



How does organic management on dairy farms affect pastures and soils?

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Background

Organic dairy farming is an important part of Wisconsin agriculture. Productive pastures play a critical role in supporting organic dairy farms because pasture is a required feed source for organic cattle in the U.S. The USDA Pasture Rule requires that organic cattle receive at least 30 percent of their dry matter intake from pasture during a grazing season that is at least 120 days long. UW-Madison researchers explored whether limitations on the inputs allowed in organic farming may result in differences in plant-soil dynamics compared to conventional dairy operations, necessitating different grazing techniques. They searched peer-reviewed scientific publications for evidence of differences between organic and conventional pastures and found relevant scientific literature to be scarce. Even when reviewing related articles outside of the Upper Midwest, mostly from New Zealand, the results were mixed.

UW-Madison researchers Brittany Isidore of the Agroecology MS program, Richard Cates of the Center for Integrated Agricultural Systems and Randy Jackson of the Department of Agronomy received support from Organic Valley — Farmers Advocating for Organic to support this project. They wondered whether substances prohibited by organic rules (including synthetic fertilizers, pesticides, antimicrobials and deworming medications) could cause differences in organic pasture ecosystems compared to conventional pastures, including changes in plant productivity, nutrient cycling and soil life. Soil life encompasses microorganisms such as bacteria and fungi, and soil invertebrates including burrowing earthworms, predatory spiders, soil pore-dwelling mites, nematodes and protozoa. The researchers searched for the term “organic pasture” in several academic databases, emphasizing articles published after 2012. They excluded articles not relevant to organic pasture management, organic pasture soil health or quality, organic pasture ecology, or organic pastures.

The articles summarized below are the papers most relevant to the question: “Are organic pastures different

from conventional pastures?” Since organic agriculture relies on biological soil processes more than synthetic fertilizer applications for nutrient availability, the researchers were particularly interested in the effects of organic management on pasture soils. These studies look at a variety of soil properties including abundance, diversity, species mix and activity of different soil organisms.

Organic versus conventional pastures

Working across a range of permanent pastures in New Zealand that were established more than 50 years ago, Parfitt et al. (2005) conducted the most direct experimental comparison of soil and plant responses to organic pasture management. Researchers compared seasonal growth in nine adjacent hill pastures with grazed sheep or beef cattle under three different long-term management approaches: certified organic, no fertilizer and synthetic fertilizer. They found no evidence that pasture growth or diversity of soil life increased under organic farming. They used the rate of net nitrogen mineralization as an indicator of soil biological activity and nitrogen availability, but it did not differ between organic and conventional pastures. Earthworm numbers and nematode diversity were similar in organic and conventional pastures. The organic pastures had been fertilized with rock phosphate, but not bulk organic manure from storage. Because sheep and beef pastures are not typically managed intensively as pastures for dairy cows, it is unknown whether these results would be the same on pastures grazed by dairy cattle.



A study in New Zealand (Schon, Mackay and Minor 2011) evaluated whether conventional pastures grazed by sheep treated with a chemical dewormer (Ivermectin) were different from organic pastures grazed by untreated sheep. They found no differences in the abundance or species composition of soil invertebrates in organic and conventional sheep pastures with similar stocking densities and fertilizer applications. Pastures had been under organic management for 11 and 20 years. Similarly, a 2005 study (Bithell et al. 2005) in New Zealand found no differences in earthworm density or biomass between paired organic and conventional pastures. These pastures had been organic from three to 16 years. Neither the organic nor the conventional pastures had received applications of bulk manure from storage in this study.

Schon (2011) did find significant differences between grazed pastures and control pastures that were ungrazed and unfertilized for 20 years. Control plots had more diversity in earthworm species and fewer earthworms overall, and tended to have larger soil pore sizes than grazed plots. The presence or absence of grazing and the amount of nutrients added to pastures resulted in more differences in the diversity of soil invertebrates than organic or conventional grazing management. Differences in ungrazed versus grazed pastures were also found by Oates, Balser and Jackson (2012). In that study, researchers found that, in the productive cool-season pastures of Wisconsin, no differences in soil microbial communities existed between side-by-side rotationally and continuously grazed conventional pastures. However, significant differences were observed in the microbial community when grazing was discontinued. For example, soils under grazing had

lower fungal-to-bacterial ratios and lower arbuscular mycorrhizal fungi (AMF) concentrations than soils in pastures without grazing.

Although not a conventional-versus-organic pasture comparison, a study by Astatkie, Joseph and Martin (2007) provides insight on inputs and yields in organic dairy pastures. In this study, the researchers compared applications of nitrogen, phosphorus, potassium, compost and seaweed extract to no applications of these materials on permanent organic dairy pastures in Nova Scotia, Canada. They used both organic and synthetic fertilizers. The addition of nitrogen and compost were both associated with increased pasture yields, reinforcing the notion that nitrogen is the most commonly limiting nutrient in pasture systems. Seaweed extract enhanced the effectiveness of nitrogen and compost, but reduced pasture yield when used alone. High levels of phosphorus and potassium already present in the soil either diminished or varied the effects of applications of those nutrients.

Caution must be used when generalizing the findings described above across different climates, soil parent materials, topography, soil organisms, and life stage and species makeup of the plant and animal community. This is especially true in grasslands as compared to crop land; the characteristics of grasslands are variable based on historical factors (Collins et al. 1998, McCulley and Burke 2004, McCulley et al. 2005), and in their response to disturbances (Jackson, Bell and Gratton 2007, Woodis and Jackson 2009, Lyon et al. 2011).

Organic versus conventional crops

The literature review identified three studies of organic, non-pasture crops that could have implications for organic pastures.

In a study of cropland in northwestern Spain, researchers found that applying organic fertilizers (rabbit manure and vermicompost) in conjunction with synthetic fertilizers increased microbial activity in soils by 16 to 20 percent compared to synthetic fertilizers alone (Lazcano et al. 2013). The different fertilizer regimes produced similar sweet corn yields. However, microbial respiration was higher in plots receiving manure, indicating a higher level of microbial activity in those plots. Soil enzyme activity levels were higher in the treatments that included manure and vermicompost. This is important because soil enzymatic activity is thought of as a 'sentinel' that responds early to soil





management changes, and because soil enzymes influence organic matter and nutrient cycling dynamics (Bowles et al. 2014).

As part of a long-term research trial in Switzerland, Birkhofer et al. (2008) found that wheat fields under long-term organic management, including the application of farmyard manure, had enhanced soil quality and increased microbial biomass compared to fields where synthetic fertilizers and herbicides were used. However, grain and straw yields were 23 percent higher in the conventional plots where mineral fertilizers and herbicides were applied, showing that there can be a tradeoff between crop productivity and organic management practices. This study also demonstrated that organic management promotes biodiversity. Several kinds of soil nematodes and earthworms were abundant in the organic system compared to the conventional system. The use of organic fertilizers enhanced biological activity within and between belowground and aboveground organisms.

A Canadian research study (Schneider et al. 2015) examined why farms with low plant-available phosphorus have acceptable crop yields, even though such deficiencies can have a negative effect on yields and the ability of legumes to fix nitrogen. The goal was to test the theory that soil biological activity, including symbiosis between plants and AMF, is involved in providing crops with phosphorus at levels not reflected by soil tests. Three forage fields that had been managed organically for more than 20 years were compared to nearby conventional forage fields with a greater than 20-year history of synthetic phosphorus fertilization application. The study found no significant differences in the number of AMF species, but found differences in the AMF species colonizing the organic versus conventional fields. The researchers theorized that the AMF communities dominating the organic fields

better promoted crop yield, phosphorus-use efficiency and legume development under low phosphorus-test conditions.

These studies support claims that increased nutrient cycling and microbial activity occur in organic as compared to conventional systems under field crops. However, these findings should not be extrapolated to pasture ecosystems, where little evidence has been found for these effects.

Conclusion

“The literature on organic pasture management is sparse,” said Isidore. “We found some evidence from the scientific literature that organic management can stimulate soil life, but a lack of conclusive evidence for productivity differences between organic and conventional pastures.”

Thus the researchers recommend that organic dairy producers employ established principles of managed grazing to maintain pasture productivity. This includes rotating livestock frequently through paddocks so that plants are uniformly grazed, with significant residual biomass and time for regrowth. These techniques are critical on organic farms, where synthetic fertilizers and herbicides cannot be used to address the effects of overgrazing. More research on organic pastures and soils in conditions typical of the Upper Midwest is needed to improve understanding and develop recommendations about managing organic pastures to enhance pasture productivity and soil life.

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Photos by Ruth McNair, CIAS.

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