Effect of Nitrogen- vs Phosphorus-Based Manure and Compost Management on Soil Health

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INTRODUCTION

- Production economics and federal and state environmental regulations may increase producer interest in shifting from N-based surface application of manure to P-based application with incorporation.
- A shift from N- to P-based manure management can impact crop yield and soil health.
- A research trial was established in Aurora, NY in 2001. After 15 years of a rotation of corn (*Zea mays* L.) and alfalfa (*Medicago sativa* L.) with manure and composted/separated dairy solids addition at N-based vs P-based rates, compared to inorganic N application, during corn years, compost amended plots had higher yields (Fig. 1) and higher organic matter levels, reflecting improved soil health.

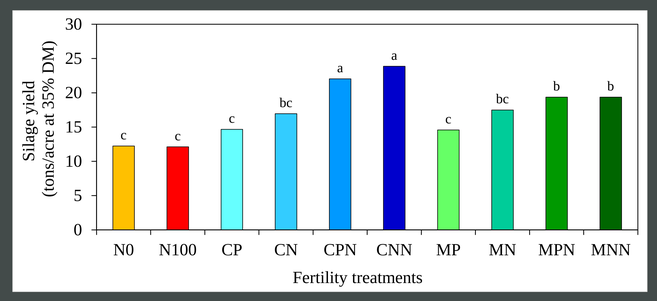


Fig. 1: Corn silage yield in 2015 as influenced by liquid dairy manure, composted/separated dairy solids and inorganic side-dress nitrogen application in a corn-alfalfa rotation system.

OBJECTIVES

Our objective was to evaluate existing soil health indicators for their ability to predict elevated yields obtained in manure and compost amended fields.

MATERIALS AND METHODS

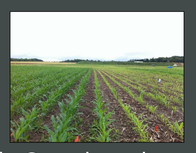
Field trial

- A randomized complete block design with five replications was implemented in April 2001 and continued through 2015 in Aurora, NY.
- In corn years (2001-2005 and 2011-2015), ten treatments consisted of:
  - Two rates of composted/separated dairy solids: P-based (CP) and N-based (CN) (15 and 40 ton/acre), each with or without side-dressing of 150 lb N/acre.
  - Two rates of liquid dairy manure: P-based (MP) and N-based (MN) manure (10,000 and 17,000 gal/acre) each with or without side-dressing of 150 lb N/acre.
  - Two inorganic nitrogen side-dress rates (0 and 100 lb N/acre) as controls.
- Phosphorus-based manure was directly incorporated after application (< 1 day).
- Under alfalfa/grass years (2006-2010), no further manure or composted solids addition was done.
- Corn was harvested for silage and grain in 2015, the 5th year in the corn portion of the rotation.

MATERIALS AND METHODS

Data collection and analysis

- Soil (0-8 inch depth) was air dried and sieved with a 6 mm sieve prior to analysis for aggregate size distribution. An automated shaker was used to separate aggregates into five sizes (4-6, 2-4, 1-2, 0.25-1, and <0.25 mm).
- A soil compaction penetrometer was used to measure soil penetrability at four depths (0-4, 4-8, 8-12, and 12-16 inches) in the field.
- Soil was sampled from a 0-8 inch depth and analyzed for the Haney soil health score derived from four factors: Solvita CO_2 respiration, water extractable organic (WEO) C:N ratio, water extractable organic C (WEOC), and water extractable organic N (WEON).
- All soil health parameters were statistically analyzed using proc GLM in SAS. A stepwise regression analysis was used to evaluate which soil health indicators can predict corn silage yield.

(a) 

(b) 

Fig. 2a-b: Organic vs. inorganic treatments (a) and Solvita test (b).

RESULTS

Aggregate size distribution

- Results of contrast analysis showed greater percentage of aggregates (2-4 mm) in organic (34%) versus inorganic (29%) treatments (P<0.03) (Table 1). Zero N control had more smaller aggregates (25%) compared with organic treatments (22%).

Table 1. Aggregate size distribution (ASD) as influenced by manure, compost, and inorganic N treatments.

Parameter		Unit	Fertility treatments					
			Inorganic N		Manure		Compost	
			0N	100N	MN	MP	CN	CP
	4-6	mm	15	15	18	16	17	16
	2-4	mm	29	30	33	34	33	34
ASD (%)	1-2	mm	25	23	22	23	22	23
	0.25-1	mm	22	22	18	18	19	19
	<0.25	mm	9	10	8	8	8	8

Soil penetrability

- Soil penetrability was similar among treatments at each depth.

Haney soil health test

- Solvita CO_2 respiration and the WEO C:N ratio ranged from 28 to 47 ppm and 10.0 to 10.6, respectively, and did not separate the composted/separated solids, manure or inorganic N treatments.
- WEOC and WEON were greater in N-based compost/separated solids than in any other treatments (Fig. 3).
- The overall Haney soil health score was greater in CN (11.7) followed by CP (10.9) and were significantly higher in the composted/separated solids than in the manure and inorganic N treatments (Fig. 3).

RESULTS

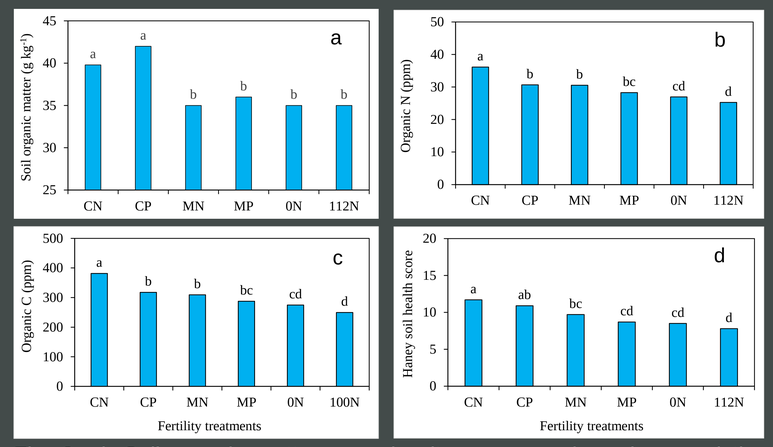


Fig. 3a-d. Soil organic matter, organic nitrogen, organic carbon, and the Haney soil heath score after 15 years of liquid dairy manure, composted/separated dairy solids, and inorganic nitrogen application in a corn-alfalfa rotation.

Predicting corn yield with soil health indicators

- Stepwise regression analysis indicated that two significant factors explained 56% of the variation in corn silage yield; WEOC was the first significant predictor explaining 47% of the variation in yield (P<0.001). The second variable was inorganic N (P<0.03; r^2=0.14). The Haney soil health score, Solvita CO_2 respiration, and WEO C:N ratio were factors that could not predict yield variability when included in the model (Fig. 4).

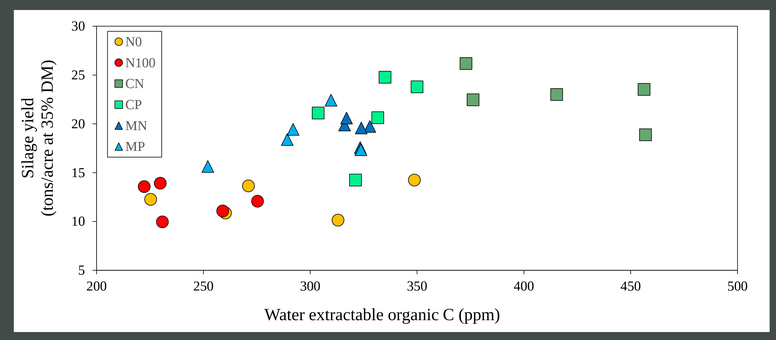


Fig. 4. Corn silage yield in ton/acre predicted by WEOC.

CONCLUSIONS

- Indicators that reflected the increase in soil health with addition of composted/separated solids and manure include aggregate distribution, WEOC , WEON, inorganic N, and the Haney soil health score.
- Soil penetrability at 0-4, 4-8, 8-12, and 12-16 inches did not show significant differences among fertility treatments.
- WEOC and inorganic N explained 56% of variability in corn silage yield.
- Our results suggest that further evaluation of soil health indicators is needed.

ACKNOWLEDGMENTS/CONTACT INFO

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