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# ARE LIVESTOCK AND FORAGES NEEDED ON ORGANIC FARMS?

*Final Research Report E2006-03*

## INTRODUCTION

The sustainability of cropping systems is largely affected by soil nutrient management and crop selection. In organic cropping systems, nutrient management can be a challenge for transitioning farmers because of restrictions in chemical fertilizer use. Soil fertility must be well-managed for production to be sustainable. Generally, organic farmers maintain or enhance soil quality by carefully selecting their rotation crops and recycling nutrients through livestock on the farm. Many farmers, however, do not have livestock on the farm, and some do not include forage crops in their rotation. Farmers are asking "How important is it to have forages and livestock on an organic farm?"

Crop rotations are widely practiced to maintain soil fertility and provide other benefits such as breaking pest cycles. Forage, including legumes and grasses, is a valuable fertility-building crop in rotations because it enhances soil organic matter and nutrient cycling. The number of years of forage in rotation varies among farms, with some farmers using no forage. Many farmers and researchers suggest that forages are an essential part of a sustainable organic farm.

Livestock manure is a valuable resource for on-farm nutrient management. Manure is typically used on organic farms after composting. However, not all farmers have access to livestock. Some farmers grow crops without access to livestock (**stockless** farms) and may argue that the biology of their soil is their livestock. Soil microbiologists indicate that over 1 billion microbes can be found in 1 teaspoon of a fertile soil. This soil biological community can weigh from 1100 to 14,000 kg $ha^{-1}$; a similar weight as 2 to 28 yearling steers!
Other farmers have livestock on their farm which may be classified as **monogastric** (e.g. poultry and pigs) or **ruminant** (e.g. cattle and sheep).

**Forage harvest at Brookside plots, 2003 (K. Liu)**

The food these livestock groups eat, and the manure they produce are different. In particular, we are interested in the kinds of soil amendments that can be returned to the field, and its influence on soil fertility. We need to consider three different fertility management systems: **stockless, monogastric,** and **ruminant.**

Different combinations of soil amendments from livestock systems and forage-based crop rotations are possible. Are these all equally sustainable from a soil quality perspective? Take nitrogen management, for example: on both stockless and livestock farms, the legumes in crop rotations provide certain amounts of nitrogen for the subsequent cash crops by mulching or tilling forage residues into the soil. In cropping systems with ruminant livestock on the farm, nitrogen is recycled. The nitrogen captured from the air by legumes is fed to ruminant livestock, a portion of which can be returned to field in the form of composted manure. Farms without livestock become more reliant on forages (or green manure crops) as a source of fertility. In some systems forages are used as a plough-down or as mulch.

## WHAT WAS DONE?

We established a 4-year study to investigate the sustainability of farming systems with or without forages in rotation, and with or without access to composted livestock manure as an amendment.

In 2002, nine farming systems were established on research plots at the Nova Scotia Agricultural College at Truro, NS and another set with the University of Manitoba at Carmen, MB (only NS results are discussed here). We established three separate rotations to study different levels of forages in a 4-year rotation. The three rotations were:

- No forage - wheat, soybean, barley, potato;
- One year of forage - wheat, barley, forage, potato; and
- Two years of forage - wheat, forage, forage, potato.

We established a separate set of three rotations for each of our three soil amendment systems:

1. Stockless – where alfalfa meal was used as the primary nitrogen source, forages were used for mulch on potatoes and cereal straw was retained on the plots, phosphorus and potassium requirements were met using mineral amendments.
2. Monogastric (in this case poultry-based) - forages were sold for animal feed, cereal straw was removed (for bedding) and composted poultry manure was applied to the field to meet cash crop nitrogen or forage crop phosphorus requirements.
3. Ruminant (in this case beef-based) - forages produced were used as feed, cereal straw was removed (for bedding), and composted beef manure was applied to the field to meet cash crop nitrogen or forage crop phosphorus requirements.

We did not own livestock, rather, we found manure that we composted. The composts and alfalfa meal were applied based on standard soil test recommendations. We measured the total amount of nitrogen in each amendment, and then made assumptions about how much would be available to the plants based on averages in scientific literature: 30% in alfalfa meal, 50% in poultry manure compost, and 25% in beef manure compost.

**Researcher Kui Liu assesses soil moisture in Potato plots (A. Hammermeister)**

In the last year of the rotation, all of the plots were growing potatoes. This way we could measure the effect of the previous three years of management on crop growth and soil quality. Our measurements of crop yield and soil quality are then based on expected optimum practices for each management system. The main differences between the nine systems relate to the number of years of forage in the rotation (and associated factors such as tillage frequency), the kind of amendment(s) that were used, and how the straw and forages were managed.

As mentioned above, we tried to manage the plots to provide enough nitrogen for the cash crops, or phosphorus for the forages to meet soil test recommendations. With organic amendments you cannot separate nitrogen or phosphorus from all of the other nutrients and organic matter. As a result, managing for nitrogen in cash crops and phosphorus in forages resulted in addition of different amounts of organic matter, nitrogen, phosphorus, potassium and other nutrients. We planned to apply amendments to the potatoes according to soil test recommendations; however, we also wanted to see how the management of the first three years affected productivity and soil quality. To accomplish this, each potato plot was split into two parts, one received soil amendments according to soil test recommendation, and the other did not. In this experiment, we tried to give all of the treatments the same amount of nitrogen so that they would have an equal chance to succeed.

Another factor to consider is that these research plots were established on land that had been in long-term pasture; the land had been grazed and manure had been applied in the past. Soil fertility levels were in the medium to high range as a result. This high fertility level meant that we didn't expect to see a big response to the amendments. In fact, there was no benefit from the amendments in year 1 when wheat was grown. The wheat crop in control plots with no amendments performed equally as well as the amended plots and used over 110 kg $ha^{-1}$ of nitrogen in the plant material aboveground. This nitrogen all came from the unamended soil. Standard soil tests may not adequately account for nitrogen availability from forages.

## WHAT HAPPENED?

We had anticipated that plots with forages in the rotation and receiving compost amendments would produce the best potato yield. Lots of research has shown the benefit of forages in a rotation, considering both soil fertility and breaking pest cycles. To our surprise, the potato yields were higher in the rotation with no forage than in the rotations with forages. This may be due to the high background fertility of the soil and the effects of tillage on releasing nutrients in the short-term. Potatoes also need good soil structure in the seedbed; slow decomposition of the sods in rotations with forages may have contributed to a poor seedbed and nutrients may have been slow to release.

**Potato plots in 2005 (K. Liu)**

In the long-term, the benefits of forages are expected to outweigh the tillage benefits as the forages provide good soil fertility and structure. A difference in yield was found between the soil amendment treatments in the one- and two-year forage rotations, but not in the no-forage rotation. The highest potato yields were found in composted beef manure under each forage rotation. Overall, the combination of composted beef manure with a no-forage rotation had the highest potato yields, followed by the combination of composted beef manure with a two-year forage rotation, but the difference between these two was very small.

When considering the benefits of the amendments applied to potatoes, we looked at the amended half of the plots compared with the unamended portion. We saw that there was little difference in the amount of nitrogen the potatoes used. We also found that there was no difference in nitrogen uptake between the three forage rotations. The kind of amendment, however, did influence nitrogen uptake by the potatoes. The highest nitrogen uptake was measured in rotations using composted beef manure and highest above all in the two-year forage rotation receiving beef manure compost.

We may also explain this data in part by looking at the amendments. The beef manure compost was made from typical manure with straw bedding. The monogastric compost was made from poultry manure that was mixed with wood chips and some grass clippings. This compost may not have provided as much nitrogen as was expected because wood is difficult to decompose and the process will tie-up nitrogen. We have seen other studies where alfalfa meal was slow in releasing nitrogen. We are currently testing to see if our assumptions about nitrogen availability in the amendments were accurate.

The lack of differences between the forage rotations may in part be related to the long-term pasture history of the site and resulting high fertility. The forages in the systems with livestock (i.e. ruminant and monogastric) received compost as a source of phosphorus in the year before potatoes. The stockless system, however, received only rock phosphorus.

**Wheat growing at the forage-rotation experiment at Brookside, NS in 2002 (A. Hammermeister)**

Further analysis of the data has shown us that the high nitrogen uptake in the plots with beef manure compost is most likely a result of previous additions of compost in year 3, and less likely a result of applications in year 4. This directly demonstrated that soil amendments had little effect on plant nitrogen uptake in the application year, but significant effects in the following years.

We also looked at the biology of the soil and found that there was no difference among the treatments. This implies that the cropping systems are either still in an ecological balance after three years, or the long-term effects of the pasture are overriding the short-term rotation effects.

## The Bottom Line…

Organic farming systems are a complex subject to study. If land is transitioning from fertile old pasture, the benefits of forage in rotation will not be evident. The benefits of forages come in the long-term.

All amendments are not equal and assumptions about nutrient availability are difficult to make. In this study, composted beef manure produced better results than poultry manure or alfalfa meal. The benefits of the compost, however, may not be seen in the year of application. Applying compost well in advance of the crop that will need it is recommended.


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