Nitrogen Credits for Cover Crops, and Composted Dairy Manure in a Long-Term Rotation Study

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INTRODUCTION

Cultural practices such as crop rotation, use of cover crops, or application of animal manure can greatly affect nitrogen (N) mineralization (the net amount of N released from organic matter) and thus the N availability for crop plants. This information is at the foundation of soil fertility management for organic farmers, particularly for corn and small grain production. Predicting the annual amount of N mineralization from organic sources is a major challenge for producers. The **objective** of this study was to determine the N credit for crop rotation, cover crop, and composted dairy manure by measuring the N accumulation of corn grown without fertilizer N. Above ground biomass N accumulation of unfertilized corn (no synthetic N fertilizer) can be considered as a 'bioassay' that estimates net soil N mineralization. Corn N uptake provides a window into soil biological processes and N availability from different organic sources.

METHODS

In 2006, our research group began managing the long-term field experiment called the Living Field Laboratory (LFL), which was started in 1993 by the CS Mott Sustainable Ag Chair, Dr. Richard Harwood. The experiment was designed to investigate the benefits of cover crops (as green manure) and/or the addition of composted dairy manure in either **rotated corn** (corn-soybean-wheat) or **continuous corn** systems. Certified organic management is one of the three management systems used in this experiment (Figure 1), allowing for important comparisons among organic, integrated compost and integrated fertilizer crop management systems. The LFL accommodates every entry point of the rotation each year which allows the impact of weather to be measured. It also has a factorial design which allows for the comparison of a number of interactions. All plots were split in two, with half planted to a cover crop each year, and half with no cover crop. Cover crops consist of red clover frost-seeded into wheat in March (incorporated the following spring), and cereal rye planted after corn harvest. In organic and integrated compost management systems, composted dairy manure was applied in the spring before corn planting to provide 100 lbs of total N. More details of the experiment can be found online at http://lter.kbs.msu.edu/research/long_term_experiments/living_field_lab.php.

RESULTS and DISCUSSION

LFL N Credits		**2006 N Credit**	**2007 N Credit**	**2006 + 2007 N Credit Ave**
Type of Credit	**System**	**lbs/A**	**lbs/A**	**lbs/A**
Rotation	IF	6.6	41.6	
	IC	7.6	54.4	
	OR	8.1	39.3	
	AVG	**7.4**	**45.1**	**26.3**
Cover Crop				
Red Clover	IF	26.3	56.2	
	IC	50.1	25.4	
	OR	52.1	26.8	
	AVG	**42.8**	**36.1**	**39.5**
Cereal Rye				
	IF	NA	7.1	
	IC	NA	-7.6	
	OR	NA	-2.6	
	AVG	**NA**	**-1.0**	**-1.0**
Compost				
Total	C-C	24.2	56.5	
	C-S-W	28.6	54.2	
	AVG	**26.4**	**55.4**	**40.9**
Historic	C-C	17.1	34.8	
	C-S-W	18.0	47.6	
	AVG	**17.6**	**41.2**	**29.4**

Table 1. N credits for crop rotation, cover crop, and composted dairy manure based on the average of data from 2006 and 2007. In 2006, crimson clover failed to establish in continuous corn and we switched to cereal rye in 2007.

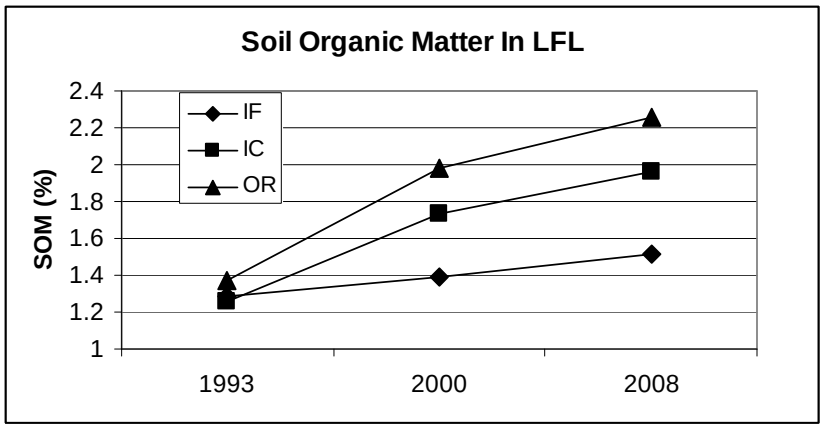

Figure 1. Soil organic matter over time for three management systems (Integrated Fertilizer = IF; Integrated Compost = IC; and Organic = OR). The IF system historically received synthetic fertilizer based on PSNT. The only difference between the IC and OR systems is that herbicide was used in IC; however, we did not apply compost to IC in 2006 and 2007. We believe the increase in soil organic matter in the OR system compared with IC is likely due to greater weed production due to the reliance on tillage only for weed control.

In 2006, we began to split corn plots in the IF and IC systems into equal halves where one-half of the plot received synthetic N fertilizer and the other half remained unfertilized for N. By not applying compost to the IC system, we were able to separate the effect of recent vs. historic compost application. This provides insights for the organic management system as well as the sustainable IF and IC systems.

Based on the difference in N accumulation in the corn bioassay and other soil nitrogen availability assessments undertaken, we compared rotated corn vs. continuous corn to determine a N credit for crop rotation, which was 26 lbs/A (Table 1). For cover crops, we found that approximately 1.8 tons of red clover/A contained 80 lbs of N/A and this provided a N credit of 40 lbs/A (Table 1). It is interesting to note that the total amount of N in weed biomass (no cover crop split plots) was approximately 20 lbs/A. Therefore our N credit for red clover represent the net difference in N mineralization between cover and no cover plots and can be considered a conservative estimate. There was no credit for cereal rye, which recycles some nitrogen and builds soil organic matter but does not apparently release sufficient N to be a significant N source for corn production. This is not surprising as the high N fertility requirements of corn necessitates that organic management include rotation with a legume such as red clover, and compost applications. The rye cover crop provides soil building benefits but was not a direct N source in our study. Composted dairy manure supplied approximately 40 lbs of N/A, of which more than 70% was due to the historic additions of compost (Table 1).

We have presented average responses here, but other data from this experiment has shown that weather has a large effect on the annual rate of N mineralization and caution that N supply will vary, and appears to be strongly influenced by precipitation patterns over the summer.

CONCLUSION

In summary, the data from the Living Field Laboratory at the Kellogg Biological Station supports the recommendation in the SARE publication 'Managing Cover Crops Profitably' 3rd Edition that about 50% of the N added in legume cover crop residues be considered as available to the subsequent corn crop managed organically. This is higher than the 33% N availability that is used in some recommendations about managing organic nutrient sources. It reflects long-term soil management, and we recommend that soil nitrogen status be considered a 'moving target' by organic farmers. Over time, compost and cover crop as well as crop rotation will all amend soils and build soil organic matter, which provides a consistent source of nutrients as well as supporting vigorous crop growth and health.