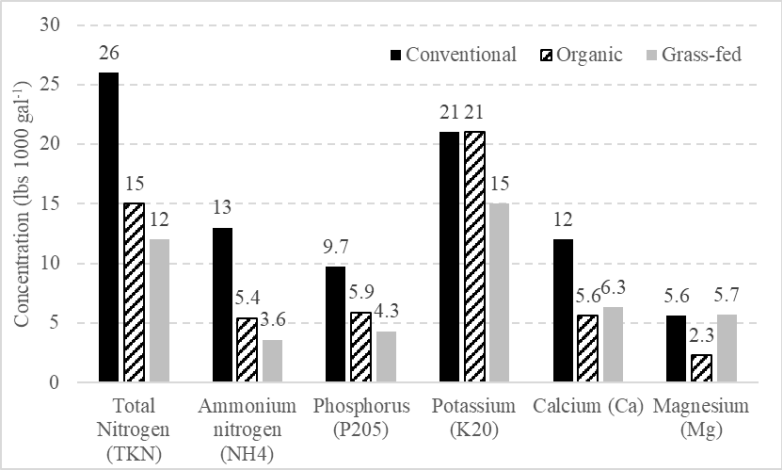
Managing Soil Fertility and Other Lessons Learned on Grass-fed Dairies
By Sara Ziegler, Heather Darby, and Sarah Flack

Grass-fed dairy continues to experience sustained market growth. While this presents opportunities for producers, it can also bring some significant challenges and require shifts in management to be successful. Through a project funded through the USDA Organic Research and Education Initiative Grant (Project no. 2018-02802), Dr. Heather Darby and her team investigated a diversity of grass-fed approaches and strategies that ultimately led to a wide range of productivity and financial viability While each farm is unique in its own ways, several trends have begun to emerge.

Amongst numerous grass-fed farms there were significant challenges in maintaining adequate soil fertility especially when the land base had to expand. Since no grain can be fed, nearly 100% of the diet must come from forages. For an all-forage diet to provide sufficient nutrition to the herd, the soil must be able to provide adequate nutrition to feed the forages. Likewise, the number of acres of land needed to produce sufficient forage quantity will also increase substantially. The average grass-fed dairy manages 5.66 acres per mature cow but ranges from 1.71 to 10.3. In general, farms with larger land bases tend to have higher costs of production, especially regarding expenses related to stored forage production (https://go.uvm.edu/xkovr). Maintaining yields and quality on an expanded land base needs to be recognized as an investment and cost to transitioning to grass-fed dairy. To minimize the number of acres required, farmers should prioritize maximizing yields and digestible fiber per acre.

Generally, most organic farms utilize manure as the major source of fertility for their crops. Some farms also import additional nutrients commonly in the forms of poultry manure, lime, and wood ash (https://go.uvm.edu/fzy04). If transitioning to grass-fed production, it is likely that the quantity and quality of manure produced on the farm will change. Manure production is directly related to milk production and dry matter intake. A farm that once produced 60 pounds of milk per animal per day feeding grain may decline to 30 pounds per animal per day when grass-fed and thus will produce 26 pounds less manure per animal per day.



In addition, nutrient concentrations in manure will change. The less grain fed, the lower the nutrient concentration of the manure. As seen in the figure, dairy animals that are fed conventional diets, which often include higher levels of grain, generally have higher nutrient concentrations in their manure. As farms transition to organic, less grain is generally fed to

animals due to cost, grazing requirements, and changing milk production goals. In grass-fed systems, with no grain at all, nutrient concentrations in manure can drop by 50%. Although grain is a costly input, it helps provide valuable dry matter, nutrients, energy, and protein to cows, supplementing the forage available on the farm. But perhaps less appreciated are the nutrients not utilized by the animal that make their way into the manure and back on to the fields, adding fertility to support forage production. In this way, grain is both a nutritional supplement and a fertilizer.

Grass-fed farms have their work cut out for them. They typically manage more land, produce less manure, produce less nutrient-dense manure, and have access to fewer and more costly purchased fertility sources. However, they also produce, and therefore ship, less milk off the farm. With lower milk production, are these systems able to maintain productivity without nutrients being imported? To help understand nutrient flows on these farms, the concept of Whole Farm Nutrient Balancing can be applied. Whole Farm Nutrient Balancing is essentially like balancing a checkbook of nutrients coming onto and leaving the farm. Farms import (or deposit) nutrients through purchased feed, bedding, fertilizers and other soil amendments, minerals, and imported manures. Farms export (withdraw) nutrients from the farm through the sale of animals, milk/meat, crops, and other products. Issues can arise when there is a severe imbalance between imports and exports, especially over long periods of time. If more nutrients come on to the farm than leave, nutrient levels in soils will continue to rise and ultimately may pose risks to the environment. On the other hand, if more nutrients leave the farm than are imported, soil fertility will decline and ultimately crop, and animal productivity will suffer.

Let's dig into this a bit more with three examples evaluating the whole farm nutrient balance: first of an organic farm, second of a grass-fed farm with purchased fertility, and third of a grass-fed farm with no purchased fertility. In the first example, an organic dairy is feeding grain and buying forage. The farm manages 48 cows with 20 replacements on 105 acres. Exports from this farm are primarily from milk but also some from cull cows and compost sales. As seen in the following table, the farm is operating in a slight nutrient excess, with nitrogen (N), phosphorus (P), and potassium (K) accumulating each year.

Organic Farm Whole Farm Nutrient Balance	N	P	K
Imported (tons) Grain, Baleage, Bedding, Minerals	5.64	1.00	3.57
Exported (tons) Milk, Meat, Compost	2.66	0.45	0.71
Balance (tons)	2.98	0.55	2.86
lbs./hundredweight (CWT)	0.87	0.16	0.84
lbs./acre	56.8	10.5	54.5

Let's compare to a grass-fed dairy with 48 cows, 40 replacements, and 240 acres. Since there are no grain imports, fertility is brought on to the farm in the form of poultry manure. As shown in this example, the

Grass-fed Farm Whole Farm Nutrient Balance	N	P	K
Imported (tons) Poultry Manure, Minerals	0.08	2.06	0.80
Exported (tons) Milk, Cull Cows	1.83	0.34	0.53
Balance (tons)	-1.03	1.72	0.27
lbs./hundredweight (CWT)	-0.32	0.53	0.08
lbs./acre	-8.62	14.3	2.27

quantity of imported nutrients is low and nearly all from the poultry manure. The level of exported nutrients exceeds the nutrients coming on to the farm.

Grass-fed Farm Whole Farm Nutrient Balance	N	P	K
Imported (tons) Minerals	0.00	0.51	0.05
Exported (tons) Milk, Cull Cows	1.83	0.34	0.53
Balance (tons)	-1.83	0.17	-0.48
lbs./hundredweight (CWT)	-0.57	0.05	-0.15
lbs./acre	-15.3	1.41	-3.98

chart 4Finally, if the same grass-fed farm does not import the poultry manure, all nutrients are at a deficit. When evaluating whole farm nutrient balances, these types of imbalances can be helpful at times (for example, to draw down high soil P), but long-term draw down of nutrients is harmful to production. Evaluation of whole farm nutrient balances is critical to monitor and balance nutrient flows on the farm.

How to avoid these pitfalls? Farmers should start by evaluating the soil nutrient levels through conducting basic soil samples and calculating the whole farm nutrient balance to develop a baseline. The "Whole Farm Nutrient Mass Balance Calculator" developed by Cornell University is an easy-to-use tool intended to help identify opportunities for improvements on dairy farms. Farmers should monitor yields and fertilize (starting with manure) to achieve realistic yield and quality goals. Fertility needs of forages can be quite substantial, depending on the desired yield. In stands that consist primarily of grass, every ton of dry matter will require 50 lbs. of N, 17 lbs. of P, and 50 lbs. of K. And the more dry matter harvested per acre, the higher the nutrient needs of the crop.

While manure is a complete fertilizer containing all 13 essential nutrients for plants, a grass-fed dairy is unlikely to produce sufficient manure to adequately cover all their acres. Accessing manure from other farms might be a cost-effective option to maintain P, K, and other nutrients. To meet N demands of grasses, legumes should be incorporated into the cropping system. Maintaining mixed stands can produce higher yields of forage and replace the need for supplemental N additions. Practices such as frost seeding or using a no-till drill to add seed on a regular basis can help maintain legume levels. In addition, addressing compaction, increasing soil biological activity, and improving overall soil health will help support these efforts. Although there are many factors and practices that influence forage quality and quantity, soil fertility and health are primary drivers that will require monitoring and investment to be successful with grass-fed dairy.

Through numerous grass-fed research projects our team has recently published Farmer's Guide to Grass-fed Dairy Production! Collectively written by agronomists, animal nutritionists, grazing experts and other practitioners, this guide provides over 50 pages of practical information on managing a grass-fed dairy herd and represents the latest research-based information to date. You can find a copy online at https://www.uvm.edu/extension/nwcrops/grass-fed-dairy or request a paper copy by contacting Sara Ziegler at sara.ziegler@uvm.edu or 802-309-3472.

While we've learned a lot over the last 5 years through our own research and working alongside our wonderful farmer partners, there are still many questions left unanswered and there is much work to be done to support the grass-fed dairy industry going forward. To aid in that endeavor, I'm pleased to announce that our project team has received another multi-year USDA OREI funded research project, titled Enhancing the Viability of Grass-Fed Dairy Production in the U.S. Through Comprehensive Research and Extension (Project no. 2023-51300). The project team includes a range of expertise from University of Vermont, University of New Hampshire, and the USDA.

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In partnership with farmers and industry the project will investigate:

- Best strategies for youngstock management and development,
- Grass-fed farm economics and cost of production,
- Research that evaluates soil fertility options and nutrient cycling on grass-fed farms,
- Research on high energy forages and utilization in grass-fed dairy rations,
- Research on sensory and nutritional quality of grass-fed milk, and
- Expanded educational and networking opportunities for farmers, processors and technical service providers.

This project will begin with survey of all grass-fed dairies in the U.S with a primary focus on youngstock management. If you are a grass-fed dairy producer, keep an eye out for the survey early in 2024!

For more information about this project or how to participate, contact Sara Ziegler at sara.ziegler@uvm.edu or 802-309-3472; Sarah Flack at sarahflackconsulting@gmail.com or 802-309-3714; or Heather Darby at heather.darby@uvm.edu or 802-656-7610.