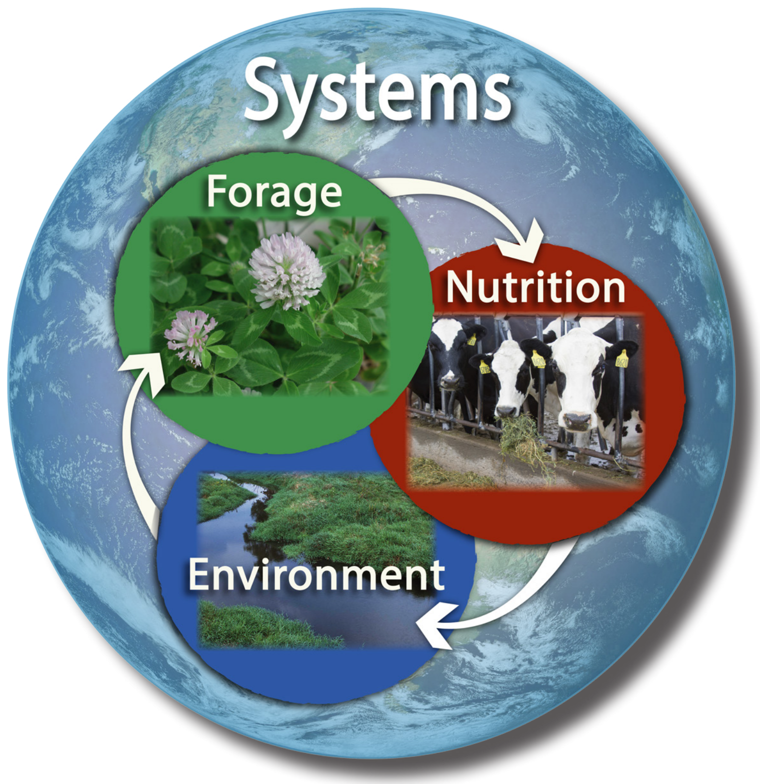
United States Department of Agriculture

U.S. Dairy Forage Research Center

In the News



September to November, 2016

Are you an ecologist?

Mark Boggess for *Progressive Forage*

AT A GLANCE

Yield does not increase in a vacuum in an agricultural system, so understanding the drive for increased yields will also require understanding the sustainability of such practices and measuring the effects of any practice.

How many of you in the farming and ranching world consider yourself to be an "ecologist?" Loosely, Webster defines an ecologist as someone who seeks to better understand "the relationships between a group of living things and their environment." So what does that mean for all of us in agriculture?

A conventional "farmer" description for an ecologist might be someone who strives to understand the relationships within plant and animal production: the environment (climate, weather, management and animal housing) and the short-term economic realities on the farm. In other words, understanding how all of these factors work together to determine farm productivity and, ultimately, profitability would be an accurate description. By that definition, you are an ecologist.

However, for those of us who work on agriculture research priorities that provide scientific solutions to the farming community, the concept of an ecologist is a bit novel. I say that because, traditionally, scientists have focused on "reducing" a scientific question down to a bite-sized piece; for example, how much does yield improve on this acre when I increase nitrogen (N) applied by 10 pounds? This kind of science has been very successful and has led to extraordinary improvements in agricultural productivity, albeit not always in favor of environmental sustainability, water quality, soil health, productivity or profitability.

To truly understand the ecology of an agricultural system requires developing an understanding of the relationships and interplay of hundreds or even thousands of variables which describe complex biological systems.

Using the example above, what are the impacts or implications associated with increasing the level of N applied to an acre of crop produced in addition to yield? Let's assume that adding an additional 10 pounds of N significantly improved yield on that acre, far in excess of the cost of the N applied. The yield increase is an economic driver in that the yield advantage will stimulate the use of 10 pounds of N supplementation industry-wide.

This is a result farmers will readily embrace and adopt without question as long as the N price and yield value improves profitability. In fact, most producers will be forced to adopt this practice to remain competitive. But what are the ecological implications of the additional 10 pounds of N and the resulting increase in yield? When you ask that question, you will find few answers, but you will find many more questions, such as:

- How does the additional N affect soil erosion, soil structure, soil mineralization, organic matter, water-holding capacity, pH and the microbial communities?

- How does the additional N affect water quality – N leaching and runoff?

- Will the increase in crop yield promote additional annual production in rotational systems versus monoculture, across climates and soil types, for perennials versus annuals? And how will it influence biological diversity?

- How will the increased yield impact the utility of the harvested product? For example, will the higher yield affect digestibility and nutritional value of the product for people or animals, what effect will it have on rumen or gut microbial communities, what effect will it have on animal or human health and well-being – or methane emissions?

Illustration by Kristen Phillips.

You get the point: Yield does not increase in a vacuum in an agricultural system.

The new reality is: Society is now asking these questions and expecting answers from the agricultural community. All around the world, consumers are taking a much more proactive approach to understanding where their food comes from, how it got to their plate, and what were the social, animal and environmental costs. Your soils and natural agricultural resources increasingly are being linked to the sustainability and even the survivability of the planet. More specifically, soils are now considered a "public resource" by many, and policies directing soil management and conservation are being considered to protect the "common good" without your input.

Clearly, there are lots of questions. So how do we find the answers to best understand and optimize complex integrated agricultural systems?

The first step is to better understand and embrace the complexity, the complex associations, relationships and trade-offs that dictate the productivity and sustainability of agricultural systems – in our case at the U.S. Dairy Forage Research Center, integrated dairy forage systems. Of course, we have all been doing that to a degree all along, but we now must better appreciate the complexity of these systems on a landscape scale or a scale that represents – or can be applied to – regional, national or even global ag systems.

Just how complex are these systems? Let's start with systems we know the least about – the microbial communities in the soil, in the cow's rumen and gut, and in other places of agricultural relevance. Recently, I heard an estimate that 99.9 percent of all the organisms that currently reside on planet Earth have not yet been identified, and 99 percent of those not yet identified are microbes. Another perspective: One estimate is that the human gut contains, on average, 40,000 bacterial species, over 9 million unique bacterial genes and 100 trillion microbial cells, and only 1 percent of these bacterial species have been identified. Contrast the fact that the human gut hosts over 9 million unique bacterial genes with the fact that the human genome has only about 20,000 genes, and you begin to understand exactly how much we do not know about microbial ecology in the human (or cow).

As a geneticist by training, I frequently ask this question of scientists and stakeholders: "On a scale of 1 to 100, where 1 is Mendel's original understanding of pea genetic inheritance, and 100 is a perfect understanding of all the genetic, genomic, epistatic, proteomic, metabolomics, epigenomic and other 'omic' effects that define an individual, where are we now?" In other words, how far up the scale of understanding are we from 1 to 100 percent? The most common answer I get from informed experts is 5 to 10 percent. We are just now learning all of the parts of the equation. A complete understanding will take many more years. Microbial systems are even more diverse and

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complex by several magnitudes.

So what can we do to get started?

In agriculture, we have been managing "phenomenon" since the first crops were planted. From the beginning, we knew that manure or organic matter improved yield as a soil amendment. The how and why really didn't matter. To this day, we manage crop and livestock production systems without a true understanding of exactly how all of the soil, plant, microbial and animal factors work together, and as evidenced by the green revolution and remarkable improvements in crop and animal productivity, we have been very successful, albeit again with some significant sustainability concerns.

Our challenge now is: We need another green revolution if we are to feed 9 to 10 billion people in 2050. To meet this challenge sustainably, we will need a much better understanding of the complexity and integration of agricultural systems. We will have to much better understand and quantify the trade-offs and points of optimization that match resources to productivity while providing ecosystem services and improving soil health and quality. Optimizing or improving any agricultural system starts and ends with soil health, and that's where we feel the low-hanging fruit may reside.

For example, what is the value of improving soil organic matter by 0.25 percent annually over time with a cover crop or perennial cropping system? What is the value of improving soil ecology through improved soil mineralization, improved structure and water-holding capacity or improved erosion control? We all know these functions contribute to farm productivity and profitability, but it is very difficult to quantify and assign a real value to these functions.

In the USDA Agricultural Research Service, we have determined that, on average, for every 1 pound of corn grain harvested in the upper Midwest, we lose 1 pound of top soil. To me, that sounds like a lot and is clearly not sustainable. But how does that rate of erosion vary for corn silage or soybeans or alfalfa hay? And what is the long-term economic value of that 1 pound of lost soil? Until we understand these factors better, we will not be able to perfect or optimize agricultural systems.

Where do we go from here? At the U.S. Dairy Forage Research Center, we just hired an ecologist. We may hire another one very soon. We have a lot of work to do.

References omitted but are available upon request.

Optimizing Oats for Use as Dairy Forage

Wisconsin dairy producers are increasingly adopting a practice that makes economic and environmental sense: raising oats in the fall as forage for their cattle.

Dairy producers plant the oats in early to mid-August and either allow them to be grazed through late November or harvested as silage in early November for later use. The strategy allows production of an additional forage crop before winter. The oats also “scavenge” excess nitrogen from the soil, and the plant residues enrich the soil.

Fall oats also are usually planted after the harvest of cereal grains, such as wheat or cereal rye, or in fields where alfalfa, which is harvested every 28 days, has been killed off. “Either scenario gives producers a window in late summer that’s important from an environmental perspective, because it allows them to spread manure stored in reservoirs onto their fields during a time period other than the spring or fall hauling opportunities bracketing corn production,” says Agricultural Research Service (ARS) dairy scientist Wayne Coblentz, who is with the U.S. Dairy Forage Research Center and is based in Marshfield, Wisconsin.

Dairy producers, however, need guidance on when to allow their cattle to start grazing the fall oats and which oat cultivars to use. If they allow cattle to graze forage too early, the heifers quickly eat up whatever is available and get less forage than if the oats were given more time to grow. Putting cattle out to graze later in the fall means running the risk of inclement weather and losing oats under snow cover. Producers also need guidance on optimal cultivars. Some mature earlier than others. When oats reach full maturity, they can become coarse and have more fiber, so that cattle digest them more slowly and less extensively, and they usually eat less.

Coblentz and his colleagues planted two types of oat cultivars (an early- and a late-maturing variety) in August and put dairy heifers out to graze for 6 hours a day at two different starting dates: in late September and mid-October.

They weighed the cattle at the beginning and end of the grazing periods and evaluated the content of the oats for their nutritional value and the amount of forage mass produced. Cattle weight gain was compared with that of a control group kept in barns. Whenever the weather was unsuitable for grazing, all heifers were fed in the barns. The animal care and handling procedures were approved by a University of Wisconsin oversight committee.

After 2 years of grazing, the results showed that it’s better to put the cattle out early in the fall rather than later, and it often is better to use late-maturing cultivars. The heifers allowed to graze early gained twice as much weight per day as the heifers started about two weeks later. The late-maturing oat variety also produced higher quality forage, with more leaves, greater energy density in the plant stems and leaves, and greater concentrations of water-soluble carbohydrates to support cattle growth. The heifers also consumed more of it. Results published in the *Journal of Dairy Science*

Key Facts

- Wisconsin dairy producers are increasingly growing oats in the fall for cattle feed.
- Producers need guidance on grazing strategies and oat varieties.
- ARS guidelines are based on yield, oat nutritional value, and cattle weight gain.

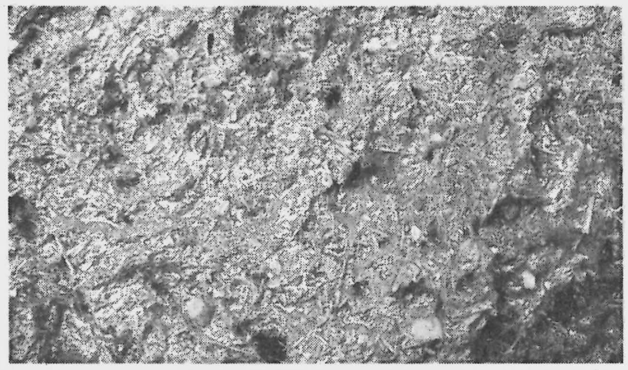
Full Story

Additional Information

Scientific Contacts

Research Links

Diarrhea is a sign of ruminal acidosis and digestive upset, or eating spoilage. It can also be caused by disease.



Eaten does not mean digested. Seeing this much grain in manure isn't normal. Farmers should question whether grain needs a finer grind, or whether forage feeding and particle size are adequate.

Foamy abnormal manure,shown here, should not be confused with manure that's watery because cows are consuming grass-legume pasture.

Manure looks the way it does for a reason

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Normal manure from lactating cows is soft but formed.

MADISON, Wis. – What connection does manure have with forage?

Plenty, said U.S. Dairy Forage Research Center dairy scientist Mary Beth Hall during a Dairy Forage Seminar at World Dairy Expo earlier this month in Madison.

"(Manure) doesn't just happen," she said.

Evaluating manure can tell producers a lot about what's going on with their cows and the forage rations they're being fed. The physical forms of the various feeds being fed make a world of different to the cow. And the aim for forage fiber is that it's the right chop length to be physically effective. It needs to enhance rumen function, increase rumination, enhance rumen retention and slow passage, as well as reduce the risk of digestive upset and allow the ration to work the way it was intended.

Larger forage particles make a mat in the rumen that holds feeds in the rumen.

"The longer time in the rumen gives more time for rumination and fermentation to digest feeds and break down particles," Hall said. "This affects the size of particles we see in manure. Finer particles are trapped in the rumen mat to be digested."

Hall reviewed the location where feed digests. The rumen, via fermentation, is the primary site for crude protein and carbohydrates – neutral detergent fiber and non-fiber carbohydrates. The small intestine, with its enzymic digestion, is the site for true protein, starch and lipids. The cecum and large intestine – also referred to as the hind gut – is another fermentation compartment to deal with crude protein and carbohydrates – neutral detergent fiber and non-fiber carbohydrate. Where the feed primarily ferments is important. She said a shift in the site of digestion, from rumen to hind gut or vice versa – changes the nutrient supply to the cow and causes some of the symptoms of ruminal acidosis and digestive upset.

"All that affects what we see here," said Hall, referring to manure deposits on the barn floor. "Looking at manure with an idea of why it might look that way tells producers how the cow is getting along with her ration."

Hall said "the good stuff" is all about consistency. Soft, but formed, cow pies are the type producers want to see from lactating cows. An exception is manure from lactating cows on pasture. Pastured cows are generally eating lots of protein and lots of water from the green feed they're consuming. Their manure will be a lot looser as a result.

What isn't normal? Foamy manure, Hall said. Excess fermentation in the hind gut creates acid and gas. Foamy manure is a clue that feed didn't digest where it should have.

Diarrhea isn't normal either. It's a sign of ruminal acidosis and digestive upset, or that cows are eating spoilage. It can, of course, also be caused by disease. Hall said producers might be more apt to see diarrhea in a cow that picked the short straw, figuratively speaking – the unlucky one that ate a clump of spoiled feed.

Undigested feed – most notably corn – in manure isn't normal either, Hall said.

"Eaten does not mean digested," she said.

She said when producers see a sizeable amount of grain in manure, they should question whether they need a finer grind. But they should also ask: Is their forage feeding and particle size adequate?

"You're not supposed to be able to identify feed that's in the manure," she said.

See **MANURE,** Page D4

Manure

Mary Beth Hall is a dairy scientist with the U.S. Dairy Forage Research Center.

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Being able to pick out whole linted cottonseed or citrus pulp means there's a feed-efficiency issue.

Other not-normal cow pies are pasty, splattered or dry. When manure is overly dry, there likely isn't enough protein or minerals being fed. "Not normal" is also when there is lots of variation in the manure produced, cow to cow within a herd, if they're eating the same ration.

"Except for maybe 5 percent of the cows, cows eating the same diet should have similar manure," Hall said. "If not, are they sorting their feed? Go look.

"Cows have very few hobbies, so they sort their feed."

She said solutions might be to chop forages to 1 to 2 inches, or add brewers grains or molasses to better hold the ration together.

Mucin casts in manure aren't normal either. Hall described mucin casts as looking similar to sausage casings. When in doubt, hosing the manure will expose mucin casts, which can sometimes be as long as 3.5 inches. They can be brown, gray or almost black.

Damage to the lining of the large intestine is what creates mucin casts. That can happen when there is too much hind-gut fermentation. The fermentation acids results in sloughing off of portions of the intestine. The large intestine can repair itself once the ration is remedied so that more fermentation is occurring in the rumen instead.

Seeing fibrin casts – much larger and tougher portions of sloughed intestine – is a clue that the damage to the cow's digestive tract has been much more severe.

"These are a lot tougher in texture than mucin casts, and rarer," Hall said.

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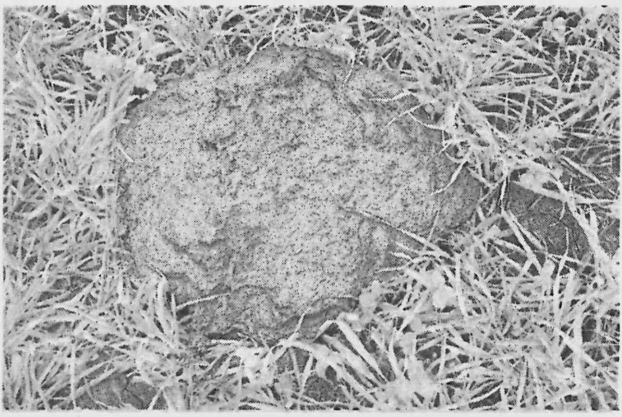

Manure from cows on green pasture will be loose, but this cow pie from a grazing milk cow is still considered to be normal-looking and an indicator of decent digestion.

Washed manure reveals clues

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MADISON, Wis. – Mary Beth Hall, a dairy scientist with the U.S. Dairy Forage Research Center, shares a simple way farmers can better examine forage-particle size in cow manure. It involves using a common kitchen strainer.

Speaking at a forage seminar during World Dairy Expo in Madison, Hall warned that if farmers remove this kitchen utensil from the kitchen that they never return it there. Not only will the chief cook in the family not appreciate it, there's also risk of bacterial contamination and zoonotic disease transfer – even if the strainer is seemingly well washed.

Use a plastic cup to scoop manure and drop it into a strainer with one-sixteenth-inch mesh openings, she said. Use a hose to wash the manure. Keep gently washing the manure until the water runs clean.

See **CLUES,** Page D3

A kitchen strainer is a handy tool to rinse manure, in order to determine the amount and physical form of feed that has passed through a cow.

Clues

Continued from Page D1

Next examine what remains in the strainer. If there are lots of easily identified feedstuffs and lots of long pieces of forage fiber – bigger than a penny – it's probably safe to conclude that something is not working correctly in the cow's gut. There's reduced ruminal retention and digestion that's less than optimal.

The fibrous material should be brown and bleached-out looking; there shouldn't be any identifiable pieces of green grass in the washed manure. Neither should a producer be able to see cottonseed with the lint intact, whole grain or an excess of cracked grain. Forage particles generally shouldn't be bigger than about a half-inch.

Hall suggests walking cows to get an idea of the variation in manure – within groups, between groups and between rations. Sample four to six pies per group for particle size. She cautioned that about 5 percent of cows will have manure that doesn't look like the rest. That's not much of a concern. She said manure sleuthing is qualitative and not quantitative. There's no way to know the amount produced to precisely quantify what a producer samples.

"Manure probably varies somewhat over 24 hours," she said,

Other clues to see if cow digestion is on track is to pay attention to how much dirt, salt or bicarbonate that cows are eating. They will do so when they suffer digestive upset. Further, the cow that holds her tail away from her back end might have a uterine infection – or gut irritation.

Hall said heat stress also causes digestive upset, so watch for heat-stress signs such as cows panting, decreased rumination, cows drooling, and slug feeding and sorting. Cows will drink a lot more water when it's hot, and their manure will be runnier, but don't use that as an excuse for manure that looks really runny and bad.

The appearance of manure – including fecal-particle size and undigested feed in the manure – is one tool to determine what's happening in the herd. It should be used in combination with keeping an eye on the level of rumination and cud-chewing among the cows, their eating behavior, overall herd health, milk production, and comfortableness and cleanliness of their environment. Also take into account management and cow time budget. Do cows have adequate time to relax in their stalls between milkings so they're ruminating and making good-looking manure?

"Use these together to build a case as to what ration or management changes are needed," Hall said.

Visit www.ars.usda.gov for more information.