Increasing High Quality Hometgrown Feeds for the Organic Dairy Fact Sheet Series

Literature Review:
Soil Fertility Management of Perennial Pastures


Summary: The percentage of dairy farms in Wisconsin and Minnesota that employ managed grazing has increased dramatically over the last 20 years. The primary reasons have been relatively low startup costs and improved profitability associated with pasture-based dairying. A major biological limitation to profitability of grazing dairy operations is low forage intake by grazing cows relative to that obtained in confinement operations. This is related to pasture sward density, seasonal yield distribution and growth rate—all functions of plant species in the pasture as well as management and environmental conditions affecting plant growth. Based on our results, our environment will require several types of pasture to optimize full season production. Genetic advances have been made in both pasture grasses and legumes that allow development of mixtures that are capable of supporting greater levels of livestock performance than currently achieved by livestock graziers. A total of 21 different combinations of improved grass and legume species/varieties were evaluated on two university research stations in WI and MN. Results indicate that best seasonal distribution of yield was obtained with tall fescue, meadow fescue, and orchardgrass, with reed canarygrass intermediate, and smooth brome grass, quackgrass and Kentucky bluegrass demonstrating poor seasonal distribution of yield. Sward height and density were greater in nitrogen fertilized grasses than in mixtures with either Kura or white clover. And yield was also greater in nitrogen fertilized grasses than mixtures with legumes. Mixtures always had greater nutritive value, including greater crude protein and digestibility and lower fiber concentrations. Farmers are aware of the greater forage quality and the biologically fixed nitrogen that Kura clover contributes to pasture systems. They recognize the value of legume persistence, but some have had difficulty with establishment.

In this study of 21 different combinations of forage mixes, sward height, density, and yield were greater in plots with applied nitrogen (200 lb/acre broken into four applications) than in mixtures with legumes. However, mixtures had overall greater nutritive content with higher crude protein and digestibility. “In summary, monoculture grasses with nitrogen fertilizer had greater total season forage production, but addition of legumes improved seasonal yield distribution by improving late season production and forage quality. Tall fescue, meadow fescue, and orchardgrass in mixture with either white or Kura clover provided what seems to be optimum total season yield, yield distribution, sward density, and forage quality among the forages evaluated in this trial.”


Introduction: The goal of this project was to build upon farmers’ observations that healthy soil grows healthy plants, which in turn grow healthy animals. For years, dairy farmers have known that, “in the soil and rumen, microbes eat first.” Biologically-minded farmers maintain the health of their crops and cows by “feeding the soil and rumen bugs” (microbes) using good organic matter management. Dairy farms rely on microbes to recycle nutrients through the food chain. In both the soil and rumen, nutrients are released from plant material by microbial action. Since microbes require carbon (C) for energy and nitrogen (N) to build protein, the balance of organic matter C and N is very important. Thus, organic matter can be managed for nutrient content to promote microbial efficiency. Health and productivity of the soil, plant and ruminant animal increase when carbon (C) and nitrogen (N) are in balance because metabolism and production are closely linked.

Summary: In a two-year study of 22 grazing and confinement dairy farms in northeast Ohio, we investigated carbon (C) and nitrogen (N) balance in soil, plants and animals. Most conventional dairy farmers applied too much soluble N to the soil, whereas most grazers fed too much soluble N to their cows. Conventional dairy farmers worked to solve soil C and N imbalance...
by reducing fertilizer rates based on their soil test results. Grazing dairy farmers brought rumen C and N into balance by supplementing pasture with grain for energy and hay for rumen health, using milk data to fine-tune their cows’ diets.

Carbon and nitrogen balance in soils, plants, and animals were examined in this two year study of 22 dairy confinement and grazing farms. Those with confinement operations primarily grew corn as livestock feed and were able to reduce nitrogen applications on their corn crops using PSNTs. Graziers are recommended to use caution with early spring applications of nitrogen on their fields. Applying nitrogen early in the growing season favors crude protein production in pasture (>23%), which can lead to elevated MUN (milk urea N) levels.


Abstract: Nutrients in a pasture system cycle through soil organisms, pasture plants, and grazing livestock. Appropriate management can enhance the nutrient cycle, increase productivity, and reduce costs. Two practical indicators of soil health are the number of earthworms and the percentage of organic matter in the soil. A diversity of pasture plants growing on healthy soils use sunlight and the nutrient resources in the soil to effectively produce animal feed. Paddock design and stocking density can also affect the efficiency of nutrient cycling in a pasture system. Supplementation of natural fertility, based on soil tests, balances the soil’s mineral composition, resulting in better plant and animal growth and increased soil health.

Soil organisms facilitate cycling of minerals in the soil and are capable of aiding the recycling of nutrients several times throughout a growing season. A thriving community of organisms can promote soil health, decrease applications of fertilizer, and ultimately minimize costs with reduced fertilizer inputs. In this way, cultivating soil organisms is beneficial to the farmer and may be considered “soil livestock.” An understanding of underground biological cycling can enable the pasture manager to benefit from this herd of biological livestock.

Each type of bacteria is associated with releasing a certain nutrient, mainly from organic matter (nitrogen, phosphorus, sulfur and trace minerals) or soil minerals (potassium, phosphorus, magnesium, calcium, and iron). Other bacteria species release hormones that regulate plant growth or are able to fix atmospheric nitrogen, improve soil structure, fight disease, and detoxify the soil. Actinomycetes decompose organic matter and secrete antibiotics that can reduce disease. Fungi also break down organic matter. Some fungal species produce antibiotics and hormones that promote root growth or suppress disease. Others can trap plant-parasitic nematodes. A particular type of fungus, mycorrhiza, forms a symbiotic relationship with plant roots, increasing nutrient uptake to the plant in exchange for carbohydrates from the plant. Algae aids to aggregate stability by producing sticky substances that hold the particles together. Protozoa prey on microbes and in doing so, release plant available nitrogen. Nematodes, of which only a few cause plant damage, increase nutrient cycling by predation of other soil flora and fauna.

Earthworms redistribute soil nutrients and their burrows increase water infiltration. Earthworm populations are correlated with forage production. Fertilizers are often beneficial to earthworm populations, with the exception of anhydrous ammonia which is detrimental. Other macrofauna (dung beetles, sowbugs, millipedes, centipedes, slugs, snails, and springtails) are primary decomposers, breaking down organic matter and bringing it in contact with other, smaller soil organisms, which increases nutrient cycling.

Organic matter increases water infiltration when it is too wet by creating macropores that allow the water to drain. Organic matter also retains water when conditions are dry. These properties of organic matter mitigate nutrient leaching and volitization and maintain water films between plant roots and soil particles that aid nutrient uptake.

When considering utilizing nitrogen stored in clovers, it should be noted that release times differ depending on the variety. Some nitrogen from white clover residue may be available 4-6 months into the growing season, red clover up to 6 months, and alfalfa nitrogen release ranges from 6-12 months. “A nitrogen molecule can be fixed by white clover in one day. If eaten by a cow and excreted in urine, it could take as little as two weeks before it’s again available in plant tissue. If the clover isn’t eaten directly, the nitrogen that is harvested from the air may naturally become available to nearby grasses in as little as four months. Nitrogen in a leaf that falls on biologically active soil can be used again in the same growing season.”

Livestock contribute to soil fertility through their own wastes. Urine contains most of the nitrogen and potassium. These nutrients are soluble and plant available. Manure contains the phosphorus not utilized by the animal. It can take 6 months to two years for manure to break down and phosphorus to cycle back to plants. Cultivating healthy soil biota populations will increase phosphorus cycling from manure.

Livestock waste can be more evenly distributed by manipulating grazing behaviors. In smaller paddocks, animals are not as selective about grazing and space themselves more evenly that in larger paddocks. Placing a source of water close to the herd facilitates drinking individually. If a water source is in a large area, cows will act as a herd a drink together, concentrating nutrients by the watering source. Likewise, if there is not enough room for all animals to drink at one time, those waiting will contribute to waste in the concentrated area. Waste will concentrate in the non-productive areas if animals must travel in lanes to get water. Similarly, changing the location of supplemental feed will also improve more uniform distribution of animal waste.

Soil tests should be taken routinely, but a yearly application of 200-500 lb of finely ground lime is recommended. Lime benefits soil bacteria, reduces abundance of certain weeds, facilitates movement and absorption of magnesium,
phosphorus, and nitrogen, encourages clover growth (they require 2X the amount of Ca than grasses), creates soil tilth, and increases palatability of forages.

“Sole reliance on commercial fertilizer short-circuits the natural mineral cycle. High fertilization coupled with frequent harvesting of hay speeds organic matter decomposition and releases minerals faster than plants growing on the site can absorb them. As a result, nutrients are leached deeper into the soil, out of the reach of plant roots, or they are lost to run off.”


Abstract: Good pasture management practices foster effective use and recycling of nutrients. Nutrient cycles important in pasture systems are the water, carbon, nitrogen, and phosphorus cycles. This publication provides basic descriptions of these cycles, and presents guidelines for managing pastures to enhance nutrient cycling efficiency — with the goal of optimizing forage and livestock growth, soil health, and water quality. Bellows gives a general introduction on interactions and transformation of water, carbon, nitrogen, phosphorus, and secondary nutrient cycles. This publication also discusses determining factors of soil fertility (parent material, prior management practices, etc.), how current practices impact nutrient distribution, the role of soil biota, and pasture management strategies to minimize nutrient loss and improve water quality. This guide also has an excellent section on timing of nutrient additions.

“Both potassium and phosphorus are important for increasing the nutrient quality of forages, extending stand life, and enhancing the persistence of desirable species in the forage stand. Phosphorus is critical for early root growth, for seed production, and for effective nitrogen fixation by legume nodules. Potassium is important during the mid-to-late growing season. It increases the ability of plants to survive winter conditions, by stimulating root growth and reducing water loss through stomata or leaf pores. It also is important for legume vigor and for enhancing plant disease resistance.” (Numbered references removed.)

“Organic material releases nutrients over a period of several years. On average, only 25 to 35% of the nitrogen in manure is mineralized and available for plant use during the year of application. Another 12% is available in the following year, 5% in the second year following application, and 2% in the third year. Manure deposited in pastures causes an increase in forage growth approximately 2 to 3 months after deposition, with positive effects on growth extending for up to two year. Alfalfa can supply approximately 120 pounds of nitrogen to crops and forages in the year after it is grown, 80 pounds of nitrogen during the following year, and 10 to 20 pounds in the third year.”


This provides general grazing management guidelines and includes nutrient information as follows. “Nutrients are primarily removed from pasture ecosystems by making hay. Animals also remove nutrients through grazing. When pastures are grazed, many of the nutrients are returned to pastures via urine and feces. About 60-80% of the nitrogen, 60-85% of the phosphorus, and 80-90% of the potassium are excreted in urine and feces. Manure also contains many micronutrients needed by pasture plants. If manure is evenly distributed throughout the paddocks, fertility can almost be maintained through natural nutrient recycling...Often, a majority of the urine and feces is concentrated around water, shade, and other areas where livestock congregate. This concentration of manure can lead to nutrient deficiencies in other parts of the pasture. Not only does concentration of manure around water and shade sites lead to lower pasture productivity, it also leads to greater opportunity for nitrate contamination of surface and ground water...To evenly distribute manure and increase soil fertility throughout the paddock, shorten the rotation, increase stocking rates, and place water, shade, salt, and supplemental feeders in nutrient-poor areas. Minimize the amount of time animals spend around water by assuring the cattle do not have to travel more than 600 to 800 feet in each paddock...To improve quality of pastures, frost seed “with clover to provide nitrogen for increased yield and to improve nutritional value of the forage mix.”


Abstract/Summary: Pastures are an integral component of livestock production in the northeast, particularly for organic dairies and small, diversified farms. One challenge for many new pasture based farms is the need to renovate old, deteriorated pastures. Spaying dilute raw milk onto pastures is a novel, untested practice that has recently gained widespread prominence as a potential means of increasing forage production and quality. Farmers are also interested in learning about other products and procedures. Graziers need a reliable means of testing pasture improvement tools. On-farm testing allows the farmer to trial a certain product or technology at a lower cost and under the farm’s specific conditions before adopting it on a much larger scale. Such practices have the potential to save farmers money and time while encouraging innovation and experimentation.
This partnership project will investigate if foliar applications of dilute raw milk on pasture will improve the productivity, palatability and quality of pasture using on an on-farm testing method on two organic dairy farms. The experiment will also provide graziers with a model research method that could be replicated on other farms in order to test other products and practices on pasture. Outreach will be accomplished by a fact sheet, pamphlet, On-Farm Testing template, and through the Vermont Grass Farmers Association events and newsletter, the Northeast Pasture Consortium.

Over the course of this study, dilute raw milk was applied on pasture at 5, 10, and 20 gallons of active ingredient per acre. Field applications sprayed dilute milk did not have increased forage quality or yield compared to plots without foliar application of dilute milk. Greenhouse studies showed an initial boost in ryegrass tillering, but not in subsequent regrowth.


Abstract: Irrigated pastures are significant contributors of phosphorus (P) to inland watercourses, with much of the P coming from applied fertilizer. It was hypothesized that the timing of P fertilizer application relative to irrigation regulates P concentrations in runoff and infiltrating water. To test this hypothesis, a two-by-two factorial experiment was conducted on twelve 8- x 30-m border-irrigated bays growing perennial pasture. Phosphorus fertilizer in the form of single superphosphate (44 kg P ha(-1)) was surface-broadcast onto the bays when the nominal change in soil water deficit reached 0 or 50 mm (U.S. Class A pan evaporation minus rainfall). Following fertilizer application, the bays were again irrigated when the nominal soil water deficit between fertilizing and the subsequent irrigation reached either 0 or 50 mm. The volume of water applied, runoff volume, and changes in soil water content were recorded for the three irrigations following fertilizer application. Total phosphorus (TP) and filtrable reactive phosphorus (FRP, <0.45 microm) concentrations in runoff and at depths of 0.1, 0.3, and 0.6 m in the soil were also measured. Soil water content at fertilizer application had less effect on P concentrations in runoff and soil water than the additional time between fertilizing and irrigating. By allowing a deficit of 50 mm between fertilizer application and irrigation, the average concentration of P in runoff and moving below a soil depth of 0.1 m was approximately halved. To maximize fertilizer use efficiency and minimize environmental effects, a delay should occur between applying P fertilizer and irrigating perennial pasture.

Concentrations of phosphorus after irrigation were measured after superphosphate fertilizer was applied in runoff and at 4 inches, 12 inches, and 24 inches (rounded from metric). By allowing a two inch deficit in soil water between fertilizer application and irrigation, phosphorus in runoff and phosphorus leaching below 4 inches was nearly halved.


Abstract: Soil samples were collected from beef pastures varying in species composition and fertilizer inputs after being grazed by cow-calf pairs for 4 yr (1995-1998) near Brandon, Manitoba. The objective of this experiment is to examine the impact of 4 yr of continuous rotational grazing on soil chemical properties and nutrient redistribution in mixed alfalfa-grass and pure-grass pastures with or without fertilization. Pastures were established on an Orthic Black Chernozemic, fine sandy-loam soil. Compared with N-fertilized pure-grass pastures, alfalfa-grass pastures had greater seasonal soil mineral-N supply, and tended to have higher total soil C, N and organic C. In grazed systems in this environment, the use of alfalfa as the primary N source may be more profitable and sustainable than using fertilizer N. However, considering the seasonal changes in soil nitrification rate observed in alfalfa-grass pastures, caution needs to be taken when stands with high legume content are used to maximize animal performance, because this may increase the risk of N losses into the environment. Fertilization over a 5-yr period (1994-1998) tended to lower surface soil pH. Application of P significantly increased soil “extractable” P levels in the top 15-cm soil layer. However, K fertilization only increased surface soil “extractable” K slightly compared with unfertilized pastures. There was also no effect of S application on soil “extractable” S. Zone effects on soil mineral N and soil “extractable” P, K and S were limited to the surface (0–7.5 cm). For mineral N, the zone effect seemed to be more pronounced in first rotation than in second rotation. The magnitude of K redistribution was greater than for S and P due to higher K intake and excretion. Use of rotational stocking with short grazing periods appears to have resulted in a relatively even redistribution of nutrients derived from animal excreta.

The authors found that alfalfa-grass pastures had greater seasonal soil mineral-N and higher soil carbon supply than N-fertilized pure-grass pastures. This study suggests that alfalfa “as a primary N source may be more profitable and sustainable than using fertilizer N.” In addition, consecutive years of N-fertilization may lower surface soil pH, which can change nutrient availability of other nutrients to plants. Phosphorus applications increased extractable P, but additions of K only nominally increased extractable K, and additions of S did not increase extractable sulfur, when compared with unfertilized pastures. K redistribution was higher than P or S due to the reallocation of this mineral in urine. Even distribution of nutrients is promoted by using rotational stocking with short grazing periods.

Abstract: Combining the benefits of legume N2 fixation and N fertilization may increase the productivity and profitability of pasture systems. Our objectives were to study the effects of N fertilization on productivity and persistence of legumes in mixtures with cool-season grasses under rotational stocking with short grazing periods. Twelve N fertilization regimes ranging from 0 to 336 kg of N per ha were applied annually to smooth bromegrass and reed canarygrass in monoculture and mixture with alfalfa, birdsfoot trefoil, and kura clover. Alfalfa was the dominant legume in mixtures with cool season grasses in 1999. As kura clover developed, it became the dominant legume species and by the trials end stands averaged over 70% in mixtures with both smooth bromegrass and reed canarygrass and across N treatments. Nitrogen fertilization did not affect alfalfa stands, but reduced kura clover stands by 17%. Smooth bromegrass-legume mixtures with no N fertilization produced more forage (10.5 Mg DM/ha) than any smooth bromegrass monoculture with N treatment (336 kg of N per ha produced 8.0 Mg DM/ha). Cost of forage mass in smooth bromegrass-legume mixtures was less than 50% of smooth brome monocultures. While N fertilization did not increase forage production in treatments with legumes, legumes were able to maintain vigorous stands with up to 336 kg of N per ha.

The authors suggest that nitrogen fertilization impacts legume species differently. It may increase some legume species stands and reduce others. Grass legume mixtures with a legume can produce more forage than a grass monoculture with nitrogen fertilization. In fact, forage production in stands with legumes did not increase with nitrogen fertilization.


Abstract: Soil mineral nitrogen (N) profiles during the growing season and changes in total soil N and available N after 3–4 years were examined under 9 different pasture swards containing annual legumes, lucerne (Medicago sativa L.), or one of 4 perennial grasses at 2 sites representative of the low and medium rainfall belt of south-eastern Australia. The effect of the presence of phalaris (Phalaris aquatica L.) or lucerne on the spatial variation in surface pH was also measured. The 9 pastures were subterranean clover (Trifolium subterraneum L.), subterranean clover with annual weeds, yellow serradella (Ornithopus compressus L.), lucerne, phalaris, cocksfoot (Dactylis glomerata L.), lovegrass (Eragrostis curvula (Schrader) Nees), wallaby grass (Austrodanthonia richardsonii (Cashm.) H.P. Linder), and a mixture of lucerne, phalaris, and cocksfoot. All the perennial treatments were sown with subterranean clover. Available mineral N values in the surface 0.10 m of soil following summer rainfall were substantially higher in pure subterranean clover or serradella (Ornithopus compressus L.) swards (24–50 μg N/g) than those containing a mixture of subterranean clover and perennials (9–20 μg N/g). Apparent leaching of soil nitrate down the profile during winter was greater in annual pasture treatments and least in swards containing perennials. Soil pH(CaCl2) at the 0–0.10 m depth varied with proximity to perennial plants and was significantly higher (+0.2–1.1 pH units) near the base of perennial plants than in gaps between the perennials or in annual-only swards. Available mineral N to 1.0 m before cropping at the end of the pasture phase was highest following subterranean clover (175–344 kg N/ha) and serradella (202–316 kg N/ha) at both sites. Available N was lowest (91–143 kg N/ha) following perennial grass–clover swards at the drier site where the annual legume content was lower, but perennial grass–clover swards produced larger soil N values (147–219 kg N/ha) at the higher rainfall site. Removal of the pasture in August–September compared with November in the year before cropping increased available N at the time of sowing by an average of 44% (51 kg N/ha) at the drier site and 43% (74 kg N/ha) at the wetter site. Incorporating perennial pasture species in swards was found to be advantageous in reducing nitrate leaching and preventing a decline in surface soil pH; however, available soil N to following crops could be lower if the annual legume content of perennial grass-based pastures declined due to competition from the perennial species.

This study evaluated nine different pasture compositions including annual and perennial with subterranean clover. Available nitrogen was higher in pure subterranean clover than pure grass perennial stands after summer rains. Although clover-perennial grass pastures had greater amounts of available nitrogen in areas with higher rainfall, in drier sites, available nitrogen was lowest in the clover-perennial grass pastures. Perennial pastures had less nitrogen leaching through the soil profile than annual pastures. Soil pH varied with proximity to perennial plants; pH was higher at the base of perennial plants. This indicates that a strong stand of perennial plants increases pH and may require lime to keep pH at optimal levels.


Abstract: To increase our insight into the above- and belowground N flows in grass and grass-clover swards relations between crop and soil parameters were studied in a cutting trial with perennial ryegrass (Lolium perenne) monocultures and ryegrass–white clover (Trifolium repens) mixtures. The effects of clover cultivar on herbage yield, the amount of clover-derived nitrogen, apparent N transfer to companion grass, dynamics of N and organic matter in the soil were estimated.

The grass monocultures had very low DM yields (<2.1 t ha-1) and a low N concentration in the harvested herbage. During 1992–1995 the annual herbage DM yield in the mixtures ranged from 7.0 to 14.3 t ha-1, the white clover DM yield from 2.4 to 11.2 t ha-1 and the mean annual clover content in the herbage DM harvested from 34 to 78%. Mixtures with the large-leaved clover cv. Alice yielded significantly more herbage and clover DM and had a higher clover content than mixtures with
Nitrogen deficiency can limit pasture growth. In this study, N mineralization rates were lower in grass and clover monocultures than under mixtures. This research suggests that there is great N availability for plant uptake in mixtures than in grass or clover monocultures. However, the C:N ratio of active soil organic matter was higher in grass systems than the mixtures.

Summary: Many farmers in the Northeast have pastures or hayfields that, over time, tend to show a decline in desirable forage species and quality as weed species increase. Common practice for pasture renovation includes mechanical cultivation, reseeding, and sometimes the use of herbicides, resulting in greater soil erosion and compaction, higher costs, and compromised natural resources. Recognizing that weeds thrive in particular conditions of low soil fertility, three one-acre test plots were amended with custom formulated blends to address mineral deficiencies, and compared to three adjacent one-acre control plots. As soil nutrition in the field increased, an increase was observed in palatable forage species, such as fescue, orchard grass, quackgrass, timothy, red clover, and vetch. A decrease was observed in broadleaf weed species including aster, buttercup, chickweed, cinquefoil, goldenrod, hawkweed, daisy, strawberry, and yarrow. Forage species were also sampled and analyzed for nutritional content to compare forage quality in test and control plots, though no consistent differences were observed in plant tissue analysis. This study took place on Zephyr Hill Farm, which consists of 130 acres of fields and woodlands in Waldo County, Maine. The farm includes three acres of organically managed vegetables with integrated flowering, fruiting, and medicinal perennial species, approximately twenty acres of pasture, and over one hundred acres of woodlands. Singing Nettle Farm operates on this land, working with a team of Haflinger draft ponies to grow produce for a CSA (community supported agriculture) program, local restaurants, the Maine Organic Farmers and Gardeners Association (MOFGA) Common Ground Fair, and a farmers market.

Pasture fertility can decline over time and this leads to a decrease in desired forage species accompanied by an increase in weed species. Amending soils to ameliorate fertility deficiencies can increase forage and decrease weed species. In this study, soils were low in calcium, magnesium, phosphorus, potassium, nitrogen, sulfur, boron, zinc, copper, and manganese. Soil amendments were chosen to meet USDA organic certification standards. In the first year, a blend totaling 2900 lb/acre (800 lb hi-cal lime, 750 lb soft rock phosphate, 450 lb dolomitic lime, 400 lb gypsum, 150 lb sul-po-mag, 100 lb sodium nitrate, 100 lb micronized humates, 50 lb sulfate of potash, 25 lb magnesium sulfate, 25 lb zinc sulfate, 20 lb calcium borate, 20 lb mangaese sulfate and 1 lb myco-seed treat) was applied. In the second year, Lancaster’s Agriculture’s Fall Blend M was applied. Fall Blend M is a proprietary blend of limestone, marl, sulfate of potash-magnesia, humus, soft rock phosphate, gypsum, brown phosphate rock, calcium borate, copper sulfate, zinc sulfate, and humates. Fall Blend M nutrient analysis includes 1.5% phosphorus, 3% potassium, 26% calcium, 2% magnesium, and 2.7% sulfur.

From spring of year one to spring of year two, soil fertility increased in Ca, Mg, S, pH, conductivity, and P levels, and to a lesser extent N and K. The observed increase in palatable forage species, such as fescue, orchard grass, quackgrass, timothy, red clover, and vetch. A decrease was observed in broadleaf weed species including aster, buttercup, chickweed, cinquefoil, goldenrod, hawkweed, daisy, strawberry, and yarrow. Forage species were also sampled and analyzed for nutritional content to compare forage quality in test and control plots, though minimal differences were observed in plant tissue analysis, with the exception of higher boron levels in the experimental plots.” This study did not report on changes in yield or the economics of the cost-benefit. The author reports that liquid amendments may improve success of increasing soil fertility, resulting in higher quality and quantity yields.


Nitrogen from legumes is mainly available to other plants after animal digestion or decomposition. When soils are above 52°F, white clover can fix 125 nitrogen lb/acre/yr. In lower soil temperatures, rhizobia are not as efficient and an application of manure early in the season can add to spring growth. Late summer pasture shortages can be corrected and fall grass growth can be encouraged with applications of manure, compost, feather meal, or fish emulsion. In pastures without legumes, apply 30 nitrogen lb/ac/month (6,000 gallons of liquid manure) during the growing season for continuous production. Potassium requirements of grazed pastures are 20% lower than in harvest pasture.
Guo, Y.J., Y. Ni, H. Raman, B.A.L. Wilson, G.J. Ash, A.S. Wang, and G.D. Li. 2011. Arbuscular mycorrhizal fungal diversity in perennial pastures; responses to long-term lime application. Plant and Soil. 351(1-2): 389—403. “We investigated the genetic diversity of arbuscular mycorrhizal fungi (AMF) in soils and the roots of Phalaris aquatica L., Trifolium subterraneum L., and Hordeum leporinum Link growing in limed and unlimed soil, the influence of lime application on AMF colonization and the relationship between AMF diversity and soil chemical properties... “Long-term lime application changed soil nutrient availability and increased AMF colonization, but decreased AMF phylotype diversity, implying that soil chemistry may determine the distribution of AMF in acid soils. Future studies are required to explore the functions of these AMF groups and select the most efficient AMF for sustainable farming in acid soils.”

Harmonery, K.R. and C.A. Thompson. 2005. Fertilizer rate and placement alters triticale forage yield and quality. Forage Grazinglands. 3(1). “On a soil low in available phosphorus (P) and nitrogen (N), 14 combinations of N and P fertilizer rates and placement were compared for ‘Presto’ winter triticale (× Triticosecale rimpauli Wittm.) forage production and forage quality. Increasing broadcast N rates increased forage yield and crude protein percentage while lowering forage fiber components. Additional P fertilizer banded with the seed increased forage yield, but crude protein percentage declined and fiber concentrations increased with the additional P. The most efficient use of the fertilizer resource was experienced with small incremental levels of N or P both banded with seed. Seed-banded N at 20 lb/acre produced as much quality forage as when 80 lb of N per acre was broadcast and incorporated. Fertilizing with P at 10 lb/acre banded with the seed produced as much or greater forage as N at 120 lb/acre broadcast and incorporated. Both N and P fertilizer, alone or in combination, can efficiently improve forage yield and quality of ‘Presto’ winter triticale, especially when banded with the seed.”

Banding nitrogen and phosphorus fertilizer was a more efficient use of resources than broadcasting. Nitrogen increased forage yield and quality (increased protein, decreased fiber). Phosphorus increased yield, but decreased quality (decreased protein, increased fiber). However, smaller rates of banded phosphorus (10 lb/acre) produced as much or more forage than higher rates of broadcasted and incorporated nitrogen (120 lb/acre).

Hoveland, C.S., 2000. Does aeration of pasture and hayfields pay? The Georgia Cattleman. Macon, GA. Studies in Oklahoma, Mississippi, and Alabama showed that if forage production increased with aeration, the value of the extra forage did not compensate for the cost of aeration. In contrast to these studies, on highly degraded land or clay soils, aeration doubled forage production in Texas and Wales.

Kersbergen, Richard. 2005. Managing smooth bedstraw (Galium mollugo L.) in forage crops [Online]. Final Report. Available at http://mysare.sare.org/mysARE/ProjectReport.aspx?do=viewRept&pn=ONE04-025&y=2005&t=1 (verified 20 Mar. 2015). In this study, four treatments were evaluated as methods for bedstraw control. “Treatments were as follows: 1) Control (mowing 2X during the summer to replicate a hayfield or pasture situation) 2) Nitrogen Management (200 lb. per acre of N applied in a split application with one in spring, and the second after mowing in July). Plots were mowed to prevent seed formation. 3) One mowing with Crossbow herbicide applied in September (traditional broadleaf herbicide recommendation). Plots were mowed during the season to prevent seed formation. 4) Glyphosate herbicide applied just prior to flowering in June. Re-seed using a no-till drill. 5)Repeated tillage beginning in June, with a buckwheat cover crop and a short fallow period. Re-seed in August.”

Repeated mowing was just as effective as herbicides applied in late summer in reducing bedstraw plant populations. Both tilling and Crossbow treatments were the most effective in reducing bedstraw (less than 1% of total dry matter yield). Nitrogen applications were not enough to reduce bedstraw, but did significantly increase yield of desirable forages compared to the control (with respective 1863 and 1215 pounds of dry matter per acre).

Knight, J.D., R. Buhler, J.Y. Leeson, and S.J. Shirtliffe. 2010. Classification and fertility status of organically managed fields across Saskatchewan, Canada. Canadian Journal of Soil Science. 90: 667—678. Soils from 60 fields on 39 farms were analyzed for for available N, P, K and S, pH, electrical conductivity (EC) and soil organic carbon. The fields were classified into the following four management systems: Perennial, Summerfallow, Cereal, and Diverse. Of the four systems, only the Perennial and Diverse systems had an effect on the examined soil properties. When alfalfa was included in the Perennial system, the soil was more acidic and the availability of P and K were reduced relative to the Diverse system. Of all the systems, the Perennial system was lowest in P and K. The fields included in this study has low applications of manure and the authors suggest that organic management should include a return of nutrients to the fields.
Manure direct from grazing livestock is a large input of N cycling. Intensive grazing can increase the efficiency of product N:fixed N by 50%. This study supports improving livestock diet and management strategies to increase the quality of excreta and spatial return.

Different types of biomass introduced into the dairy barn influence the ratio of N, P, and K. The inputs were mixed with manures and redistributed throughout the farmland. Overall, there was a transfer of K from grassland to arable land. Manure was rather ineffective on permanent grassland with a high percentage of legumes. This study suggested that stable manures were best suited for arable land and pastureland nutrient demand could be met with mineral inputs.

“Runoff from flood-irrigated perennial pastures generally contains higher phosphorus (P) and nitrogen (N) concentrations than the irrigation water applied to the pastures. We examined the sources of P and N that could contribute to these elevated nutrient concentrations in runoff.
The first experiment compared P and N losses in runoff from pasture cut to different residual pasture masses. Flow-weighted P and N concentrations and loads were about 100% higher from pasture cut to 47 mm above ground than from pasture standing at 155 mm. These results indicated that severely defoliated pasture may be a significant source of nutrients when flood irrigated.

In the second experiment, pastures were defoliated at a single grazing with different stocking intensities and the flow-weighted P and N concentrations in runoff were determined during 4 successive flood irrigation events. Nitrogen and P concentrations in runoff after the first irrigation following defoliation were higher at the highest stocking intensity. However, the effect of the grazing on nutrient concentrations in runoff declined in subsequent irrigation events. A regression model fitted to the P data indicated that there was a significant linear increase in P concentrations with stocking density and a significant non-linear decline in concentrations with successive irrigations. A similar relationship for TKN concentrations in runoff at each stocking density over the 4 irrigation events was not found. An inconsistency of the TKN concentrations of the supply water between irrigation events possibly helped to mask a similar relationship between N concentrations in runoff and stocking density over the 4 irrigation events. We postulate that both animal excreta and the pasture itself can contribute to elevated nutrient concentrations in flood-irrigation runoff.”

Concentrations of phosphorus and nitrogen in runoff resulting from flood-irrigation in forage stands at 6.10” were half that than concentrations in runoff from 1.85” grass stands. Nitrogen and phosphorus concentrations are higher in flood-irrigation events with higher stocking rates

Under Voisin intensive management grazing system, effects of eight different soil fertility treatments on irrigated and non-irrigated pasture were evaluated for changes in soil fertility and forage yield and quality over three years. Pastures were irrigated when moisture was greater than 60 centibars. There were eight soil fertility treatments plus one control where fertilizers or amendments were not applied. The eight treatments were: recommended rates of PKlime, recommended rates of NPKlime, 3.5 qt./acre of hydrolyzed fish after each grazing, 3.5 qt./acre fish/seaweed blend after each grazing, 200 lb/acre of crab shell in the spring before grazing began, 5 tons/acre of 1-year-old dairy manure compost after the first grazing in the spring, and 10 tons/acre of 1-year-old dairy manure compost after the first grazing in the spring, and nitrogen as Chilean nitrate was applied according to Voisin suggestions and Prince Edward Island split-application results at 22 lb/acre in early spring, 10 lb/acre in mid-June and early August, and at 15 lb/acre in early September.

In the first year, irrigation increased forage yield by an average of 0.4 tons across all treatments. During the first year, irrigation did not affect NPKlime treatments (2.8 tons/acre). Yields increased with applications of nitrogen as much as they did with irrigation. However, plots with nitrogen applications had lower quality forage because grass growth (as opposed to legume growth) is favored under those conditions. Although red and white clover content was 2% higher in irrigated (17%) than non-irrigated (15%) plots, forage quality remained fairly constant throughout all treatments during the course of this study.
Irrigated plots with 5 tons/acre of applied manure had the highest yield (3.5 tons/acre). Non-irrigated 5 tons/acre manure compost plots had more dry matter (2.9 tons/acre) than the non-amended, irrigated control (2.7 tons/acre). However, additional amendments of either rate of compost in the subsequent two years did not increase yields to the 2003 levels. In contrast, all other treatments either met or exceeded 2003 yields in 2005. This suggests that forage yields do not increase from consecutive yearly applications of compost.

The average cost of fertilizer was $120.00/acre. The hydrolyzed fish, fish/seaweed blend, and crab shell did not impact forage quality or yield. The Chilean nitrate cost was $765/acre and plots with this amendment had decreased forage yield. Compost produced on farm had the greatest effect on forage yield. At the time of this study (2005), average hay prices were $200/ton. The compost increased yield from 0.7–1.0 tons/acre, making applications of compost an economic net gain in terms of yield and reducing need to invest in irrigation equipment.


“With the reduction in S inputs through atmospheric deposition and high analyses fertilizers, soil organic S will become a more important source of S to crops. Sulfur mineralization in 20 meadow soils was investigated using a long-term aerobic incubation and a greenhouse bioassay with alfalfa (Medicago sativa L.). The cumulative S mineralization (Sm) was linear with time for 13 soils whereas 7 soils showed an exponential phase over the first 10 wk followed by a linear release phase. Podzolic soils dominated the latter group. The data were described by an incremental zero-order model where an initial flush was accounted for. The total amount of mineralizable S (Sm), the amount of S mineralized in the first 1.4 wk (Se), the S mineralization potential (So) and the rate constant (k) were all very closely correlated to the N mineralization potential and to the amount of N mineralized in the first 1.4 wk of incubation (r = 0.64–0.85; P < 0.01). The S mineralization parameters were not significantly correlated to soil pH, total C, N, and S, C:S and N:S ratios and extractable P content. The Se and So mineralization parameters were significantly correlated to the soil sand content (r = 0.51 and 0.53; P < 0.05) suggesting the possible involvement of particulate organic matter as a pool of mineralizable S. Alfalfa yield response to S addition was observed only on seven soils with lowest cumulative S. Total S uptake of alfalfa represented, on average, 10% of Sm and was strongly correlated to Sm (r < 0.81**). The effect of S fertilizer on plant S uptake was observed only for the third cut (P < 0.01), this being probably due to mineralizable S depletion in soils. The results of this study suggest that the initial potential of N mineralization is a good indicator of Sm and that a short term incubation could measure the S supplying power of Québec soils.”

Sulfur fertilization may become necessary as atmospheric sulfur deposition lessen. Effects of sulfur fertilization on alfalfa yield were only observed on soils low in sulfur. Sulfur uptake was influenced by sulfur addition primarily in the third cut. This may be due to depleted reserves of mineralizable sulfur in soils. Sulfur mineralization was related to sand and labile organic nitrogen content. This study suggested that organic material is a good source of sulfur.


“Leaching losses of N and P were examined in separately tile-drained field plots on a clay soil with two 6-year organic crop rotations (1998–2006). Two different farming systems (with dairy cows (+L) and without stock (−L)) were evaluated to identify parts of the crop rotations with the greatest risks of N and P leaching losses and to examine the scope for improvement. Although N and P leaching losses tended to be higher without livestock, the mean annual leaching loads from both systems were low and did not differ significantly (6.8 and 9.1 kg N ha−1 year−1 and 0.39 and 0.55 kg P ha−1 year−1 for +L and −L, respectively). For both systems, there were increased amounts of N and P in drainage water in the period following sowing of winter wheat after incorporation of clover–grass ley (CG). This could be attributed to the early date of CG incorporation, as late incorporation followed by bare fallow gave lower nutrient leaching. Drainage from bare fallow after a broad bean crop was identified as a critical part of the crop rotation for P leaching, with P losses possibly enhanced by macropropore formation by the taproot of broad bean. The lowest leaching losses were observed during CG growth, demonstrating that CG had a buffering effect on leaching during heavy precipitation events. It was concluded that in organic farming on clay soils, countermeasures such as undersown CG and late incorporation of this CG can be effective in reducing N and P leaching losses.”

Nitrogen and phosphorus leaching were studied on tile-drained clay soils managed with a 6-year crop rotation, with and without livestock for a period of eight years. Leaching of nitrogen and phosphorus was lower in tile-drained fields with livestock than without. The study showed that taproots of broad beans created macropropores that increased phosphorus leaching through tile drains. The clover–grass planting had the lowest leaching loss during heavy precipitation.


“Low organic matter content and weak soil structure, combined with high annual precipitation, make the soils of the Maritime Provinces extremely susceptible to compaction. Although many pasture studies have been conducted in the Maritime Provinces, none has investigated the impact of pasturing cattle on soil physical properties. Soil properties such as resistance to penetration, bulk density and hydraulic conductivity were monitored on pasture swards receiving various rotational-grazing
increasing the amount of legumes in pasture stands would improve pasture conditions. Made on 15% of pastures. Of all the indicators assessed, pastures scored lowest in percent legume. This suggests that changes were noted on 40% of pastures, some improvements needed on 44% of pasture, and immediate changes needed to be made on 25% of pastures. The indicator “percent legume” scored lowest of all the indicators. The low rating for legume content suggests that producers should focus management on establishing and maintaining legumes, which contribute valuable N and high quality forage to the pasture system. Pasture condition score was negatively related to plant species richness. Pastures with the highest species richness generally had many weedy species. This indicates that focusing on increasing the number of species in a pasture without regard to the species composition may not be wise. The PCS system was designed to determine how management has influenced pastures. The Pasture Condition Score (PCS) system, developed by the NRCS, was used to assess 108 pastures on 31 farms across the Northeast. We examined the applicability of the system to identify potential problems with its uses and obtain a snapshot of pastureland status. None of the pastures evaluated scored in the highest category (PCS > 45). More than 40% of the pastures scored in the category where only minor changes to management were needed (PCS = 36 to 45) and another 44% fell into the category where some improvements were needed (PCS = 26 to 35). About 15% of pastures scored 16 to 25, indicating immediate management changes were needed. The indicator “percent legume” scored lowest of all the indicators. The low rating for legume content suggests that producers should focus management on establishing and maintaining legumes, which contribute valuable N and high quality forage to the pasture system. Pasture condition score was negatively related to plant species richness. Pastures with the highest species richness generally had many weedy species. This indicates that focusing on increasing the number of species in a pasture without regard to the species composition may not be wise. The PCS system was readily implemented on pastures. Producers would benefit by observing individual pasture condition indicators at regular intervals to track trends and inform management decisions.”

Compaction from cattle was greatest in the top 2.4 inches (rounded from metric). However, the frost from winter and spring reduced the compaction to that of non-grazed areas.


Abstract: Improved nutrient cycling and reduced soil nutrient accumulation are perceived benefits of management-intensive grazing. Some management-intensive practices, such as increased stocking rates, rapid rotations, and supplemental feeding, could affect the soil through nutrient additions and the concentration of grazing animals. In this case study of a beef cattle farm in the Chesapeake Bay watershed, we compared changes in soil test P levels resulting from a land use change (row crops and hay in the 1980s to management-intensive grazing from 1990 to 2010). Soil test P data from farm records maintained since 1980 were augmented with spatially explicit soil sampling in 1999, 2004, and 2010. Pastures on fields that had historically received manure and were used for corn silage production changed the most in soil test P (median of 132 mg/kg P in 1980 to 70 mg/kg in 2010). Median soil test P in fields used for corn grain production in the 1980s decreased by 30%, fields used for hay production decreased by 26%, and permanent pastures decreased by 17%. The decreases in soil test P may have resulted from less inorganic P imported for use on corn, redistribution of P around the farm, and fixation of P in the soil.

Interpretative Summary: Improved nutrient cycling along with less soil nutrient accumulation are perceived benefits of management-intensive grazing compared with traditional continuous stocking management and confined feeding systems. Recent efforts to develop total maximum daily loads for phosphorus (P) for the Chesapeake Bay watershed highlight grazing and pasture management as agricultural best management practices to reduce P loads. In this case study, we compiled 30 years of soil P data for a beef cattle farm in the Chesapeake Bay watershed. The dataset provided an opportunity to compare changes in soil P before and after a change from row crops and hay production to management-intensive grazing. Variation in soil test P among paddocks on the case study farm was related to cropping history, manure management, and grazing management. Soil test P levels in fields used for corn grain production decreased by 30%, fields used for hay production decreased by 26%, and permanent pastures decreased by 17% after conversion of the farm to grazing. The largest reductions in soil test P occurred on corn silage fields previously used for manure disposal. Farmers who convert cropland to pasture and adopt management-intensive grazing practices with lower inputs can stabilize or reduce soil test P levels in the long term and potentially increase profits. Graziers need to monitor soil fertility regularly and implement appropriate nutrient management practices.


“Many livestock producers have intensified management of pastures in the Northeast and need assessment and monitoring tools to determine how management has influenced pastures. The Pasture Condition Score (PCS) system, developed by the NRCS, was used to assess 108 pastures on 31 farms across the Northeast. We examined the applicability of the system to identify potential problems with its uses and obtain a snapshot of pastureland status. None of the pastures evaluated scored in the lowest category (PCS < 15), and only a few pastures scored in the highest category (PCS > 45). More than 40% of the pastures scored in the category where only minor changes to management were needed (PCS = 36 to 45) and another 44% fell into the category where some improvements were needed (PCS = 26 to 35). About 15% of pastures scored 16 to 25, indicating immediate management changes were needed. The indicator “percent legume” scored lowest of all the indicators. The low rating for legume content suggests that producers should focus management on establishing and maintaining legumes, which contribute valuable N and high quality forage to the pasture system. Pasture condition score was negatively related to plant species richness. Pastures with the highest species richness generally had many weedy species. This indicates that focusing on increasing the number of species in a pasture without regard to the species composition may not be wise. The PCS system was readily implemented on pastures. Producers would benefit by observing individual pasture condition indicators at regular intervals to track trends and inform management decisions.”

Of 108 pastures evaluated in the Northeast, only a few (1%) had a high NRCS Pasture Condition Score (PCS). Minor changes were noted on 40% of pastures, some improvements needed on 44% of pasture, and immediate changes needed to be made on 15% of pastures. Of the indicators assessed, pastures scored lowest in percent legume. This suggests that increasing the amount of legumes in pasture stands would improve pasture conditions.

“Crabgrass (Digitaria spp.) could provide high quality summer grazing in the southeastern U.S. However, little information is available on the tendency of crabgrass to accumulate nitrate. This study evaluated the effect of N fertilizer rate and source on the nitrate concentration of crabgrass forage. Plots were established in late spring of 2001-2003 near Blackstone, VA. Seven N rates ranging from 0 to 300 lb/acre were applied in 50 lb intervals at seeding as ammonium nitrate or broiler litter. Nitrate concentrations in the forage increased with N rate (P < 0.01) and were greater during periods of moisture stress. First harvest nitrate accumulated to dangerous levels (> 5000 ppm) when more than 84 and 143 lb of N per acre was applied as ammonium nitrate in 2001 and 2002, respectively. In 2002, nitrate concentrations in second harvest forage fertilized with ammonium nitrate ranged from 1000 to 20000 ppm and increased with N rate (P < 0.001). In contrast, nitrate concentrations in first and second harvest forage fertilized with broiler litter never exceeded the generally safe range (P < 0.01). Final harvest nitrate concentrations never exceeded the generally safe range regardless of N source.”

Crabgrass protein concentrations increased with nitrogen application rate. In dry conditions, nitrogen concentrations increased in crabgrass. Nitrogen as either ammonium nitrate or broiler litter was applied at seeding time. Forages amended with ammonium nitrate reached dangerous levels of nitrate concentration in the first cut and decreased in the subsequent two cuttings. All cuttings of the forage amended with broiler litter stayed within the general range of safety.


“The study was conducted at the Lacombe Research Station, Alberta, on an Orthic Black Chernozem of loam to silt loam texture to investigate grazing impacts and cultivation on near-surface soil compaction. Four forages, smooth bromegrass (Bromus inermis Leyss ‘Carlton’), meadow bromegrass (Bromus riparius Rhem ‘Paddock’), a mixture of triticate (X Triticosecale Wittmack ‘Pika’) and barley (Hordeum vulgare L. AC Lacombe), and triticale were used for the study. Each forage species was subjected to heavy, medium and light intensity grazing. Measurements of bulk density and volumetric moisture content for the 0- to 10-cm depth interval were conducted using a surface moisture-density probe between spring 1994 and fall 1996. Relative compaction was calculated as the actual bulk density expressed as a percentage of the Proctor maximum density. Relative compaction values for all treatments and that for the benchmark were less than 90%, which is considered critical for limiting plant growth. Cultivation reduced bulk density under annual forages by only 3% and lowered it under heavy grazed annual treatments most. Regression analysis conducted on the dependence of bulk density to cumulative cow-days indicated a curvilinear relationship. Bulk density increased more rapidly with increasing cumulative cow-days for annuals compared to perennials. From a management perspective, adopting intensive rotational grazing systems for perennial and annual forages may not cause any serious surface compaction problems for soils in this area.”

On loam and silt loam textured soil, the impacts of different stocking rates on compaction were measured in annual and perennial pasture. Cultivation reduced compaction more under heavy grazed annual pastures than in perennial pastures. Annual pastures showed more compaction than perennial pastures with increased cumulative cow-days.


“When application rates of manure are based on providing adequate nitrogen for crop growth, added phosphorus and potassium levels will often exceed crop need, so manure should not ve [sic] the sole N source in an organic system. Excess levels of soil P can increase the amount of P in runoff, increasing the risk of surface water pollution. Many crops can handle high levels of K, but livestock can be harmed by nutrient imbalances if they consume a diet of forages with high K levels. Annual P-based manure or compost application is the most effective method of application when soil P buildup is a concern (Eghball and Power, 1999). Phosphorus-based application rates improve water quality, but reduce the amount of manure applied per area and so increase the land base needed for manure application. Where P buildup is a concern, legumes should be included in the rotation to provide additional nitrogen.

“Solid manures contain most of their nitrogen in the organic form, but poultry manure contains substantial rhizobium–N and so should not be surface applied to avoid loss of ammonia gas. Poultry and other manures that contain a large proportion of ammonium–N should be tilled into the soil the same day they are spread. Ammonia loss is greater in warm, dry, and breezy conditions where soil pH is high and is reduced in cool, wet weather.”


“Organic agriculture aims to build soil quality and provide long-term benefits to people and the environment; however, organic practices may reduce crop yields. This long-term study near Mead, NE was conducted to determine differences in soil fertility and crop yields among conventional and organic cropping systems between 1996 and 2007. The conventional system (CR)
consisted of corn (Zea mays L.) or sorghum (Sorghum bicolor (L.) Moench)–soybean (Glycine max (L.) Merr.)–soybean, whereas the diversified conventional system (DIR) consisted of corn or sorghum–sorghum or corn–soybean–winter wheat (wheat, Triticum aestivum L.). The animal manure-based organic system (OAM) consisted of soybean–corn or sorghum–soybean–wheat, while the forage-based organic system (OFG) consisted of alfalfa (Medicago sativa L.)–alfalfa–corn or sorghum–wheat. Averaged across sampling years, soil organic matter content (OMC), P, pH, Ca, K, Mg and Zn in the top 15 cm of soil were greatest in the OAM system. However, by 2008 OMC was not different between the two organic systems despite almost two times greater carbon inputs in the OAM system. Corn, sorghum and soybean average annual yields were greatest in either of the two conventional systems (7.65, 6.36 and 2.60Mgha-1, respectively), whereas wheat yields were greatest in the OAM system (3.07Mgha-1). Relative to the mean of the conventional systems, corn yields were reduced by 13 and 33% in the OAM and OFG systems, respectively. Similarly, sorghum yields in the OAM and OFG systems were reduced by 16 and 27%, respectively. Soybean yields were 20% greater in the conventional systems compared with the OAM system. However, wheat yields were 10% greater in the OAM system compared with the conventional DIR system and 23% greater than yield in the OFG system. Alfalfa in the OFG system yielded an average of 7.41Mgha-1 annually. Competitive yields of organic wheat and alfalfa along with the soil fertility benefits associated with animal manure and perennial forage suggest that aspects of the two organic systems be combined to maximize the productivity and sustainability of organic cropping systems.”


This farmer based research compared the impact of composted manure, raw manure, and no manure on forage quality and yield. The forage stands were comprised mainly of alfalfa. Raw manure applied was roughly twice that of composted manure. On the third year of treatment, the plots with composted manure had three tons more dry matter yield (6.9 tons/acre) than plots with raw manure (3.9 tons/acre). The plots without any fertility amendment had a dry yield of 2.3 tons/acre or 1.6-4.9 tons/acre less than manured plots. Composted plots reached maturity a few days earlier than plots with raw manure. The increased maturity of the alfalfa in the composted plots may have contributed to its lower RFV than the forage in plots with raw manure. Despite the lower RFV content of alfalfa plots amended with compost, the alfalfa consistently had higher protein levels, highest phosphorus, highest potassium, and lowest calcium across all three cuttings.

When adjusting profit for yield and cost of application by treatment, the composted treatments outperform the raw manure treatment and control. The profit of the composted alfalfa treatment is estimated to net $225 more than the raw manure treatment and $292 more than the control.