NY Agricultural Development Program
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Expanding Soil Health Assessment in NNY: Dairy Farms and Biofuel Production

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Background:

The intensive production of agronomic crops has contributed to reduced soil quality, and resulted in lower crop productivity and farm profitability. Among the causes are soil compaction, surface crusting, low organic matter, increased pressure and damage from diseases, weeds, insects and other pests, as well as a lower density and diversity of beneficial soil organisms. These constraints have increased the interest of land managers in assessing the health status of their soils and in implementing sustainable soil management practices. The Cornell Soil Health team has recently established a standard protocol for soil health assessment based on extensive research that included long-term field experiments (at Willsboro and Chazy) and growers' fields in NNY. Recently, dairy producers have shown interest in assessing the effects of manure management practices on soil health. A targeted study on how soil health indicators are affected in dairy systems will help these growers to better manage their soils.

The use of crop biomass as an alternative energy source has been generating a national debate in both the agricultural and energy sectors. Farmers are gaining interest in harvesting corn stover for biofuel production through cellulosic conversion. This provides additional income, and would reduce concerns about diversion of food into energy production. However, there are significant concerns whether soil health will be jeopardized through long-term removal of corn stover and the agricultural community is

eager to find answers to this question. A long-term (32 years) experiment at Chazy in NNY is a unique resource that would allow us to provide good quantitative data through our soil health assessment methods.

Methods:

We used the standard Cornell soil health protocol to assess dairy production fields in NNY and some other parts of NY to have a better statewide view on how soil health indicators are affected in dairy production systems. The Cornell Soil Health Test (CSHT) protocol consists of 15 soil indicator measurements that are integrated to assess soil constraints of farm fields. The indicators used in the CSHT include wet aggregate stability, available water capacity, surface hardness, sub-surface hardness, organic matter, active carbon, potentially mineralizable nitrogen (PMN), root health, pH, extractable phosphorus, extractable potassium and some minor elements.

Evaluation of the long-term effect of crop biomass removal on soil health was performed on a 32 year old Cornell experimental plot in Chazy, NY. The experiment consisted of four treatments replicated in four blocks:

- plow-till with stover returned (PT-R),
- plow-till with stover harvested (PT-H),
- no-till with stover returned (NT-R) and
- no-till with stover harvested (NT-H).

PT plots were moldboard plowed in the fall of each year, disked in the spring and then planted. NT plots were planted at the same time. In stover-harvested (H) plots, all above-ground plant matter was removed in the fall of each year. In stover-returned (R) plots only grain was harvested. Corn residues were incorporated into PT plots, and left on the surface of NT plots.

Soil samples were collected from the surface horizon for the measurement of physical, chemical and biological soil properties to be used as indicators of soil health. Laboratory measurements were performed for 24 soil physical, biological and chemical properties, and additionally water infiltration was assessed in the field making a total of 25 measurements.

Results:

Our first research objective was to investigate how soil health indicators are affected in dairy production systems from growers' fields across NY State. From figure 1, relatively higher percentages of the fields sampled had soil physical indicators constraints compared to biological and chemical indicators. About 40% of the fields had low available water capacity, and between 45-50% had problems with surface and sub-surface compaction (Fig. 1). Close to 20% of the fields had low organic matter and about 40% had low active carbon in the soil (Fig. 1). Very few fields (<10%) had constraint of PMN which is an indicator of nitrogen release potential of the soil (Fig. 1). As expected, relatively fewer fields were constrained by the chemical indicators (Fig. 1). From this result, it is evident that the major soil health indicators to address in dairy systems are the surface and subsurface compaction. These problems may be due to the heavy equipment and machinery such as manure spreaders going over the field. The result suggests the need for growers to exercise caution in how they go over the land with field equipment to avoid compaction of the soil. In those fields that are already compacted, there may be need for some remediation to avoid the deleterious effects of compaction on crop growth.

Our second research objective was to evaluate the long-term effects of harvesting corn stover on soil health indicators. Our results from the 32 years Chazy study are outlined below:

Overall Treatment Effects

Residue treatment significantly affected eight out of the 25 measured soil properties while the tillage treatment affected 15 out of the 26 measured soil properties (Table 1). Nine out of the 25 measured properties did not respond significantly to either stover harvest or tillage (Table 1). It was noted during field sampling, that the soil surface of the plow till plots, especially those with stover harvested, were crusted, sealed, cracked, compacted and lacking aggregation, while this was not the case for no till plots (Plate 1)

Residue management effects

A comparison of the overall stover-harvested relative to stover-returned treatments means showed that the former consistently had lower soil health scores: They had less organic matter by 8%, lower decomposition rates by 57% and lower easily extractable and total glomalin contents (proteins involved in biological functions and soil aggregation) by 25% and by 16%, respectively. Stover harvest also decreased the available water capacity by 8% and increased the bulk density by 5%, while K and Mg concentrations decreased by 44%, and 20%, respectively.

Comparison of residue and tillage effects

Of the soil properties that were affected by tillage and residue treatment, the majority changed more dramatically due to tillage than due to stover harvest. In comparison to a 5% difference in bulk density due to stover harvest, tilled soils (PT) were 10% denser relative to NT. Relative to NT, PT decreased available water capacity by 13%, OM by 25%, total glomalin by 26%, Mg contents by 15%, decomposition rate by 51%, and easily extractable glomalin by 19%. Other soil properties also showed significant differences between tillage treatments (Table 1): aggregate stability decreased by 62% under PT relative to NT, PMN by 40%, NO_3-N by 27%, and Zn by 33%. Overall pH was higher, i.e. more alkaline under PT (8.05) compared to NT (7.81). Higher Al by 27%, higher Mn by 18% and lower Parasitic Nematodes by 85% were also found under PT.

Conclusions/Outcomes/Impacts:

Soil Health Indicators in Dairy Systems:

Significant numbers of dairy farm fields have problems of surface and subsurface compaction. A similar observation was made for the fields in cash grain crops from previous years' results. Specific research and educational outreach to target the prevention of soil compaction and to remediate already compacted fields would help NNY growers sustain and improve the soil quality of their fields.

Corn Stover Harvest Study:

Comparing the means of soil health indicator separated by tillage and residue treatment, there was a consistent trend from "better" to "worse" as follows: NT-R > NT-H > PT-R > PT-H. No-tillage significantly improves many soil processes (as measured through soil health indicators) irrespective of residue treatment, and stover return provides additional (although smaller) soil health benefits, especially with respect to several organic-matter-dependent soil processes. This results in improved soil structure and stability, water

storage capacity, carbon storage, cellulose decomposition potential, and nutrient availability.

We conclude from this study that, on a silt loam soil in a temperate climate, long-term stover harvest had lower adverse impacts on soil health than long-term tillage. Stover harvest appears to be sustainable when practiced under no tillage management. In real commercial farm situations, management strategies such as crop rotation, cover cropping and additions of organic amendments can help improve soil health, making stover use as feedstock for energy industries a more viable and sustainable option. Also, partial stover removal, rather than complete harvest, may adequately address soil health and erosion concerns, while providing valuable additional income for biofuel.

Outreach:

Our outreach in the past year focused on producing educational materials to help growers and educators in the region understand the concepts and assessment of soil health better. We published a Soil Health Training Manual which we distributed to growers in the region. This manual is also accessible on the soil health website. The link for accessing the manual is:
http://soilhealth.cals.cornell.edu/Cornell%20Soil%20Health%20Manual.htm
We also reworked our website to provide more information on the progress of soil health initiative in NY and the Northeast. The Cornell Soil Health website link is:
http://soilhealth.cals.cornell.edu
We have planned 4 winter meetings to hold in January and February of 2008 to promote soil health knowledge among growers in all the NNY regions.

Next steps

We plan to continue our soil health educational activities in NNY. We will continue to promote the new Cornell Soil Health Test as a soil management tool among NNY growers. This new test will help growers to identify and manage soil health constraints in their fields for increased and sustained productivity. We will continue to advance management strategies to overcome soil health constrains that we have observed in many NNY fields. We also plan to produce more educational materials such as fact sheets and case studies to help growers and educators learn more about the benefits of soil health management.

Reports and/or articles associated with this project.

1. Gugino, B.K, Idowu, O.J., Schindelbeck, R.R, van Es, H.M., Wolfe, D.W., Moebius, B.N., Thies, J.E. and G.S. Abawi (2007) Cornell Soil Health Assessment Training Manual, 1st ed. Cornell University, Geneva, NY.
2. Bianca Moebius, Harold van Es, John Idowu, Robert Schindelbeck, Daniel Clune, David Wolfe, George Abawi, Janice Thies and Beth Gugino (2007) Harvesting Corn Stover for Bioenery: Does it have Long-term Effects on Soil Health? What's Cropping Up? 17, (3) 5-8.
3. John Idowu, Bianca Moebius, Harold van Es, Robert Schindelbeck, George Abawi; David Wolfe; Janice Thies; Beth Gugino; Dan Clune. (2007) The New Cornell Soil Health Test: Protocols and Interpretations. What's Cropping Up? 17, (1) 6-7.

For more information

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Photos

Plate 1. A picture of soil surface of 2 plots comparing 32 years of moldboard plow tillage with stover harvested with no-till soil with stover returned as surface residue.