer to turn off sections when they pass over an area that has already been sprayed. This reduces over-application, chemical usage and risk of damage to plants. An added benefit of using section control is that environmentally sensitive areas within the field, such as grassed waterways and buffer strips, can be excluded from receiving the chemical application, thereby reducing runoff potential.
- ✓ **Consider automatic guidance systems** which can reduce costs in a number of ways.
  - ✶ Accurate pass-to-pass guidance reduces overlap and skips when spraying, maintains proper row spacing when planting, and minimizes the number of passes required to cover the field translating into fuel savings.
  - ✶ A secondary benefit is reduced operator fatigue, allowing the operator to stay in the machine longer and perform the operation at the optimal time.
  - ✶ Also, the operator can focus attention on the implement to ensure that it is functioning properly. Having the ability to detect a clogged seeding tube or nozzle before misapplication has occurred over several acres saves time and money needed to correct the problem avoids reduction in yield in the fall.
- ✓ **Planter technology can save seed inputs** and help the crop get off to a good start.
  - ✶ Use of soil moisture sensors coupled with automatic row-unit downforce control and automatic planting depth control could help adjust seed placement on-the-go to ensure sufficient soil moisture for the seed and uniform germination.
  - ✶ Using technology like electric or hydraulic row shut-off systems can be a good investment as they can help save on seed input costs and maintain yield potential by avoiding double planting and skipped areas within a field. Having the ability to adjust seeding rates on-the-go can provide advantages in controlling seeding rates in fields with variability in fertility, diseases and historical productivity.

Data

- ✓ **Utilize farm-level production data collected from fields** to help advise management decisions throughout the year. Collecting data over time can also inform on variations in weather, soil types and topography from year-to-year.
  - ✶ Yield monitor data is a relatively low cost of entry to begin data collection. Most new combines come equipped with a yield and crop moisture measurement system. Coupling this data with Global Navigation Satellite System (GNSS; GPS) data can provide spatial variability indicators.

Click or scan the code to watch a video on **corn silage harvest!**

- Variable rate seeding prescriptions and as-applied maps and any remote sensing (drone or satellite) data available can give indications on areas of the field that are not profitable and would benefit from reduced inputs to optimize profitability.
- UAV and satellite remote sensing data collection is a new possibility to add extra data and visual observations to help advise management decisions. Research is ongoing to help growers use these tools and determine how to use them efficiently.

Grazing systems

✓ **Improve or adopt grazing** in agroecosystems, including systems with no previous grazing history.

- Profitable and resilient grazing systems require careful management. It's important to soil test, allocate livestock manure, rotate pastures and maintain a proper stocking rate to balance forage production with livestock need.
- Rotate livestock through paddocks in a pasture to allow each paddock plenty of time to rest before grazing it again. Rotational grazing increases forage utilization and yield. In drought conditions, allow longer periods of rest for each paddock if possible and avoid clipping the pastures. If pastures are clipped, they should be clipped fairly high through the use of an implement such as a haybine.
- Low fertility areas away from surface water or concentrated flow channels should be targeted first when selecting areas that will get more manure, such as out-wintering or bale grazing areas. For more information on bale grazing, go to: https://cropsandsoils.extension.wisc.edu/articles/bale-grazing-a-winter-feeding-strategy/
- Grazing in confinement dairy systems presents the opportunity to promote animal health, save money on feed costs and build farm resiliency. Heifers and dry cows are great candidates for grazing, as they have lower nutritional requirements than lactating animals and many farms may have the land and resources already available.
- Farm direct access to markets to sell meat, milk, or eggs from grazing systems in local areas presents a unique opportunity to maintain a level of economic resilience from the sometimes-volatile global agricultural markets.
- For emergency forages, graziers have the same options as other farms if they have annual row crops in their system. Graziers might also consider stockpile grazing:
  - Consider stockpiling forage by setting a paddock aside for 60-80 days to be grazed later in the season or by using a strip grazing strategy. This tends to work better with meadow fescue and orchardgrass species but can also be accomplished if a paddock is planted to oats, which winterkill in Wisconsin. Be careful with high concentrations of legumes; they contribute to wilt, which amplifies the possibility of bloat when frost starts setting in.

PEST MANAGEMENT

Integrated pest management (IPM) is a continuum of sustainable management practices that range from simple field scouting to biointensive management. IPM considers all available pest control options and is not reliant on a single tactic. Whenever feasible, IPM first considers preventative non-chemical control tactics as the first line of defense.

Overall, IPM strategies focus on making educated decisions about effective management for insect, disease and weed control. There are many opportunities to incorporate emerging innovations with proven IPM practices.

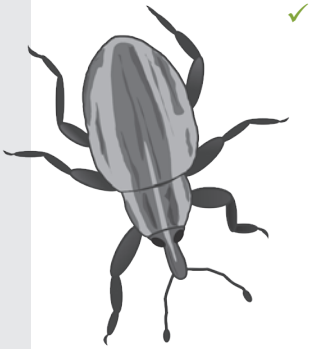
INSECT PEST MANAGEMENT

-------- SUSTAINABILITY --------

The foundation of a sustainable insect management program includes using multiple tactics and timely field scouting to control insect pests.

IPM practices

- ✓ **Maintain basic knowledge of the insects life cycles** and ensure proper identification to target pests properly.
- ✓ **Know how and when to make insect control decisions** (based on insect numbers, plant damage or both, and using University-based economic thresholds) to ensure proper timing of insecticide applications that maximize control and profitability.



- ✓ **Manage pests with a variety of approaches.**
  - ✶ Use insect resistant varieties when field history dictates a need.
  - ✶ Incorporate cultural control methods including crop rotation, tillage operations, timing of planting and harvesting activities to control pests prior to infestation.
  - ✶ Incorporate biological controls.
  - ✶ Spot treat when possible.
  - ✶ Use insecticides based on appropriate timing, rate and in accordance with a proper resistance management plan.
- ✓ **Be aware of insect pest dynamics!** Insects move and can be tricky to time or keep track of during their lifespans.
  - ✶ Certain insects arrive at fields based on accumulating temperature, which can be predicted with growing degree day (GDD) models. These GDD and other models that incorporate weather conditions, winds and pest dynamics help predict when pests will arrive in Wisconsin and trigger management needs.
  - ✶ Other pest movements occur within the growing season. For example, when alfalfa is cut, pests such as the potato leafhopper move to adjacent fields and can infest another field quickly. These may include other crops which the potato leafhopper infests, like potato, other forages and many types of vegetables.

Resistance mgmt

- ✓ **Understand how resistance management practices maintain the efficacy of insecticides** and the ability to adequately control pest species.
  - ✶ First, use effective IPM cultural and biological control practices.
  - ✶ When insecticide use is warranted:
    - ✶ Use at the proper time and verify that insect pest economic thresholds have been reached. When possible, select insecticides that conserve beneficial insects.

Resistance can be defined as:

"A heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species."

Because pest insect populations breed quickly, there is always a risk that insecticide resistance may evolve, especially when insecticides are misused or over-used.

- Use insecticides at their recommended rates. Using reduced (sub-lethal) rates helps select populations with a tolerance to insecticides. Using high rates can also impose excessive selection pressure for insect resistance.
- Use Insecticide Resistance Action Committee (IRAC) general resistance management rules and guidelines, including altering chemistries for consecutive applications to the same pest and alternating within the rotation.

- For corn hybrids with *Bt* or other insecticidal traits, include refuge corn acres that do not contain the insecticidal trait.
- Monitor fields for insect pest resistance and assess control levels. If control concerns are found have those insects tested to document resistance.

-------- INNOVATION --------

New techniques to traditional IPM, as well as novel approaches, are being developed and incorporated into general IPM strategies.

Real-time detection

- ✓ **Use remote sensing and aerial photography** to identify damage/hot spots and help guide field scouting.
- ✓ **Watch for new technologies** like camera traps (cameras aimed at sticky cards) and light detection and radar (LiDAR) that are being developed for scouting without needing to catch the insect pest first.

Genetic technologies

- ✓ **Pay attention to emerging genetic approaches** to determining pest presence and altering pest attributes.
  - A genetic based approach screens the air for an insect pests DNA — using a method called **eDNA**. While the technique is often used in aquatic environments, early testing by researchers will help determine if insect pests have arrived in the region. The use of eDNA to screen for insect pest presence is a highly promising method that may be used in the future to time insecticide or biological treatments.
  - RNA interference (known as **RNAi**) research involves using a gene-silencing mechanism — double-stranded RNA molecules matching a specific target gene sequence — that can alter a pest insect species' growth, development or reproduction, ultimately limiting their ability to damage crops. A key benefit of this type of selectively is that it has the potential to control the pest without adversely affecting non-target species.

WEED PEST MANAGEMENT

-------- SUSTAINABILITY --------

A zero-tolerance approach to weed control in annual cropping systems is recommended because of widespread resistance to commonly applied post-emergence foliar herbicides and the continuous evolution of novel resistance cases. The only way to prevent further resistance evolution is by preventing weed seed production; to achieve this, a holistic integrated weed management program is warranted.

Annual cropping systems

- ✓ **Prevent introduction and dispersal of troublesome weeds.** Imported feed and equipment movement are the most common ways weed seeds are introduced in Wisconsin. Palmer amaranth has been brought in through dairy feed (and spread through manure), and waterhemp infestations in fields are often associated with combine movement.

Click or scan the code to watch a video on **weed management in corn/soy rotations!**

- ✓ **Know the field history and the predominant weed species** within a field to plan your weed management program.
- ✓ **Understand the emergence and growth pattern of the predominant weed species** in fields to help you plan the ideal time for intervention.
- ✓ **Incorporate non-chemical weed control tools as often as possible** like tillage, in-row cultivation, weed zapper, rouging, rope wick, equipment hygiene and cover crops.
- ✓ **Use and rotate herbicide mixtures containing multiple modes of action** (MOAs) to reduce the risk of herbicide resistance evolution.
- ✓ **Use soil residual herbicides in pre- and post-emergence applications** (layered soil residual approach) to manage infestations of herbicide-resistant waterhemp.
- ✓ **Select effective post-emergence foliar herbicides** based on established weeds and spray when weeds are small (less than 2-4 inches).
  - ✶ Scout the field prior to the post-emergence herbicide application AND two weeks after to evaluate the control and to determine if any spots were missed.
  - ✶ Apply herbicides at the full labeled rate. Reduced rates are not be as effective at control and exposure to reduced herbicide rates favors resistance evolution.
  - ✶ Use adjuvants when the pesticide label calls for them.
- ✓ **Ensure sprayers are properly setup and calibrated** to optimize herbicide delivery and efficacy and to reduce the risk of environmental contamination and carryover. Select the appropriate nozzle tips and carrier volume rate for each application.

Forage systems

- ✓ **Alfalfa and pasture weed management** guidelines are pretty simple:
  - ✶ Identify goals for the field while considering cost of implementation and select the management options that fit those goals.
  - ✶ Know the field history and predominate weed species and understand the emergence and growth pattern to help plan the ideal time for intervention.
  - ✶ Evaluate costs, effectiveness, and long-term impacts of management options for specific weed species present in the field.
  - ✶ Evaluate if weeds are a driver or passenger for impact, as often weeds are present as other mismanagement is impacting forage growth (such as overgrazing).
  - ✶ Remember that proper forage management is best form of weed management.

-------- INNOVATION --------

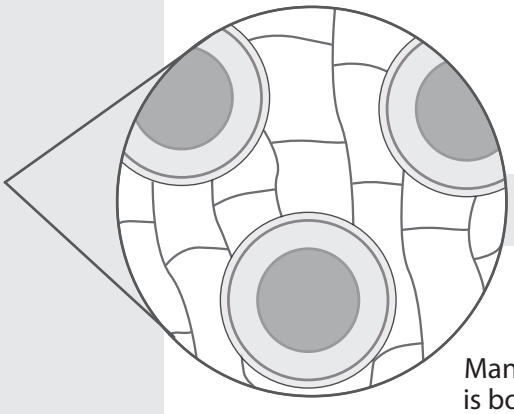
Precision agriculture offers opportunities to reduce pesticide usage compared to traditional broadcast spray platforms by optimizing applications with a site-specific approach. Despite the potential of precision agriculture tools for weed management, there are currently practical and financial roadblocks to their adoption. Moreover, in order for these technologies to succeed, effective chemicals and low weed infestations will be of paramount importance.

Real-time detection

- ✓ **Watch for upcoming novel technologies with real-time weed detection systems** for site-specific weed management to account for spatial variation in weed density and only spray foliar herbicides in areas with weed infestation ("green-on-brown" for burndown pre-emergence applications and "green-on-green" for foliar post-emergence applications), whereas

conventional broadcast applications will continue to treat entire fields.

- These site-specific technologies can significantly improve weed management efficiency and cut operational costs by reducing herbicide inputs, application time (fewer refills), wear and machinery cost, and off-target spray movement.
- Using site-specific spray systems for season-long weed management could represent an efficient complement to traditional weed control practices.



DISEASE PEST MANAGEMENT

-------- SUSTAINABILITY --------

Management of plant diseases always starts with the disease triangle which is both innovative and sustainable! The plant disease triangle demonstrates that it takes a virulent pathogen, a susceptible host and favorable environment occurring at the same time for a plant disease to develop (see graphic on next page). If any one of these components is missing, a plant disease will not occur. Likewise, if a component of the triangle is manipulated in some way, the magnitude of a disease can be affected.

- ✓ **Choose the varieties or hybrids** best suited for the location that also have the best disease resistance ratings.
- ✓ **Use fungicides for corn at the right growth stage.** Data suggests that the best fungicide response occurs when the application is made near or immediately after tasseling.
  - Scout prior to the tasseling (VT growth stage) and base the decision to spray fungicide on the past field history, the foliar disease resistance rating of the hybrid, planting date and the amount of disease observed on lower leaves.
  - If a disease like northern corn leaf blight is observed with severity (area of the lower leaves covered by disease lesions) greater than 10% on 50% or more of the plants, fungicide could be effective in controlling foliar disease, and a positive yield response observed.
  - Spraying when no northern corn leaf blight is observed results in less than a 20% chance of recovering the cost of the fungicide and application. For some diseases like common rust, severity will rarely reach a point to cause yield loss in Wisconsin.

Fungicide mgmt

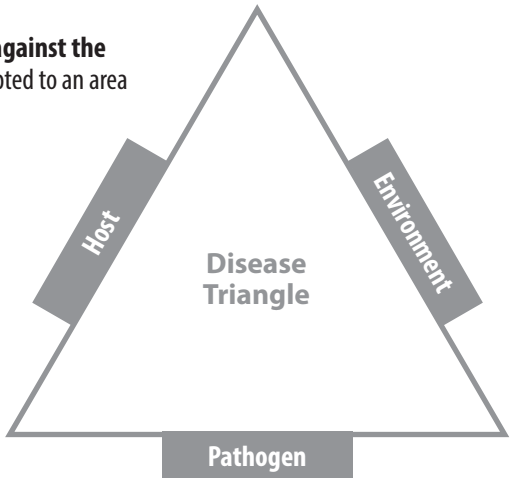
- ✓ **Use fungicides for soybean at the right growth stage and temperature for white mold** — the major disease of concern in Wisconsin.
  - Know the field history and perform any fungicide applications in at-risk fields during the early reproductive (R1-R3) growth stages.
  - The weather (before and during R1-R3) will influence this decision. If weather has been wet (above average) and average temperatures mild (less than 80° F) then conditions will be conducive for white mold development.
  - If weather has been dry and average temperatures above 80° F, spraying for white mold may not be needed.
  - If weather is conducive, and the right product is used at the right time, return on investment will typically be positive in situations where white mold is a problem. For other diseases of soybean in Wisconsin, the odds of positive return when foliar fungicide is used will be less than 50%.

Pathogen resistance

- ✓ **Understand how pathogen resistance occurs** and employ proper strategies to limit its development.
  - ✶ Fungicide resistance results from genetic adjustment of the fungus, which leads to reduced sensitivity to a fungicide.
  - ✶ Genetic mutations in fungi that result in fungicide resistance are thought to occur at low frequency and can be governed by a single gene or multiple genes.
  - ✶ Mechanisms that lead to reduced sensitivity to a fungicide can vary but can include a change in the target site, active export of the fungicide out of the fungal cell, breakdown of the fungicide active ingredient and reduced fungicide uptake.
  - ✶ Fungicide resistance occurs when the frequency of resistant fungal strains in the population outnumbers the fungicide-sensitive individuals. This happens through repeated and exclusive use of fungicides with high-risk for fungicide resistance development.
  - ✶ To limit resistance development, apply fungicides at the proper time and rate, and use alternative options for controls to limit pathogen incidence.

- ✓ **The host component can be manipulated by using plants that have genetic resistance against the pathogen of interest.** Also, managing plant stress and using hybrids/varieties that are well adapted to an area equates to plants that are less likely to be predisposed to a plant disease.

- ✓ **The environment immediately around a plant (micro environment) can be changed, to a certain extent.** For example, managing soil fertility can provide an environment favorable for plant growth and reduce plant disease.
One of the best ways to innovate and improve sustainability is to use prescriptive planting technology to change planting populations on the fly. For example, in soybean we know that reducing planting populations in known white mold areas can reduce white mold risk and reduce the need for fungicide applications. Prescriptive technology can help you use yield maps and past disease severity records to up planting populations in areas of the field that have low disease risk and drop the populations in areas with high disease risk. Recouping the cost of precision planters can be done through the seed savings gleaned from using this technology.



- ✓ **The pathogen component can be manipulated in several different ways.** Excluding a pathogen from an area is an excellent way to control plant diseases. Using certified pathogen-free seed and cleaning field implements between fields could prevent the introduction of a pathogen to a non-infested field. Eradication can also be applied to pathogens. This strategy can be very difficult because it can be nearly impossible to remove all infested plants and/or soil from an area to completely rid it of a pathogen. Sanitation can be utilized by removing or burying pathogen-infested plant material. As mentioned previously, fungicides are also used to manipulate the pathogen with a lot of innovation in products that have a lower environmental impact, site-specific chemistries and the ability to apply a smaller amount of less active ingredient per acre.

Click or scan the code to watch a video on **smartphone apps!**

-------- INNOVATION --------

New innovations in plant disease forecasting have occurred resulting in the development of applications (apps) that can bring the environmental component of the plant disease triangle right to a smartphone. By answering a few simple questions about the crop, the app does the work by incorporating cloud-based, site-specific weather data into automated forecasting models to provide a risk of disease in minutes!

Smart apps

- ✓ **Tarspotter predicts the likelihood of an increase in tar spot in corn.** Using the field location, recent weather data and a preferred action threshold, this app predicts the level of risk of finding tar spot and can alert growers to the potential for tar spot development allowing for response with field scouting and/or fungicide applications.
- ✓ **Sporecaster predicts the likelihood of the white mold pathogen to infect soybeans** by using field location, recent weather data, row-spacing, and irrigation status to determine the likelihood of white mold pathogen presence in a field with the history of the disease. The best time to use the Sporecaster app is during the R1-R3 growth stages in soybeans (R1 is when one or more flowers present at the first node on the soybean stem).

Download the mobile apps!

https://ipcm.wisc.edu/apps/tarspotter/

https://ipcm.wisc.edu/apps/sporecaster/

ECONOMICS

Innovation requires investments of managerial time and money and these investments need to generate an acceptable rate return to be economically sustainable.

-------- SUSTAINABILITY --------

Three closely intertwined farm management activities are useful for managing economic sustainability.

✓ **Projecting cash flow** over the crop production and marketing season can help manage the timing of large input purchases, capital investments and major commodity sales, and can also reduce interest expenses.

- ✶ Larger farm operations often use farm accountants and/or lenders to formally manage their cash flow, while smaller farms can often adequately manage cash flow informally but can still benefit from projections. Also, recent cost inflation likely means that many farmers need a mental reset of typical credit needs – a $100,000 isn't what it used to be.

  UW Extension's Farm Management Program has materials and tools on farm finance topics, including cash flow analysis and estimating your cost of production: https://farms.extension.wisc.edu/article-topic/financial-strategic-management/

Production costs

✓ **Estimating the cost of production** for each crop (or even each field) is a key part of the planning process. Every year, farmers plan what crops to plant in which fields and how much of which inputs to use for each. These estimates help guide rental negotiations, acreage allocations, input and machinery purchases, and plan for credit needs and expected income.

- ✶ Estimating costs for purchased inputs is straightforward. Records for Schedule F are useful, but input costs should be put in the crop year they are used, which may not match the tax year.

  UW Extension's Crops and Soils Program has budgeting tools: https://cropsandsoils.extension.wisc.edu/article-topic/economics-budgets-financial/

- ✶ Machinery costs are more difficult to estimate. Custom rates are a good starting point, but machinery costs for custom operators tend to be lower than for individual farmers because operators usually run machinery over more acres, and so spread fixed machinery costs over more acres. Depreciation, deferred maintenance, opportunity costs and other non-cash costs can be ignored in the short-term, but eventually these costs will be paid. Covering such costs is part of economic sustainability.

  Iowa State University Extension provides a detailed process for more accurate estimates of machinery costs: https://www.extension.iastate.edu/agdm/crops/html/a3-29.html

Marketing plan

✓ **Developing a marketing plan** can add a few extra cents per bushel to the season-average price, which can be just as beneficial as adding a few extra bushels with improved crop management. Of course, getting both higher yields and prices is even better!

- ✶ A key part of marketing plans are deadlines by which sales of pre-set sizes are made so profits are captured if they are available or minimize expected losses if it's that type of year.
- ✶ Marketing plans can also help manage cash flow to reduce interest costs. Marketing tools can seem quite complex, but marketing plans can be quite simple. Many farmers find it useful to hire an expert to help them with marketing. There is no right or wrong marketing plan, but good marketers should be able to help develop a marketing plan that is understandable.

  University of Minnesota Center for Farm Financial Management has examples and templates of marketing plans: https://www.cffm.umn.edu/grain-marketing-plans/

-------- INNOVATION --------

All changes or investments in innovation are risky so it's important to assess both small or large to understand the risk. Even a good investment can lose, and sometimes bad investments pay off. On average and over the long run, good investments pay off but likely not every year in every field.

Partial budget

- ✓ **Doing a partial budget analysis** can estimate the net return from making small changes.
  - ✶ Some are as simple as comparing the cost of a new seed treatment to the expected yield benefits. Many farmers can analyze these types of questions "on the back of an envelope".
  - ✶ However, analyses can be more complex, such as selling an old combine and buying a newer one. You could do custom work to spread fixed costs over more acres and so lower the per acre harvest cost for your grain, but how many acres of custom work would you need to get your per acre costs down to where you need them? Analyses this involved can take a few hours, can require research to make accurate assumptions, and can use sensitivity analysis to understand the robustness of results.
  - ✶ Partial budget analysis answers four questions: What revenues increase? What revenues decrease? What costs increase? What costs decrease? The answers are used to calculate the net change in returns or the break-even change needed to earn positive returns.

    UW Extension Farm Management Program Partial Budgeting
    https://farms.extension.wisc.edu/articles/partial-budgeting/

Business plan

- ✓ **Developing a business plan** can be useful for assessing larger changes in a farm operation.
  - ✶ Such plans involve clarifying goals and strategies to achieve them, often including a marketing plan, annual budgets, and estimated capital needs and income flows. Examples include making multiple machinery and facility investments over a few years to address chronic labor shortages, growing specialty grains and adding on-farm processing, or converting from conventional to organic grain production.
  - ✶ Assessing changes of this magnitude requires more time and effort, often involving explaining it to lenders or investors and making several updates and refinements based on feedback and new information.

    Wisconsin Small Business Development Center's Farm Business Initiative:
    https://wisconsinsbdc.org/services/consulting/farms/

    A Guide to Developing a Business Plan for Farms and Rural Businesses:
    https://www.sare.org/wp-content/uploads/Building-a-Sustainable-Business.pdf

-------- A FEW GENERAL CONSIDERATIONS --------

- ✓ **Labor:** Be wary of making changes that increase off-farm labor needs as labor is in short supply and will likely continue for a while.
- ✓ **Off-farm Income:** When margins are thin, farm families may seek additional off-farm income to keep farming. Many farmers have in-demand skills but may need additional training or certification, such as a commercial driver's or pesticide applicator license. Doing custom work can also be a way to earn extra income and reduce per-acre fixed machinery costs.
- ✓ **Break-even yields:** Divide your cost of production by the expected price to find your break-even yield (the yield needed to earn a profit). Yield maps will show which areas are not making money. Consider the following:
  - ✶ Can changes in management in these areas lead to reduce cost?
  - ✶ What else can be done with these areas to make money?

- ✶ Can conservation payments make these areas profitable?
- ✶ What about growing forage or another crop?

✓ **Carbon credits:** Many options exist for "selling" carbon credits.

- ✶ Be cautious as to which package is selected as it can preclude the farm from better options.
- ✶ Carbon sequestration in annual cropping systems, regardless of conservation practice implementation, is often minimal or non-existent. Minimal additions are immediately depleted with tillage. Thus, the integrity of these contracts may be questionable.

-------- A FEW MORE RESOURCES --------

Conservation Programs: USDA-NRCS has increased funding for existing conservation programs providing cost share and technical assistance for farmers to adopt conservation practices on working lands. USDA also funded numerous Climate Smart Partnerships for companies and organizations to develop climate-smart commodities that pay farmers to implement climate-smart production practices, activities and systems on working lands. These programs can make conservation sustainable by helping farms through the initial, high-cost/low-benefit stages of innovation to get to the long-term positive economic benefits they can generate. Farmers should look at practices they are already considering, carefully examine program requirements and analyze both the short- and long-term benefits. In some cases,these programs can make innovative conservation practices practical, even in times of thin margins.

Information on these programs is rapidly evolving. Farmers can expect more decision-making resources in the future, including from USDA and UW Division of Extension-Madison.

- ✶ Iowa State University Extension Carbon Market Information: https://www.extension.iastate.edu/agdm/info/currentissues.html
- ✶ Iowa State University Extension Carbon Website: https://carbon.extension.iastate.edu/

Click or scan the code to watch a video on **low-interest loans!**

USDA Farm Loan Programs: USDA-FSA has several loan programs, many focused on small and mid-sized or limited resource farms. However, most are eligible for marketing assistance loans, which use harvested grain as collateral to provide short-term low-interest loans for managing cash flow around harvest. Contact your local USDA service center for information.

- ✶ Marketing Assistance Loans: https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/mal_ldp_090420_fact_sheet.pdf
- ✶ Farm Storage Facility Loans: https://www.fsa.usda.gov/programs-and-services/price-support/facility-loans/farm-storage/index
- ✶ Emergency Farm Loans (in counties with disaster declarations): https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/emergency-farm-loans/index

Farm land leases

Negotiate rental rates based on yield history, price expectations and costs. Explore flex leases to share yield or revenue risk with a landlord and input share leases to share cost risk.

- ✶ North Central Farm Management Extension Committee, farm lease resources, including guides and examples: https://aglease101.org/
- ✶ UW Extension Cash Farm Land Lease Example https://farms.extension.wisc.edu/articles/wisconsin-cash-farm-land-lease-example/

Drone broadcasting cover crop seed

Click or scan the code to access the complete **video playlist for this series!**

NUTRIENT & PEST MANAGEMENT PROGRAM

Jordan Schuler
Deana Knuteson
Mimi Broeske
Chris Clark
Michael Geissinger
Dan Marzu
Roger Schmidt
Kevin Shelley
Daniel Smith

NPM 10/2023

This publication is available from the Nutrient and Pest Management Program.
For more information,
email us at npm@hort.wisc.edu
or visit our website at ipcm.wisc.edu

Extension
UNIVERSITY OF WISCONSIN-MADISON

PLANT AND AGROECOSYSTEM SCIENCES

Shawn Conley, Professor & Soybean and Small Grains Extension Specialist

Marta Kohmann, Assistant Professor & Forage Systems Agroecology Extension Specialist

Joe Lauer, Professor & Extension Corn Agronomist

Mark Renz, Professor & Extension Weed Specialist

Rodrigo Werle, Associate Professor Plant & Extension Cropping Systems Weed Scientist

DIVISION OF EXTENSION CROPS AND SOILS PROGRAM

Anne Pfeiffer, Program Manager

BIOLOGICAL SYSTEMS ENGINEERING

Brian Luck, Associate Professor & Extension Specialist

SOIL SCIENCE

Francisco Arriaga, Associate Professor

Matthew Ruark, Professor & Extension Specialist

AGRICULTURAL AND APPLIED ECONOMICS

Paul Mitchell, Professor & Extension Agriculture Economics Specialist

ENTOMOLOGY

Emily Bick, Assistant Professor & Extension Specialist

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Damon Smith, Professor & Extension Field Crop Disease Specialist