PRO DAIRY
Education & Applied Research

The Manager

MARCH 2023

Forages & cover crops

Opportunities to combat rising costs

The **Manager**

MARCH 2023

FOCUS:
EVOLVING TO KEEP PACE

INSIDE

Cover photo: A 2022 corn crop at Mulligan Farm in Avon, NY that was planted into a growing cover crop mix of cereals, legumes and brassicas. The cover crop was then terminated with a roller-crimper and herbicide after planting. Photo credit: Aaron Ristow, American Farmland Trust

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Alfalfa-grass mixes increase forage quality to support high-producing dairy cows

Rink Tacoma-Fogal, Debbie Cherney, and Jerry Cherney

Seeding alfalfa with a grass produces a mixed forage with higher neutral detergent fiber digestibility (NDFD), important for high-producing dairy cows. Meadow fescue (MF) grass varieties originated in Europe and North Africa and over the past decade our lab has been investigating opportunities to seed alfalfa with meadow fescue grass varieties to improve the quality of alfalfa-grass mixtures for high-producing dairy cows. Given its hardy nature, persistency during the harsh winters in the Northeast is not typically an issue. Relative competitiveness and qualities of varieties, however, is largely unknown in the region.

2021 AND 2022 FIELD TRIALS

During the spring of 2021 and 2022, field trials were carried out on three commercial dairy farms in New York (N.Y.); two centrally located and one farm in northern N.Y. Two of the field plots were seeded in the spring of 2020 and one was seeded in the spring of 2021. Timing of first cutting is particularly important for dairy producers to achieve high quality forage because fiber accumulates faster in the spring, leading to reduced NDFD. Therefore, our objective was to assess nutritive value of MF cultivars in N.Y. at spring harvest.

METHODOLOGY

Nine MF varieties were seeded, including three tetraploid and six diploid varieties with four field replicates at each farm, at three different seeding rates (one, two, and three lbs./acre; **TABLE 1**). One tall fescue variety was seeded for comparison.

TABLE 1
Grass varieties used in the study

Meadow Fescue varieties	
Tetrax *	SW Revansch
Schwetra *	Pradel
Tetralonia *	Driftless
Tored	Hidden Valley
SW Minto	BarianeTF ¤

* Tetraploid meadow fescue varieties,
¤ a tall fescue variety.

Harvest date of the forage crop is typically based on the maturity of the alfalfa and sample collection for this study was conducted shorty before field harvest in both years to evaluate grass quality of varieties around the time of field harvest. All plots were in farm fields and sampled prior to spring mowing. Grass samples were harvested using a handheld trimmer at a four-inch stubble height. Samples were analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP), in vitro true digestibility (IVTD) at 48 hours, NDFD, and lignin. Grass proportions were also estimated at the three sites by visual evaluation.

RESULTS

Increased seeding rate resulted in higher grass proportions in the grass: alfalfa mix on the two central N.Y. farms in 2022, ranging from 18 to 34 percent when seeded at one lb./acre and between 26 to 38 percent when seeded at three lbs./acre. On the northern N.Y. farm site, grass proportion averaged 20 percent when seeded at one lb./acre and increased to approximately 26 percent when seeded at three lbs./acre. Grass proportions in mixtures were higher in 2021 compared to 2022, likely due to drought conditions experienced in 2022. On the central N.Y. farm sown in 2021, grass proportion ranged from 30 to 47 percent when seeded at one lb./acre and between 42 to 46 percent in 2022 when seeded at three lbs./acre. We recommend grass proportions of 20 to 30 percent to achieve highest forage yield along with highest forage quality, particularly with respect to higher NDFD.

Average CP of all varieties was 19 percent and ranged from 14 to 29 percent, with the SW Revansch variety having consistently higher CP levels at the three farm locations in 2022. In 2021, CP data was only available for the northern N.Y. farm, where varieties averaged 16 percent and ranged between 13 to 21 percent, again the SW Revansch variety having consistently higher CP compared to the other varieties. Average NDF in 2022 was 49 percent, ranging from 44 to 55 percent where the tetraploid varieties **(FIGURE 1)** had consistently lower NDF at each farm site. In 2021, NDF averaged 48 percent and ranged between 42 to 54 percent across varieties. Similar to results in 2022, the three tetraploid varieties had markedly lower NDF values in 2021 compared to other varieties. Varieties with consistently higher NDFD in 2022 were Hidden Valley, Schwetra, SW Revansch, and SW Minto. Bariane tall fescue had lower NDFD values in 2022. Average NDFD of all grass varieties in 2022 was 86 percent, with a range of 76 to 91 percent. Similar trends were measured in 2021 with the average NDFD at 82 percent and a range of 71 to 88 percent across all varieties. Again, varieties with higher NDFD values were Hidden Valley, Schwetra, and SW Revansch.

SUMMARY

Tetraploid meadow fescue varieties tend to have reduced NDF at the optimal harvest time for alfalfa, compared to diploid varieties. Therefore, tetraploid meadow fescue varieties exhibit great potential for optimal forage quality when mixed in combination with alfalfa across different environments. Grass seeding rate should not exceed three lbs./acre to minimize the possibility of excess grass in mixtures.

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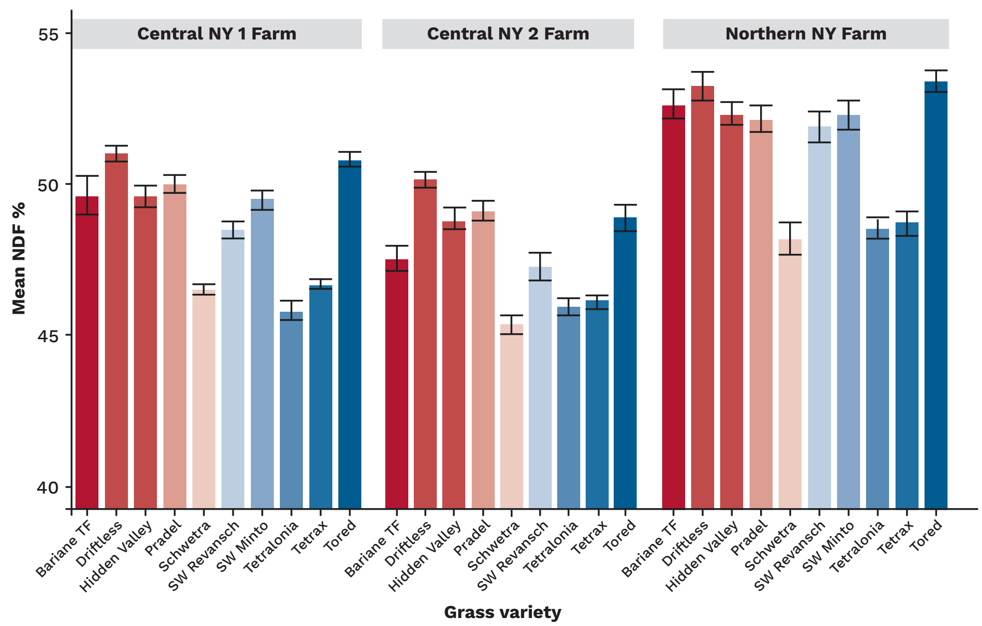
FIGURE 1

Average NDF for each grass variety at harvest at each farm location in 2022



Best management practices for dairy producers to reduce their GHG emissions from manure

Jason Oliver, Lauren Ray, and Kirsten Workman

Dairy farmers may not consider greenhouse gas (GHG) emissions a key issue, but federal and state governments, the dairy industry, and perhaps more importantly, consumers of dairy products, do. While federal and state GHG reduction targets vary, most have set aggressive goals to cut GHG emissions roughly in half from recent levels by the year 2030. Similarly, the U.S. dairy industry has a Net Zero Initiative with the goal of reaching GHG neutrality by 2050. Consumers are also looking for milk with a lower carbon footprint and dairy processors

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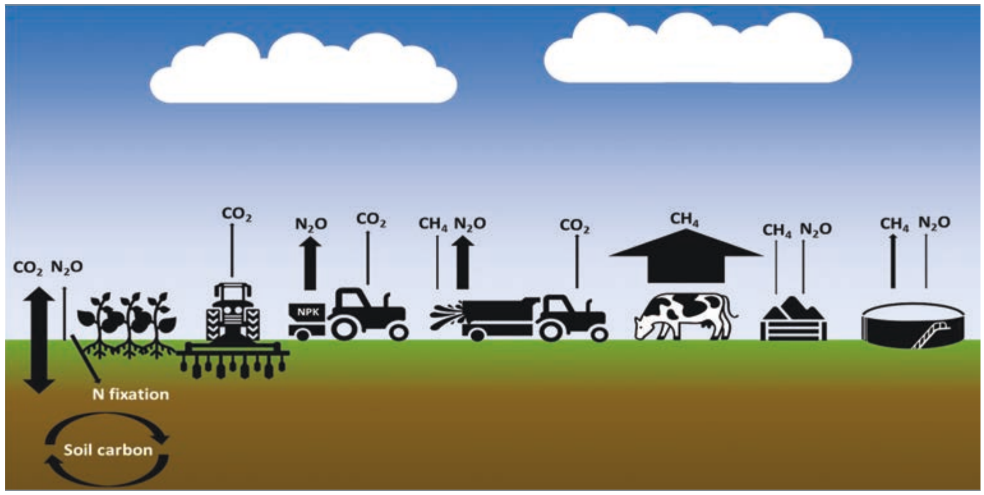
Best management practices for dairy producers to reduce their GHG emissions, *cont'd from page 3*

and food industries are responding to those demands. Furthermore, climate change in the Northeast is increasing the annual average temperatures and the number of hot days that can cause heat stress in cattle. Substantially more precipitation is also occurring, including a 55 percent increase in the heaviest precipitation events. This will impact field work, regional grain production, and will certainly increase manure storage needs as more bunk leachate and rainwater will be collected.

Though dairy production systems may be a relatively small regional contributor to climate change, our farms are uniquely positioned to be an important part of the solution through GHG reduction strategies, opportunities to sequester carbon, and even to generate renewable energy. Livestock production in the Northeast is generally a minor (five to 15 percent) part of a state's GHG inventory that is typically dominated by other sectors like buildings or transportation. The greenhouse gases of interest to dairy farmers **(FIGURE 1)** include carbon dioxide (CO_2), methane (CH_4) that is 84 times as potent at trapping heat as CO_2, and nitrous oxide (N_2O) that is around 300 times as potent. Most dairy farm GHG emissions are CH_4 from the anaerobic (oxygen-free) conditions of enteric fermentation and long-term manure storage, with N_2O emissions emitted to a lesser extent from manure management and agricultural soils. In addition to being the major gas emitted, reducing CH_4 emissions is critical as its short lifetime in the atmosphere (less than 12 years) can result in a near immediate reduction in the impacts of warming. While many strategies to reduce GHG emissions are still in development, particularly for enteric CH_4, many things can be done today to reduce GHG emissions from manure storages and crop fields.

FIGURE 1

Representation of GHG emissions from dairy farms, adapted by O. Godber from the original publication in Cornell University Agronomy Fact Sheet #119: Farm Greenhouse Gas (GHG) Inventory: nmsp.cals.cornell.edu/publications/factsheets/factsheet119.pdf. Arrow size depicts relative contribution to specific GHG emissions.



Perhaps the easiest way to reduce GHG emissions is to reduce the amount of manure in storage during summer months. While long-term manure storage is a critical strategy to optimize manure application and nutrient delivery to agricultural soils in a way that protects water quality, anaerobic storage conditions are a leading source of GHG emissions from manure. In cool northern climates, modeled and observational data show the majority of CH_4 emissions occur in late summer and early fall **(FIGURE 2)**. Thus, getting manure spread onto cropland during the growing season and reducing the volume stored in the summer or fall can substantially reduce GHG emissions associated with manure. Many farmers already apply manure following hay harvests, but research suggests potential benefits of side dressing corn and other annual crops with manure, as well as applications to fall cover crops that utilize the nutrients and benefit the soil. In addition to reducing the volume of manure stored, in-season manure applications coupled with proper timing and application methods maximize the nitrogen efficiency of manure and reduce purchased fertilizer inputs, which can have high N_2O emissions. Another means to reduce storage volumes in the summer is to get replacement stock out of barns and onto quality pasture during the growing season. In addition to enhancing the industry's image, this can be a profitable strategy to feed heifers and dry cows.

Solid storage and compost are another means to store less manure anaerobically. Research suggests that stockpiles can reduce GHG emissions by 20 percent and compost by more than 40 percent compared to long-term liquid or slurry storage. It is important to note that management can have a significant effect here as aeration and mixing, particularly in the first few weeks of composting, can release CH_4 and lead to the generation of N_2O, a potent GHG.

One of the most promising means to reduce manure storage GHG may be solid-liquid separation **(FIGURE 3)**. High efficiency screw presses that are well-suited for use in the Northeast may reduce GHG emissions by more than 60 percent. Additionally, well-managed solid-liquid separation (SLS) generates dry manure fibers that are suitable for cattle bedding. The savings associated with producing bedding, estimated at $0.65 per cubic foot per lactating cow per day, may also justify the cost of a screw press SLS system. While we recognize the hesitation by some farmers to use separated manure solids as cattle bedding, many farmers across the region are having success with low somatic cell counts and high-quality cow comfort and health.

Solid-liquid separation also positions a farm to install an impermeable manure storage cover. Covers enable the capture of CH_4 emissions and their combustion with a flare to the less potent CO_2. Cover and flare systems thus offer a near complete elimination of CH_4 emissions depending on flare efficiency and the maintenance of leak free covers. These systems are expensive, around $3.00 to $4.50 per square foot for the cover and $70,000 to $300,000 for a flare, depending on its sophistication. There are also concerns about manure agitation under the cover, which is why SLS is critical. Despite the significant investment, covers provide important additional benefits, including nitrogen retention via reduced ammonia emissions, rainwater exclusion reducing manure volumes that need to be transported, and odor mitigation.

Anaerobic digestion (AD) is an even more capital-intensive manure treatment option, promoting a rapid conversion of manure volatile solids to CH_4 that is captured. The steady methane production from AD enables it to be used as energy, including for electricity generation, heating, and upgrading to vehicle or pipeline quality gas. When this energy displaces the use of fossil fuels, additional GHG reductions are achieved. However, the storage of warm digestate may be a significant source of CH_4. Research has found that that AD paired with SLS can further reduce GHG emissions **(FIGURE 3)** and covering the effluent storage captures remaining CH_4.

If reducing storage volumes, or higher capital investments (SLS, AD, cover and flare) are not suitable for your farm, promoting crust formation on your storage can help reduce CH_4 emissions. There is likely a balance though, as high total solids content (more than five percent) has been associated with substantially higher CH_4 generation, and very thick crusts that can also generate N_2O. On the contrary, manure low in total solids may not develop a thick enough crust and may require the addition of shredded straw to the surface. Crusts also will require additional agitation prior to manure storage emptying.

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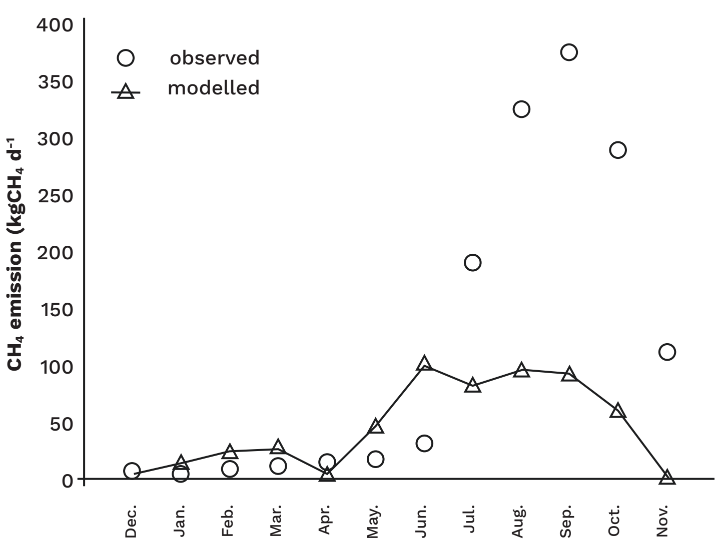
GHG BEST MANAGEMENT PRACTICES FOR MANURE

- Reduce manure storage volumes in summer/early fall
- Maximize nitrogen retention of applied manure
- Use solid manure storage or composting
- Solid liquid separation (SLS)
- Cover manure storages after SLS and flare methane
- Anaerobic digestion
- Maintain a "thick crust" on manure storages

FIGURE 2

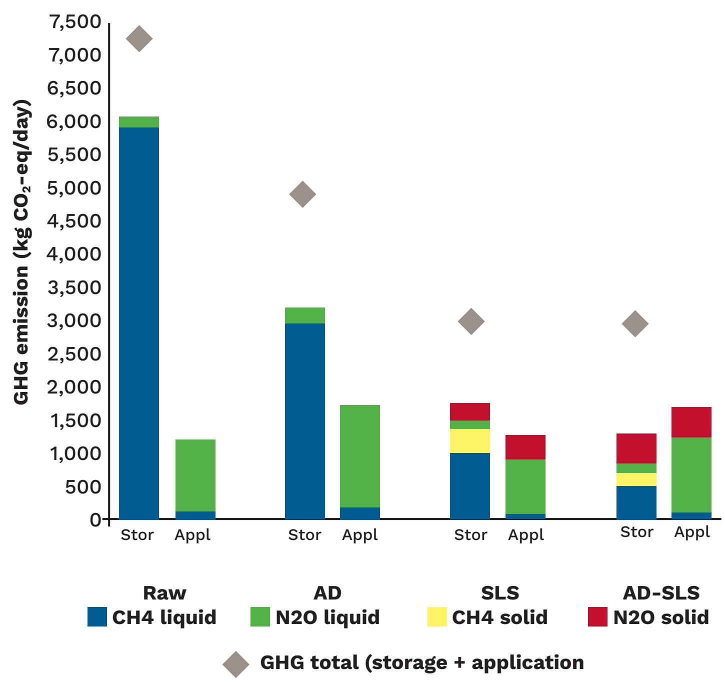
Calculated (U.S. Environmental Protection Agency model) and observed methane (CH_4) emissions from cattle liquid manure stored from December through November in Canada.



Ref. Baldé et al. (2016) Measured versus modeled methane emissions from separated liquid dairy manure show large model underestimates. Agriculture, Ecosystems & Environment. 230: 261-270.

FIGURE 3

Modeled daily GHG during storage and land application of manure for the scenarios i) raw manure, ii) anaerobic digestion (AD), iii) solid-liquid separation (SLS), and iv) AD and SLS after improvements of VS reduction for AD scenarios and separation efficiency for SLS scenarios.



Ref. Aguirre-Villegas et al. (2019) Anerobic digestion, solid-liquid separation, and drying of dairy manure: Measuring constituents and modeling emission. Science of the Total Environment. 696: 134059.

EVOLVING TO KEEP PACE

Making cover crops work in the Northeast: Termination strategies for success

Kirsten Workman, Heather Darby, Matthew Ryan, and Aaron Ristow

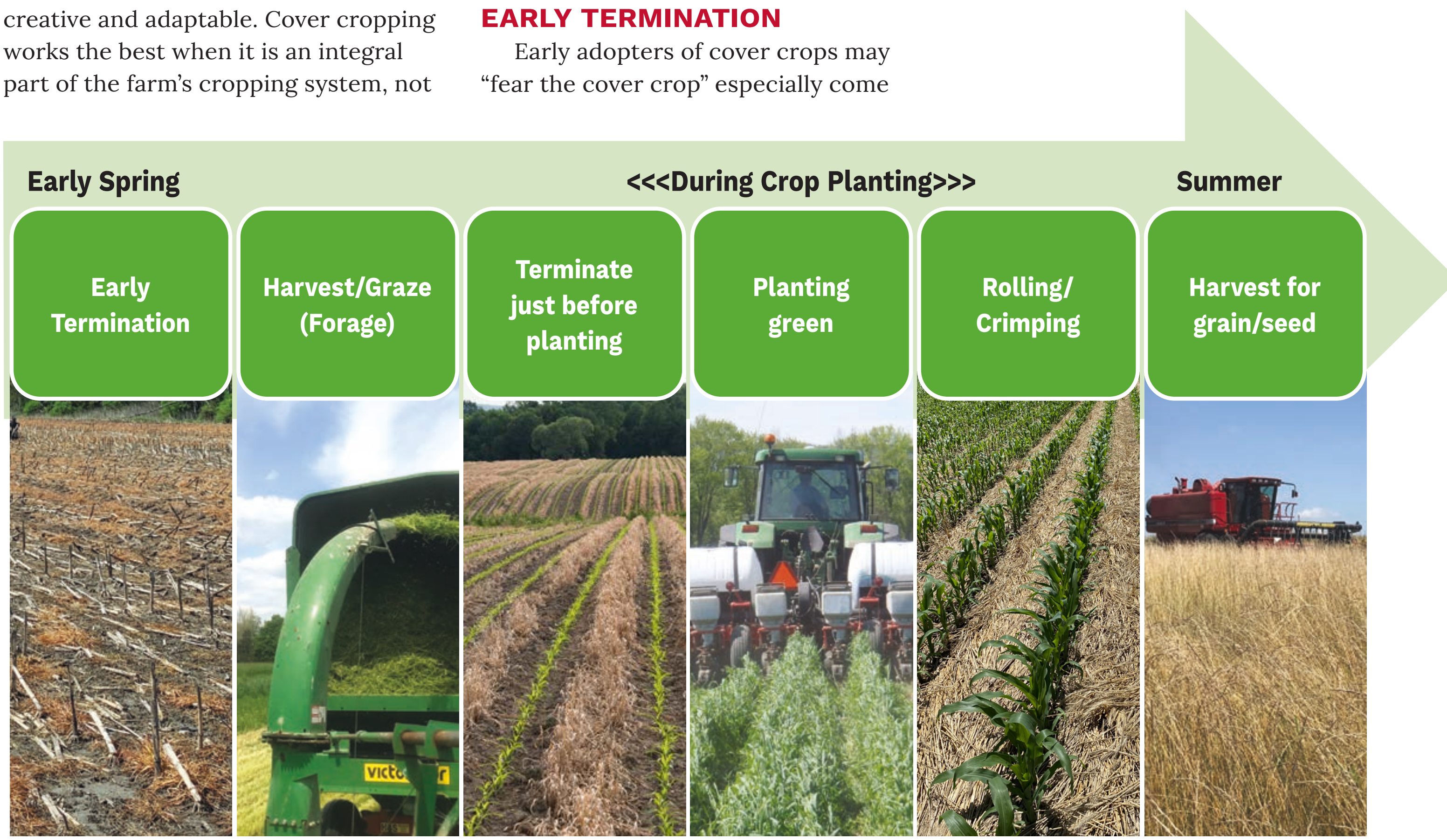
According to the 2017 USDA Agriculture Census, Northeast farms are planting over one million acres of cover crops, and momentum for this conservation practice continues to grow because of its crop, soil, and environmental benefit. Increasing financial incentives coupled with environmental regulations have pushed even more farmers to adopt cover crops. However, like any other crop grown on the farm, the benefits will only be realized with proper planning and timely management.

To make cover crops a successful part of crop rotation, especially in the Northeast, it is important to be creative and adaptable. Cover cropping works the best when it is an integral part of the farm's cropping system, not just an afterthought. This is imperative to realize the biggest benefits of utilizing this practice, but also to mitigate any of the potential pitfalls. With spring knocking on our door, our focus is on the best strategies to terminate winter cereal cover crops. Emphasis is on being flexible based on weather, field conditions, and management goals. The best plan is to always have a backup plan!

Spring termination strategies for winter cereal cover crops in the Northeast

EARLY TERMINATION

Early adopters of cover crops may "fear the cover crop" especially come spring! The first impulse is to get rid of it as soon as possible so it doesn't interfere with cropping activities. This is a normal response, but as experience and knowledge builds, so will ability to manage the cover crop in the spring to maximize benefits and minimize challenges. In many cases if spring conditions are dry, it may be advisable to terminate the cover crop so that soil moisture is conserved for the cash crop. The cover crop begins to grow much earlier than most grass species and will actively remove moisture and nutrients from the soil. This obviously can be helpful if it is wet, but detrimental to the subsequent



crop if conditions remain dry. Early termination generally results in low cover crop growth resulting in minimal organic matter additions and nitrogen (N) credits. For farmers interested in higher cover crop biomass that still terminates early, consider sowing a winter tender species like oats, radishes or annual legumes that will kill with winter frost, keeping in mind these should be planted late summer or early fall.

HARVEST OR GRAZE AS FORAGE

Harvesting or grazing a cover crop for forage provides a measurable benefit and return on a planting investment. It can be challenging to fit this harvest into the busy spring, but if timed properly (flag leaf or boot stage), between one and four tons of high-quality dry matter can be harvested in May, which can be especially helpful if feed inventories are getting low. A timely harvest means that feed quality can be exceptional, with over 65 percent of the fiber being digested in 30 hours. Target highest fertility fields with the highest seeding rates (think lots of biomass), but don't mortgage ruining your soils with compaction if field conditions are not conducive to equipment or livestock - creating compaction and mud. 50 pounds of N fertilizer at green-up will boost protein content, and often yields. Because a lot of biomass is removed from the field, a N credit is not reaped for the following crop. If manure is to be applied on these fields, applying in fall is best to avoid possible feed contamination, or it can be a great place for manure between cover crop harvest and cash crop planting. With increased total crop N removal, higher annual application rates in the nutrient management plan can be justified. Be realistic about how many acres of cover crop that can be harvested. Winter cereal grains grow quickly in the spring and can get overmature in a matter of days. Target a few fields until sure of capacity.

CONVENTIONAL TERMINATION TIMING

Many farmers terminate the cover crop just prior to corn planting (seven to 10 days) or before the stems begin to elongate. There are many advantages to terminating at this time/stage. First, if the cover crop is terminated through tillage, it is easier to incorporate and may take fewer passes through the field. It also is generally easier for most no-till planters to push through the biomass and less chance for the cover crop to impede corn seedling growth. Cover crops incorporated at this stage can also provide some N credit to the subsequent corn crop, ranging from 25 to 45 pounds of N per acre. Of course, this is highly dependent on the amount of cover crop biomass, prior fertility, and stage at incorporation. Using a pre-sidedress nitrate test (PSNT) is a good way to determine N that has come available from the cover crop and manure. Many farmers select the time of termination based on moisture content of the soil, letting the cover crop grow closer to planting to reduce soil moisture in wet years or terminating earlier if the spring is dry. Herbicide termination too close to the time of planting might cause issues with the planter as the cover crop can become wiry and wrap-up around the coulters and row cleaners and ultimately plug up the planter. Manure can be applied on these fields as soon as field conditions are good in the spring, minimizing losses, but also getting it on soon enough to not impede cover crop herbicide termination.

PLANTING GREEN

Planting corn directly through a living cover crop prior to terminating it has become a popular approach because of the flexibility it allows the farmer to plant corn when the conditions are right without needing to worry about terminating the cover crop first. This maximizes the benefits of the cover crop by allowing it to grow as long as possible without getting overmature. It is often easier for a corn planter to work effectively, as the cover crop is still green and anchored to the soil, preventing wrapping on row cleaners and closing wheels or pinning residue in the furrow. However, once the corn is planted it is important to terminate the cover crop quickly to keep the cover crop from impeding corn growth and development. In-season nitrogen return is generally minimal when the cover crop is terminated through herbicide application. However, this really depends on the stage of termination, biomass, and weather. A PSNT is the best tool to determine N contributions. If the cover crop has elongated and heads are visible or nearly visible, the corn crop may require additional early nitrogen since the cover crop will be slower to decompose and release N. This approach also offers a lot of flexibility for manure applications as manure can be applied anytime from the fall through spring on a living crop, reducing nutrient loss and runoff risk.

ROLLING AND CRIMPING

Cover crops can be mechanically terminated with a process that involves rolling down of the cover crop while simultaneously crimping the stems. This practice is gaining favor as a tool to manage cover crops that have "gone by" and with organic farmers interested in reducing tillage. Farmers are generally striving to terminate the cover crop before it begins to head/

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Making cover crops work in the Northeast: Termination strategies for success, *cont'd from page 7*

flower to minimize issues with planting of the cash crop. However in wet years many farmers have found it difficult to get in the field and terminate the cover crop whether they have planted green or not. Once the cover crop has fully headed, biomass quantities can be very high and herbicides are less effective. The cereal grain is tall and even if the corn or soybeans are already planted, it can severely impede corn growth and development due to shading and nitrogen tie up. Rolling and crimping the cover crop is a proven method to terminate a cover crop that is flowering and can be done before or after the annual cash crop is planted. Special equipment (a roller-crimper) is required and can even be mounted on the planter. Benefits to rolling and crimping include soil erosion protection, weed suppression, and keeping the soil cooler and retaining moisture during the hot summer months. It does, however, take intensive management and there are many considerations to take into account. This strategy can work particularly well for soybeans and is covered in much more detail in this guidebook: blogs.cornell.edu/scslab/organic-no-till-planted-soybean-production-guide/.

HARVEST FOR GRAIN, SEED, OR STRAW

Many farmers have been interested in taking the winter cereal grains to maturity, at least on some acres, to produce their own grain, cover crop seed or straw. Growing grain for seed may require additional equipment such as a combine, drier, seed cleaner, and some type of storage. However, it can save the farm input costs and help to diversify the farm rotation. Winter cereal grains are harvested between July and August depending on location in the Northeast. Yields can range from one to four tons depending on the environment. Even at a low yield of 3,000 pounds per acre is enough seed to plant 30 to 40 acres of cover crop. The straw is then available for bedding, feed or to sell off-farm for additional revenue. The crop is harvested early enough to allow for a summer new perennial seeding or a legume cover crop ahead of corn or sorghum the next year. It also opens a summer window to spread manure.

ECONOMICS

Many farmers believe the scientific evidence that soil health practices improve soil and water quality, but may be reluctant to change management techniques without knowing how it will impact their bottom line. Steve Gould of HaR-Go Farms, an organic dairy in western New York, has been "double cropping" or harvesting triticale in the early spring, and has found economic as well as soil health benefits while doing so. Not only is the farm increasing forage by about three tons per acre each year, a partial budget analysis shows an annual net value of harvesting triticale as forage of $123 per acre once seed and harvest costs are considered. To learn more about the costs and benefits of adopting soil health practices, like including cover crops into the crop rotation and potential for a return on investment, visit: farmlandinfo.org/publications/soil-health-case-studies/. ∎

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NEW TO COVER CROPPING OR JUST WANT MORE INFORMATION? TRY THESE RESOURCES:

- **Need more information on cover crops?** Northeast Cover Crops Council's website has some great tools available to help make decisions about species, seeding rates, planting dates, and more. Visit northeastcovercrops.com/decision-tool/.
- **A great general cover crop handbook** is available from SARE: www.sare.org/wp-content/ uploads/Managing-Cover-Crops-Profitably.pdf.
- **Looking for federal cost share programs?** USDA-Natural Resource Conservation Service (NRCS) has several incentive programs designed to help defray the cost of cover cropping. Learn more about these initiatives or find a NRCS office near you at ncrs.usda.gov.
- **Want to see what your local area offers for cover crop support?** Check with your state government's Agriculture Department or your county's Soil and Water Conservation District for local programs and technical assistance. Many of these programs are focused on water quality, climate smart farming/greenhouse gas, soil health, and other initiatives.
- **Worried about your crop insurance?** NRCS and Farm Service Agency (FSA) have updated a coordinated policy regarding cover crop termination and have guidance here: www.rma.usda.gov/-/media/RMA/Cover-Crops/NRCS-Guidelines-version-4-June-2019.ashx?la=en.
- **Find Extension and university resources by state** by visiting Northeast Cover Crops Council (NECCC) resources page and click on your state: northeastcovercrops.com/resources/.

Forage opportunities to combat rising costs

Joe Lawrence

The cost of crop inputs and common feed ingredients used in dairy rations has dominated many discussions this past year. A commonality in growing crops and feeding cows is the need to balance cost and efficiency with production and return on investment. A number of fixed costs are associated with both tasks and it is critical to evaluate if potential cost-cutting measures will end up costing more than they save through declines in production.

Many growers spent the spring of 2022 searching for adjustments that could be made, and while there may be some marginal relief in areas such as fertilizer prices, higher costs look to continue to 2023. While the lessons learned from 2022 will be helpful to develop successful strategies for the 2023 season, it is important to determine which changes made in 2022 can continue without hurting production, and which ones may have been feasible in the short-term but cannot be used continuously without negative impacts, such as drawing down nutrient levels in fields identified to have higher soil test levels.

Within the discussion of managing feed cost, optimizing forage quality is often discussed, and it certainly is an important strategy. Beyond measures of nutritional quality, when considering managing cost, working to minimize shrink losses in our feeding system is often overlooked. When each ton of forage costs more to grow, the value of the losses also increases, increasing its impact on overall cost.

With fermented forages, some level of silage shrink is unavoidable, which is attributed to dry matter (DM) losses through the fermentation process itself. In the best scenarios, total shrink in fermented forages can near 10 percent. The real opportunity exists in all other areas of the ensiling process where both yield and quality are lost. Many of those practices also help to assure the best possible fermentation, which helps reduce the fermentation losses to the lowest feasible levels.

Harvest

The threat for losses in the hay harvest process are greater than in corn silage, though both systems can experience avoidable losses.

CORN SILAGE

Much of the focus for harvesting corn silage is on the balance of kernel maturity and whole plant DM to optimize nutritional value, yield, and proper storage. While harvest timing is the final factor, critical steps are needed much earlier in the process, including selecting correct relative maturity hybrids that provide the best chances the crop will reach optimum harvest maturity for a specific geographic area.

HAY CROP - RESPIRATION LOSSES IN THE WINDROW

When a plant is cut, it continues to respire. This aids the drying process but also burns plant sugars and reduces overall yield. Studies report respiration losses of one to seven percent of dry matter (DM) yield. Plant sugars provide an important food source to the microbes, responsible for proper fermentation. Therefore excessive losses of sugars during the drying process have the combined impact of reducing yield and quality while also increasing the risk of improper fermentation.

Respiration losses can be minimized by shortening the time mowed hay remains in the windrow prior to harvest. One of the most significant management factors to control this is maximizing windrow width to allow as much exposure to sunlight as possible. Windrows should be a minimum of 80 percent of cutter bar width and preferably more.

Other factor to consider include;

- *No conditioning*. Some studies show this speeds the silage drying process, though it is not recommended for dry hay. It also tends to be more beneficial in alfalfa than grass.
- *Increase cutting height*. Increasing cutting height comes with the tradeoff of leaving more material in the field but can result in higher quality and less harvest losses, particularly in the spring when the soil is still damp, which slows drying.


Photo credit: Joe Lawrence.

Speeding the drying process has the additional benefit of reducing weather associated risk. Dry matter losses from hay rained on in the windrow are reported to range from three to 50 percent, with as little as 0.2 inches to 2.0 inches, respectively.

HAY CROP - LEAF LOSS

Particularly with legumes, leaf-loss through tedding, raking, and harvesting can be significant, reducing both quality and yield. Losses are generally most significant when the crop becomes too dry prior to the completion of these tasks. Practices to encourage uniform and rapid drying of the windrow, as well as proper setup of hay handling equipment will minimize these losses. Finally, harvesting at the correct DM minimizes losses. Particularly when chopping forages, losses in drier hay crop silage can add up, but can also exist when baling.

TRANSPORTATION LOSSES

Losses during the transportation process may seem insignificant, however, they too can add up, particularly in drier silages and when transported at higher speeds as is more common with the increasing use of

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Forage opportunities to combat rising costs, *cont'd from page 9*

trucks. Additionally, theses losses can create safety and public perception concerns when forages blow onto roadways. Evaluate the use of forage box covers to minimizes these losses.

Storage

After managing the hurdles to get the maximum yield and quality out of the field, storage represents the next challenge and opportunity. Managing these opportunities starts as soon as the forage is delivered to the storage, and continues through feedout. Horizontal silos (bunk and drive-over piles) continue to gain popularity given their logistical advantages for large quantities of forage but can also present the most challenges to maintain forage quantity and quality.

FORAGE DRY MATTER

Ensiling within an accepted DM range can aid the fermentation process. For most silages, a forage DM close to 35 percent is suggested to optimize yield, quality, and fermentation. While it is possible to achieve proper fermentation over a range of DM content, being too dry or too wet significantly increases the risk of something going wrong in the fermentation process. Further, storage structure can impact the optimum DM range with a slightly greater DM generally favored for upright silos and baleage.

EXCLUDING AIR AND WATER

Air and water are essential to life but are enemies of forage fermentation. In all fermented forages, focus should always be on achieving high silage densities to exclude oxygen and maximize the quantity of forage stored within a storage.

FERMENTATION OF LEGUMES

Legumes present additional challenges to achieving optimum fermentation. Legumes tend to be lower in plant sugars than grass, and also have a greater buffering capacity, which makes it more difficult to drop the pH to desired levels. Additionally, hay crops and specifically legumes can be more difficult to spread into thin layers and adequately pack into a horizontal silo. Understanding these added challenges can help ensure steps are taken to mitigate them.

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Technology makes on-farm research easier: Single-strip spatial evaluation approach (SSEA)

Subhashree Srinivasagan, Manuel Marcaida III, Sunoj Shajahan, and Quirine Ketterings

On-farm research is a great way for farmers to discover if a management change will benefit yield, increase the quality of a crop, reduce the environmental footprint, enhance soil health, or has other benefits. In on-farm research, farmers conduct experiments in their own fields, using their soil conditions, farming practices, and resources. This creates a real-world, practical condition and can be initiated by a farmer, scientist, industry, or any combination. Additional benefits are obtained when more farms conduct the same type of research and findings are shared for peer-to-peer learning. When shared with researchers, this can lead to larger datasets that may allow for extrapolation of findings across multiple farms, regions, years or growing seasons, and the development of statewide guidance that can advance practices and policy.

RESEARCH APPROACHES

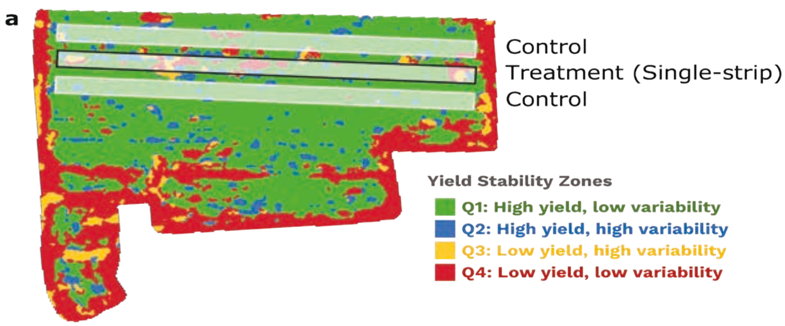
Conventionally, most on-farm research has been carried out using a randomized complete block design (RCBD) approach, using either smaller plots and field-length strips (strip trials). In this approach, typically the control or business-as-usual is compared to a change in management treatment in alternating strips, and these strips are replicated three to four times (or more where feasible). A single yield value is collected from each strip using truck or farm scales to determine the yield per strip. The results are then compared using analysis of variance (ANOVA) to show if there was a statistical difference between the management change (treatment) and business-as-usual (control) strips. This method of conducting on-farm research is scientifically valid but has limited statistical power. Further, it also presents challenges to farmers and researchers as it takes up space in the field and can be logistically demanding to implement and harvest. This has discouraged farmers from participating in on-farm research. Can we do better?

TECHNOLOGY ADVANCEMENT

As precision agriculture has rapidly advanced over the past decade, more tools

FIGURES 1A AND 1B

Single strip evaluation approach (SSEA) (a) yield stability zone map with treatment and control strips; and (b) confidence table for treatment yield response in each zone.



b

Yield response (tons/acre)	Q1 (%)	Q2 (%)	Q3 (%)	Q4 (%)
≤ −1.00	0	0	0	0
≤ −0.75	0	0	0	0
≤ −0.50	0	0	0	0
≤ −0.25	1	1	0	0
≥ 0	97	95	100	100
≥ 0.25	90	85	100	100
≥ 0.50	76	65	99	100
≥ 0.75	55	40	95	98
≥ 1.00	33	19	87	92
≥ 1.25	15	6	71	79
≥ 1.50	5	2	49	59
≥ 1.75	1	0	27	36
≥ 2.00	0	0	12	17

High (81 % - 100 %); Somewhat (61 % - 80 %); Neutral (41 % - 60 %); Low (21 % - 40 %); Not confident (0 % - 20 %)

have become available enabling farmers to conduct on-farm research much easier. Among the most popularly adopted by farmers is yield monitoring technology, which allows generation of yield maps as crops are harvested. Such yield information, when properly cleaned post-harvest, can then be used to evaluate experiments without the slowdown and coordination challenges that often come with weighing harvest trucks/wagons. But, there is more!

With accurate yield data, a farmer can now obtain yield-based zone maps that show where yield is consistently high or low, and variable or stable across growing seasons. Yield-stability based management zone maps are practical, and the maps are easy to understand since the concept is based on a key factor of interest: yield. It recognizes that yield varies from year to year, and zones are farm-specific. For each farm, there will always be areas in fields that yield below and above average. Specifically, in non-irrigated agriculture, there are also stable yield areas and areas where weather greatly impacts yield over time.

Yield stability zone maps can be derived for fields with three or more years of yield monitor data **(FIGURE 1A)**. Farmers who participate in the statewide corn yield project conducted by Cornell University's Nutrient Management Spear Program (NMSP), obtain maps where areas in fields are classified as one of four zones: Q1 are areas that are consistently yielding higher than the farm's average yield; Q2 also has a higher yield than the average but is variable across years; Q3 are areas that are variable and low-yielding; and Q4 is consistently low-yielding areas (NMSP Factsheet #123). When plotted on a map **(FIGURE 1A)**, zones are denoted as green (Q1), blue (Q2), yellow (Q3), and red (Q4). In this approach, the crop itself becomes a "bioindicator" of productivity.

So, we can generate zone maps but how to manage these zones?

SINGLE-STRIP ANALYSIS

Using high-resolution spatial yield data (typically collected at one-second intervals) from yield monitor sensors, variability caused by soil, climate, and other environmental factors is captured and questions about zone-based management can be answered. Do I need to fertilizer areas in Q1 more or less than in Q4? Should I change population density according to zones? Is sulfur limiting productivity in any of our zones? What could be limiting production in Q4?

Here again technology comes in place. With advanced spatial statistics we can now combine information about zones with yield data for the current year and conduct on-farm research using a single-strip treatment design (NMSP Factsheet #124). In this new approach, a management alternative is applied in a strip that goes across the field while the rest of the field is considered business-as-usual or control **(FIGURE 1A)**. A single-strip approach is much more accessible in terms of space and time to implement than the RCBD design. With the single-strip approach, any two-treatment research question (with versus without, high versus low, late versus early, etc.) can be evaluated. A spatial model known as the single-strip spatial evaluation approach (SSEA) was developed to determine our confidence that the management alternative benefited yield. The SSEA results are presented as a confidence table, which represents the level of confidence in the estimated average yield response in each of the zones where the strip was placed in. For example, the highlighted section in the confidence chart **(FIGURE 1B)** shows that we are highly confident in a minimum yield increase of one ton/acre from the

Continued on page 12

EVOLVING TO KEEP PACE

Technology makes on-farm research easier: Single-strip spatial evaluation approach (SSEA), *cont'd from page 11*

management alternative for Q4 (92 percent) and Q3 (87 percent), but have low confidence for Q1 (33 percent), and no confidence for Q2 (19 percent) that year. Such single strip trials can be implemented in multiple fields and combined across fields, as well as years, to draw conclusions for farm management changes.

A farmer can select where to place the strip within a field or across multiple fields if the research provides answers for zones of interest (Q1, Q2, Q3, and/or Q4). Longer strips are preferred as greater length means more datapoints to compare. The strip width should be two to four chopper or combine widths, but is also partially determined by the width of equipment used (manure spreader, side dress N boom, etc.). To the left and the right of the treatment strip are control or business-as-usual. Therefore, care should be taken that adequate space is allocated and that control strips are not near the field edge. Multiple strips can be placed in a field, provided enough space for control strips between treatment strips.

IN THE FUTURE

Not all farmers have access to harvesters equipped with yield monitor sensors and equipment can break during harvest. In addition, yield data cleaning remains a tedious process, but if not done properly, both zone maps and single trial results can be incorrect.

Much work is ongoing to evaluate remotely sensed data obtained with drones and satellites for their use to accurately estimate yield and generate yield stability zones. The sensors capture spectral signature (color and infrared bands) used to calculate vegetation indices that help understand plant health and crop growth status. The remotely-sensed data, combined with weather and soil information, is being explored for their ability to accurately estimate yield. While drones cover a smaller area, satellites can cover a large area in a short time. Satellites are not created equal as they have different spatial and time scales. Also, satellite data is highly dependent on cloud coverage which can restrict data quality. However, over the last 10 years, the revisit time for satellites has greatly improved. This also opens up a window to explore if single-strip analysis can be done remotely, in the hopes that on-farm research using single-strip approach becomes accessible to all farmers and not just those with access to yield monitor systems.

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Herbicide-resistant weed management strategies

Mike Hunter

Photo credit: Mike Hunter.

According to the International Survey of Herbicide Resistant Weeds, there are currently 515 unique cases (site of action x species) of herbicide resistant weeds globally. This organization also reports that weeds have evolved resistance to 21 of the 31 known herbicide sites of action and 165 different herbicides.

One or more herbicide resistant weed specie can be found in every state in the Northeast and are present in major crop production areas across the country. Herbicide resistant weeds are not new. In 1977, a population of triazine resistant common lambsquarter found in a New York corn field was the first confirmed herbicide resistant weed in the Northeast. The list of herbicide resistant weed cases throughout the Northeast continues to grow as time goes on. Populations of horseweed (marestail) with resistance to both glyphosate and acetolactate synthase (ALS) herbicides are rapidly expanding. Herbicide resistant Palmer amaranth and tall waterhemp are found in the Northeast with reported cases of populations resistant to glyphosate, atrazine, and ALS herbicides.

This situation has prompted refinements to control recommendations for these multiple resistant annual broadleaf weeds in field corn, soybeans, and wheat. Triazine, glyphosate and ALS herbicides have played, and will continue to play, an important role in field corn weed control programs. However, effective control programs for these resistant strains will involve the use of crop rotation and cultivation along with herbicide rotation and/or use of herbicide combinations that include herbicides with different sites of action (SOA). The SOA is the location in the plant where the herbicide acts or has its effect on the plant. These practices will also delay development of weed populations to these and other herbicide groups.

The first line of defense for herbicide resistant weed management is knowing what weeds are present - proper identification and frequent monitoring of weed populations for early detection of any potential resistant weeds present. If resistant weed populations are identified early, it provides growers an opportunity to contain and minimize the spread to additional acres across the farm operation.

Start clean, stay clean, control emerged weeds prior to planting the crop

This can be achieved by using either tillage or a preplant burndown herbicide. This reduces the risk of not controlling the weeds after the crop has emerged. Once the crop has emerged, many of our effective preplant burndown herbicides are no longer an option to use. Utilizing practices that maintain weed-free fields, such as the use of soil residual herbicides or inter-row crop cultivation, reduces the chances for additional weed seed production.

MINIMIZE HERBICIDE SELECTION PRESSURE

Minimizing herbicide selection pressure on the weed populations is an effective strategy to delay the development of resistance. Rotating herbicides with different sites of action and the use of tank mixes or sequential applications that involve herbicides with different sites of action are key elements in herbicide resistance management plans. Emphasis should be placed on using herbicides with different sites of action in the tank mix. For this strategy to work, there must be products with at least two different sites of action that are effective on the targeted weed.

To do this most effectively, everyone involved in decisions about weed management must have site of action classification for the herbicides readily available. The Weed Science Society of America (WSSA) has approved a numbering system to classify herbicides by their site of action (Mallory-Smith, C.A. and Retzinger, E.J. 2003. Revised classification of herbicides by site of action for weed resistance management strategies. Weed Technol. 17:605-619). In this system, a group number is given to all herbicides with the same site of action. Take Action has a very handy SOA(s) herbicide lookup tool app found at: iwilltakeaction.com/app.

CROP ROTATION

Crop rotation can be another effective herbicide resistant weed management tool. Planting different crops allows for rotation of herbicides with different sites of action, reducing the weed's exposure to the same chemistry in consecutive years. Diversity of crops in the rotation that have different planting dates, uses, and harvest schedules can disrupt the weed life cycle and competitiveness. For example, perennial forages crops such as alfalfa and grasses suppress many of the annual weeds. Multiple harvests of these forage crops during the growing season prevents many of these annual weeds from producing any seeds. Planting a winter cereal crop or other fall-planted cover crop is an effective strategy to suppress horseweed growth. It works best if the crop is planted early enough to provide the necessary biomass to suppress the emerging horseweed.

PREVENTION

Prevention is the most overlooked weed management strategy. The easiest way to control weeds is to not let them get established on your farm or in your field. Cleaning equipment to prevent the spread of weed seeds is an important weed control strategy. When harvesting a field with patches of resistant weeds, try to begin in the cleanest area of the field before harvesting the areas where the resistant weeds are present. If there are fields on the farm without resistant weeds, harvest those first and save the most infested fields for last.

Purchasing used farm equipment from other states or areas with known herbicide resistant weed, such as tall waterhemp and Palmer amaranth, is a documented way to import new weeds to the farm. To demonstrate how weed seeds can be moved via combines, Cornell Cooperative Extension North Country Regional Ag Team field crop specialists worked with a grower that recently purchased a used combine from Illinois. It has been previously documented that combines can contain approximately 150 pounds of biomaterial (chaff, grain, weed seed). Prior to its use on the farm, the combine was thoroughly cleaned, the biomaterial was screened multiple times, and weed seeds were sorted out individually by hand. Approximately 97 percent of the weed seeds collected from the combine were tall waterhemp, a weed currently not found on this grower's farm.

Using diverse weed management techniques to prevent or slow the spread of herbicide resistant weeds is extremely important. Once herbicide resistant weeds become established on a farm it requires changes in management practices and weed control costs will be increased.

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EVOLVING TO KEEP PACE

Northeast dairy and the circular economy

Olivia Godber, Kirsten Workman, and Quirine Ketterings

It is well-established that the dairy sector provides essential livelihoods and vital nutrition to billions of people, and that the dairy sector is dedicated to addressing sustainability challenges. Current conversations about dairy sustainability include terms like circularity, regenerative agriculture, and carbon footprint. What is that all about?

WHAT IS A CIRCULAR ECONOMY?

Traditionally economies are linear, starting with raw materials that are made into products that are used and eventually become part of a waste stream. In a circular economy, one looks at the bigger picture, takes into account the whole system, and tries to form a closed loop, keeping materials, products, and services in circulation for as long possible. A circular economy is based on three main principles: to eliminate waste and pollution, to circulate products and materials, and to regenerate nature. This concept strives to reduce environmental impact, while improving financial and social aspects of production, including agricultural production.

One illustration of a linear versus circular economy within an agricultural system is the application of nutrients. A linear example is applying fertilizers mined from the earth or manufactured through industrial processes to crops that feed animals and produce manure that is not recycled back onto the cropland. In comparison, use of livestock manure to fertilize crops that are fed to livestock and produce more manure to apply to cropland and continue the cycle are a circular economy. **(FIGURE 1)**

Dairy farms can have various degrees of circularity, often influenced by their location and availability of local resources, including manure, land for feed production, climate, water availability, contractors, and equipment. Farm management and decisions on how to use these resources can also greatly influence the degree of circularity on a dairy farm.

SUSTAINABILITY BENEFITS OF A CIRCULAR ECONOMY

Circular economies are strongly encouraged in all industries because of their sustainability benefits. A circular economy can help lower greenhouse gas (GHG) emissions through shorter supply chains, reduced transport needs for inputs and waste materials, reduced processing needs and use of energy, fuel and other raw material, and reduced use of end-life of products.

In dairy systems, many of the beneficial and protective management practices adopted by farmers already reflect principles of a circular economy and improved sustainability. This includes practices such as use of cover crops and subsequent reductions in nitrogen fertilizer use, injection of manure to capture more of its nutrients, and reducing tillage intensity to protect soil and soil carbon. Positive results of these efforts are seen in water quality, soil carbon sequestration, and overall resilience of the agriculture system and nature. Further, good management of feed storage on farm to avoid waste through spoilage and feed refusals, and animal husbandry practices that promote good animal health and welfare to reduce the need for veterinary inputs, milk disposal and animal culls, all follow the principles of a circular economy.

HOW CIRCULAR IS THE NORTHEAST DAIRY INDUSTRY?

The Northeast region of the U.S. has a high potential to achieve an advanced circular economy. Why?

The dairy industry in the Northeast takes advantage of a local climate that allows for production of high-quality forages with natural rainfall, resulting in production of significant amounts of home-grown feed for dairy cattle. A recent assessment of whole-farm nutrient mass balances of dairies in the Northeast showed that 70 percent of the feed fed on the dairy farms that completed the assessment between 2016 and 2018 (Ros et al., 2023) was homegrown, and almost all this feed was forages such as corn silage, alfalfa, and grass.

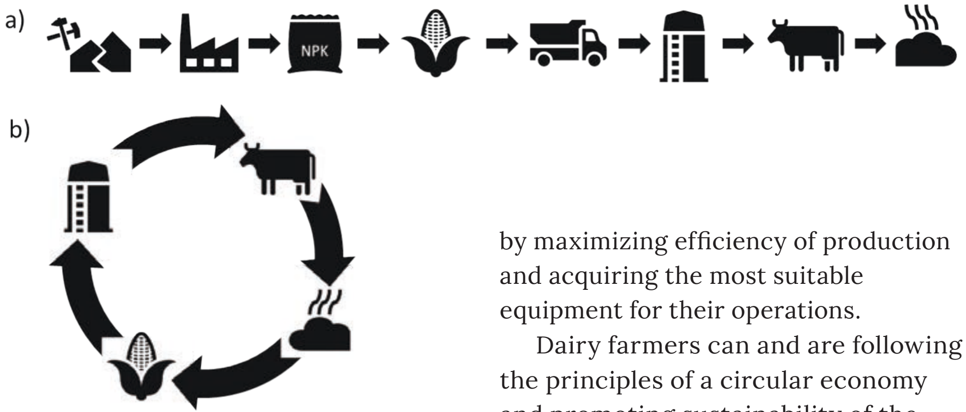
The land base associated with dairy farms in the Northeast allows for a relatively low number of animals per acre of land (animal density), and that ensures the ability to recycle the nutrients excreted by the manure of these animals both locally and responsibly.

This integration of animal and crop production has multiple benefits. A most relevant benefit to a circular economy is reduced reliance on synthetic fertilizers. This integration helped dairy farms in the Northeast who conducted whole farm nutrient mass balance assessments between 2016 and 2018 to achieve fertilizer application rates that averaged just 3.8 lbs. per acre for phosphorus, and 57 lbs. per acre for nitrogen (Ros et al., 2023). In disconnected animal and crop regions, the principles of a circular economy are much more difficult to achieve.

Despite producing most of their feed at home, dairy farmers in the Northeast still need to import some feed, mainly protein and energy sources to balance cow diets, and optimize cow health, efficiency, and milk production. Yet, there is a tendency for farmers to source these products regionally where possible. There are several examples of successful relationships between dairy farmers and corn grain and soybean

FIGURE 1

An example of a linear economy (a) versus a circular economy (b) within an agricultural system.



growers in the Northeast, which allows for local sourcing of cornmeal, soybean meal, and other feedstuffs in addition to local recycling of manure nutrients. While the incentive behind these practices make sense financially, they also follow the principles of a circular economy, benefitting the circularity and sustainability of both the dairy industry, and the related industries.

In addition to utilizing locally produced feedstuff, many dairies in the Northeast utilize both waste and by-products from other local industries such as whey, distillers' and brewers' grains, oilseed meals, candy and bakery waste, and others. This too contributes directly to the circular economy, by avoiding the landfilling of products that can be converted to milk by cows.

Efficient use of equipment is important in a circular economy as well. It is now becoming increasingly popular for farmers to make use of contracting companies for the field activities associated with homegrown feed production (such as manure spreading, planting, and harvest), in contrast to every farmer purchasing their own machinery for every task. This reduces the amount of raw materials required to build and maintain equipment and the amount of equipment that needs to be disposed when it reaches the end of its useful life, again following the principles of a circular economy. Farmers who do choose to purchase and operate their own machinery can still contribute to a circular economy by maximizing efficiency of production and acquiring the most suitable equipment for their operations.

Dairy farmers can and are following the principles of a circular economy and promoting sustainability of the dairy industry for their region. Many of these practices have the potential to not only reduce the environmental impact of dairy production, but also improve financial and social aspects on individual farms, and across the region. ▮

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WHAT CAN YOU DO TO PROMOTE A CIRCULAR ECONOMY AND SUSTAINABILITY ON YOUR FARM?

1. Maximize homegrown feed and high-quality forage production and storage.
2. Capitalize on the nutrient and biological value of manure.
3. Utilize locally available resources, including waste and by-products for both feed and energy production (anaerobic digestion).
4. Establish relationships with neighbors for feed imports and manure exports.
5. Adopt beneficial and protective crop management practices, such as cover crops, manure injection and reduced tillage to protect soil, water, and air quality.

UPCOMING PROGRAMS

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- Connecting the Dots – Particle Size, Fiber Digestibility and Cow Performance | Dr. Luiz Ferraretto, University of Wisconsin
- Impact of Heat Stress on Northern NY Dairy Farms with Varying Heat Abatement – What the Cows Told Us | Katie Ballard, Miner Institute
- US Dairy Outlook: Opportunities, Challenges, and Outlook | Lucas Fuess, Rabobank
- Comparison of Crossbreds with Holsteins for Confinement and Pasture Production Herds | Dr. Glenda Pereira, University of Maine

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