Final Report - SARE
Testing a Biological Fertility Program for Organic Grains
FNE 00-303

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INTRODUCTION

The primary goals of this two year project was to evaluate the cost effectiveness of complimenting my crop rotation program with inputs of composted manure made on my own farm and to carefully balance the mineral levels in the soil. The expected results were:

1. To dramatically reduce the incidence of diseases such as fusarium head blight through improved soil health, the fungicidal properties of the compost, and by composting the wheat straw before incorporation back into the soil.
2. To utilize surplus dairy manure available in my area to supply needed nutrients and organic matter and to use the composting process to destroy the weed seeds in this manure.
3. To allow me to incorporate rock phosphate and other needed minerals at an affordable rate by increasing their availability through enhanced microbial activity.
4. To increase both crop yield and grain quality, and there-by improve my bottom line.

My farm operation is 75 acres including rented land close to my farm and has been organic since 1980. My rotation includes wheat, hay, and soybeans. I grow about 30 acres of wheat each year, much of which I mill and sell as flour for human consumption. As a "value-added" crop grown in relatively small quantities, a reliable harvest of good quality is imperative.

PROJECT DESIGN

Year 1

A portion of Field #11 on my farm was chosen for the study as it was scheduled to be planted into wheat, had a relatively uniform soil type and a relatively vigorous standing crop of alfalfa. Unfortunately, after this study was completed, I discovered this section was also more poorly drained than I'd previously thought.

The field was divided into six test plots (41' x 300' each) - including two control plots, two plots for two different treatments, and two plots for replicates of these two treatments. Assigning numbers to each plot and then using a random number generator, Plots # 1 and #6 were selected as the "controls" to receive composted chicken manure, Plots #3 and #5 were selected for a "composted dairy/horse manure" treatment, and Plots #2 and #4 were selected to receive the "composted dairy/horse manure plus balanced rock minerals" treatment.

To establish baseline data and to determine optimum manure, compost, and mineral applications, soil samples were taken from each plot and sent both to Midwestern Bio-Ag and the University of Vermont for standard soil analysis. Soil samples were also sent to BBC Lab in Arizona for "Microbial Diversity Analysis". Compost samples were also sent to Midwest Laboratories Inc. Based on these test results, Midwest Bio-Ag recommended the mineral supplements used in Plots #2 and #4, as well as compost applications for Plots #2,#3,#4, and #5. These recommendations were for 8T/acre compost on plots #2, #3, #4, and #5. On Plots #2 and #4, the recommendations were for 8T/acre compost, as well as 500lbs/acre gypsum, 15lbs/acre copper sulphate, 15 lbs/acre zinc sulphate, 15 lbs/acre manganese sulphate, and 10lbs/acre borate. The control Plots #1 and #6 received partially composted chicken manure at a rate of 3T/acre. The compost and chicken manure were applied with a manure spreader while the minerals were applied by hand after plowing and before harrowing. The fields were then planted with AC Morley HR Winter Wheat at 140 lbs/AC on 9/16/00.

Year 2

The same soil and compost tests were performed in 2001, once again using recommendations from Midwest Bio Ag. Compost application was 9T/acre on Plots #2, #3, #4, and #5 and minerals were applied to Plots #2 and #4 in the following amounts: 150 lbs/acre gypsum, 5 lbs/acre copper sulphate, 15 lbs/acre zinc sulphate, 15 lbs/acre manganese sulphate, and 10 lbs/acre borate. Partially composted chicken manure was again applied to Plots #1 and #6 at 3T/acre. The ground worked up nicely in 2001 unlike the difficult conditions of 2000. AC Morley HR Winter Wheat was planted Sept.7, 2001 at 140lbs/AC. The wheat over wintered nicely. Yield measurements were made immediately prior to harvest by collecting all the wheat plants growing within five randomly selected four-foot square sampling areas within each of the six test plots. The average height of all the plants in the sample area was measured and then they were harvested and placed into grain bags. The wheat was then manually removed from the shafts and weighed. Grain samples were also sent for "grain quality" analyses to Intertek Testing Services (Year 1) and the University of Vermont (Year 2).

ON-FARM COMPOST PRODUCTION

Year 1

For the first year of this study, I purchased surplus cow manure from a large dairy farm about a mile away and hauled horse manure from another nearby farm. I also purchased some semi-composted poultry manure which was used both in the compost operation as well as applied directly to the test plots used as our controls. All these materials were dumped into two windrows during the fall and winter on a field closer to my barn. The following spring when the ground had dried sufficiently, Steven Wisbaum of Champlain Valley Compost Co. (CVCC) redistributed the different types of manure throughout the two windrows and trimmed them with a skid steer loader to the proper width (8 ft) and height (4.5 ft) to accommodate his self-propelled, straddle-type compost turner. Steven then turned the windrows three times over the next two months to maintain optimum biological activity, temperature (120 to 150F), and to expose any weed seeds to the hottest parts of the windrow.

Based on the costs of purchasing, hauling, and turning these materials, we estimate that the cost of producing this compost was approximately $9.50 per cu yd. This cost assumes about a 50% reduction in the volume during composting. It also includes the cost for contracting the windrow building and turning services to CVCC which added only another $2.50 per cu yd (and saved numerous hours of my labor and equipment use). However, this on-farm compost production cost is still about 47% higher than the cost of simply purchasing semi-composted poultry manure at about $6.50 per cu yd (including delivery).

Year 2

In the late autumn of 2000 I built another windrow with heavily bedded horse manure and partially composted chicken manure. Next to this, I built another windrow with square bales of wheat straw and partially composted chicken manure. Rock phosphate was also sprinkled on both windrows. However, since they were both excessively dry, Steven again trimmed them to an 8 ft width and then applied liquid cow manure that he incorporated with the compost turner until they had sufficient moisture and nitrogen to initiate proper decomposition. These two windrows were again turned at 3-week intervals to maintain optimum biological activity, temperature (120 to 150F) and exposure to the hottest zones inside the windrow to destroy both weed seeds and the fusarium pathogen.

Although I did not purchase raw dairy manure to make compost this year, I had a larger investment of labor associated with handling the straw bales. I also had to purchase multiple loads of liquid manure to add moisture and nitrogen to the straw and heavily bedded horse manure to ensure the success of the compost process. For this reason, the cost of producing this compost was still in the range of $9.50 per cu yd.

DATA COLLECTION/RESULTS

Year 1

Baseline Soil Microbial Bioassays: Soil samples were collected and sent to BBC Laboratory to obtain baseline data on the microbial populations present in the test plots. The analytical results provided data on both the concentration (or "enumeration") of microbes within key functional groups of microorganisms as well as the variety of microbes (or "species richness diversity") within each of the functional groups using an indexed scale. The "total species richness diversity" in this analysis is the sum of the species richness diversity index numbers for each of the key functional groups analyzed. In general, the different treatments (e.g. composted dairy/horse manure versus composted poultry manure) were projected to yield greater changes in the species richness diversity rather than the concentration of microbes.

Baseline Soil Nutrient Analyses: Soil samples were also collected for establishing baseline data on the nutrient content of the soil in the test plot and to determine application rates for the composted dairy/horse manure, composted poultry manure, and minerals. There were no significant nutrient deficiciencies or surpluses identified.

Fusarium Levels and Crop Yield: The presence of fusarium in all the test plots (as well as the rest of my farm) appeared to be significantly less than pervious years. However, due to a combination of inclement weather, poor drainage, and poorly prepared soil, the test plots showed reduced and uneven crop yields. For this reason, it was determined that measuring yields from the test plots would not provide useful data.

Protein Analyses: Samples from plots #4,#5, #6 were sent to Intertek Testing Service for analyses. The sample from Plot #4 (compost and minerals) contained 11.74% protein. The sample from Plot #5 (composted dairy/horse manure) contained 11.68% protein and the sample from Plot #6 (composted poultry manure) contained 11.37% protein. These data did not indicate any significant differences between the treatments.

Year 2

Soil Microbial Bioassays: Although there were not enough samples analyzed to perform standard statistical analyses for a true measure of "significance", significance in this interpretive application is based on changes of 1 log or greater (a factor of 10) for the enumerations and 1 index point or greater for the total species richness diversity.

When comparing the baseline with the year 2001 sample, the soil sample from the plot treated with compost dairy/horse manure and minerals (Plot #4) indicated a significant increase in concentration of the heterotrophic aerobic bacteria, anaerobic bacteria (including facultative anaerobes) and nitrogen fixing bacteria as well as measurable improvement in the yeasts and molds (fungi) and actinomycetes. The pseudomonads remained relatively constant. The sample from the plot treated only with composted dairy/horse manure (Plot #5) also showed significant increases in the concentrations (enumerations) of anaerobic bacteria and nitrogen fixing bacteria and some increase in the actinomycetes. However, the control (Plot #6) also showed significant increases in the concentrations of yeast and molds (fungi) as well as the nitrogen-fixing bacteria.

While the total species richness diversity in all the samples from all three test plots decreased between the baseline year and the year 2001, the most significant decrease was found in the control, which fell almost 5 index points. The possible reasons for this decrease in diversity include differences in the timing of sample collection, crop types (i.e. alfalfa to wheat), and/or environmental/climate conditions. However, here again without an analysis of a greater number of samples, it was not possible to determine the significance of the differences observed.

Soil Nutrient Analyses: Nutrient analyses soil samples collected from the test plots showed no significant differences between the three treatments in respect to organic matter, cation exchange capacity (CEC), pH, or minor and macro-nutrient levels.

Fusarium Infection and Crop Yield: Visual observations again indicated low levels of fusarium on the test plots as well as the rest of my farm. In addition, the average crop yields were .87 ton/acre (41" average plant height) in the control plots treated with composted poultry manure (Plot #'s1 and 6), 0.9 ton/acre (40" average plant height) in the plots treated with composted dairy/horse manure and minerals (Plot #'s 2 and 4), and 1.2 tons/acre (41" average plant height) in the plots treated just with composted dairy/horse manure (Plot #'s 3 and 5). These data showed no significant difference in yields between the three treatments. Surprisingly, these yields were also significantly below the 1.34 ton/acre yield (44" to 48" average plant height) for the rest of my farm during this same crop year.

Protein Analyses: Wheat samples collected from three test plots were sent to the University of Vermont for protein content testing. As shown on the attached table, the sample from Plot #4 (compost and minerals) contained 11.3% protein, the sample from Plot #5 (composted dairy/horse manure) contained 11.4% protein, and the sample from Plot #6 (composted poultry manure) contained 11.3% protein. These data did not indicate any significant differences between either the individual treatments or between the two study years. As with crop yield, these results were also less than the protein content of 12.5% in a sample collected from my entire harvest for this same crop year.

CONCLUSIONS/LESSONS LEARNED

While there were some differences observed in the analytical results produced during this study (e.g. grain yield, plant height, soil microbial assays, and grain quality), these differences were neither consistent or significant enough to prove or disprove the benefits of the respective treatments. It is also impossible to know if the relative wetness of the field used (compared to the rest of my farm) unfairly skewed these results. Despite these uncertainties, there were still some valuable insights gained from this study:

Importance of Fusarium Resistant Seed

I have since discovered that the AC Morley wheat I started using when this study began has an increased resistance to fusarium - which likely explains the fact that fusarium levels throughout my farm have decreased while crop yields have increased. I am now also saving and replanting my own AC Morley seed to gain further advantage.

Buying versus Making Compost

For the following reasons, I am now purchasing and using composted poultry manure on my farm instead of using either raw poultry manure (as done before this study) or compost made on my farm from surplus dairy and horse manure:

1. While there was some slight increase in yields in the plots that received composted dairy/horse manure compared to the control plots (treated with the composted poultry manure), this increase was not seen in the plots treated with the composted dairy/horse manure plus the minerals. In addition, even the higher yields in the plots receiving compost alone were not greater than the yields observed on the rest of my farm where I applied only composted poultry manure.

2. Although composting can potentially kill most of the weed seeds found in raw dairy and horse manure, we observed some weeds growing in the vicinity of the compost area from seeds likely present in the raw manure. Conversely, weed seeds are not typically associated with poultry manure and there was no indication of viable weed seeds in the composted poultry manure I started using during this project.

3. While the custom composting services offered by Champlain Compost Co. are convenient and added only about $2.50 to $3/cu yd (for finished compost) and although there is surplus manure available nearby, the cost of making my own compost (including the cost of purchasing and/or hauling this manure) is still higher than purchasing composted poultry manure that happens to be readily available in this area. In addition, because this composted poultry manure is higher in phosphorus and nitrogen, application rates are also less than the dairy/horse manure compost I could make myself.

4. Although not a significant disadvantage on my farm, composting still takes up space that could otherwise be used to grow crops.

Mineral Balancing

While mineral balancing has apparently helped other farmers throughout the country, data from this limited study did not indicate any benefit to my soil and crop conditions.

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GRAIN QUALITY TEST

	2001 CROP YEAR	2002 CROP YEAR
Plot #4		
Falling Number (seconds)	316	
Protein (%)	11.74	11.3
Plot #5		
Falling Number	318	
Protein (%)	11.68	11.4
Plot #6		
Falling Number	324	
Protein (%)	11.37	11.3
Whole Farm Sample		
Falling Number		
Protein (%)		12.5

MICROBIAL BIOASSAYS

Plot #4	ENUMERATION YEAR 2000 (BASELINE)	SPECIES RICHNESS DIVERSITY	ENUMERATION YEAR 2001	SPECIES RICHNESS DIVERSITY
Heterotrophic Plate (Aerobic)	5.4 x 10 6 CFU/gdw	2.2	6.2 x 10 7 CFU/gdw	2.4
Anaerobic Bacteria	4.5 x 10 6 CFU/gdw	0.9	4.2 x 10 7 CFU/gdw	0.8
Yeasts and Molds	4.0 x 10 4 CFU/gdw	1.7	1.0 x 10 5 CFU/gdw	1.4
Actinomycetes	1.5 x 10 5 CFU/gdw	1	7 x 10 5 CFU/gdw	0.3
Pseudomonads	3.0 x 10 5 CFU/gdw	2	1.8 x 10 5 CFU/gdw	1.7
Nitrogen-Fixing Bacteria	2.8 x 10 4 CFU/gdw	1.3	2.5 x 10 6 CFU/gdw	0.5
Total Species Richness Diversity (SRDT)		9.1		7.1
Plot #5				
Heterotrophic Plate (Aerobic)	6.2 x 10 6 CFU/gdw	2.2	4.0 x 10 6 CFU/gdw	2.3
Anaerobic Bacteria	3.7 x 10 6 CFU/gdw	1.7	3.4 x 10 7 CFU/gdw	0.3
Yeasts and Molds	3.6 x 10 4 CFU/gdw	0.9	3.1 x 10 4 CFU/gdw	1.1
Actinomycetes	1.9 x 10 5 CFU/gdw	1.7	7 x 10 5 CFU/gdw	0.5
Pseudomonads	1.3 x 10 5 CFU/gdw	1	4.6 x 10 4 CFU/gdw	2.4
Nitrogen-Fixing Bacteria	5.0 x 10 4 CFU/gdw	1.3	1 x 10 6 CFU/gdw	0.2
Total Species Richness Diversity (SRDT)		8.8		6.8
Plot #6				
Heterotrophic Plate (Aerobic)	7.1 x 10 7 CFU/gdw	3.6	5.6 x 10 7 CFU/gdw	2.1
Anaerobic Bacteria	3.1 x 10 6 CFU/gdw	1.8	5.1 x 10 6 CFU/gdw	0.6
Yeasts and Molds	2.6 x 10 4 CFU/gdw	0.9	5.4 x 10 5 CFU/gdw	1.2
Actinomycetes	3.2 x 10 5 CFU/gdw	1.8	4.3 x 10 4 CFU/gdw	0.9
Pseudomonads	1.7 x 10 5 CFU/gdw	2.5	2.8 x 10 5 CFU/gdw	1.7
Nitrogen-Fixing Bacteria	1.7 x 10 4 CFU/gdw	0.9	5.6 x 10 6 CFU/gdw	0.3
Total Species Richness Diversity (SRDT)		11.5		6.8