Effects of Organic Dairy Manure Amendment on Soil Phosphatase Activities

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INTRODUCTION

Organic dairy (OD) production is increasing in the Northeastern U.S. in response to consumer demand. Typically, management of OD farms differs from conventional dairies (CD), with bedding provided in barns and inclusion of more grazing and forage-based feedstuffs (***Fig. 1***). Some of the physico-chemical properties of OD manure differ from CD manure. Specifically, OD manure contains more soluble inorganic phosphorus (P) and Ca/Mg-associated P, and less monoester P and stable phytate P, than CD manure. In addition, OD manure can be high in carbon (C), and contains more stable humic- and lignin-related organic matter than CD manure. Thus, soil fertility and nutrient cycling may not be the same when OD manure is used as fertilizer as is typically observed with CD manure. Organic systems are necessarily reliant on manure and compost as fertilizer; therefore, information is needed on the availability of P from OD manure and its effects on key enzymes involved in P cycling.

OBJECTIVES: **Evaluate the effects of OD manure on soil phosphatase activities, available soil P, and the growth of sorghum-sudangrass (*Sorghum bicolor* subsp. *Drummondii*).**

Fig. 1. An organic dairy in Mapleton, Maine.

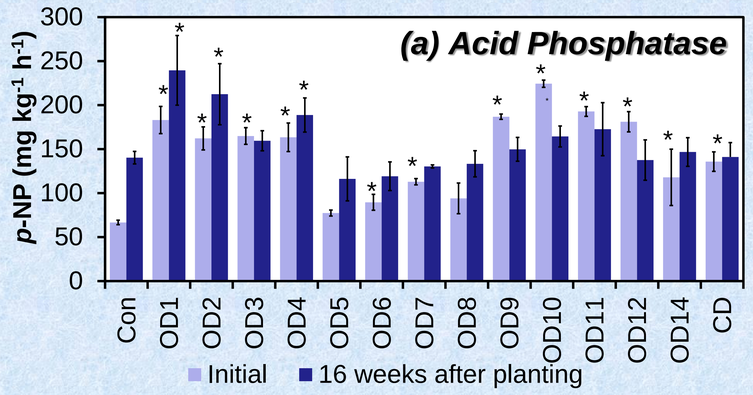
Fig. 2. Sudangrass plants growing in greenhouse.

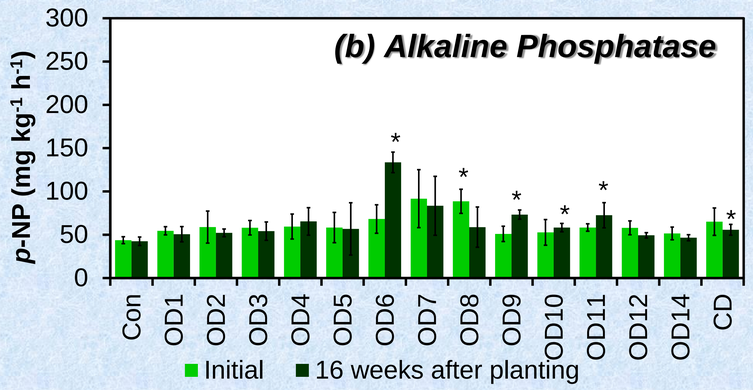
MATERIALS AND METHODS

- Manure samples were collected from 13 certified OD farms in Maine and one CD farm. Selected manure properties are shown in ***Table 2.***
- Soil (0-20 cm) was collected from a USDA-ARS site at Newport, Maine (Bangor silt loam, coarse-loamy, mixed, frigid Typic Haplorthod). Specific soil properties were: 42% sand, 6% clay, 2.52% C, 2.5 mg kg^{-1} modified Morgan P, 2.0 g kg^{-1} total N, pH 5.2, CEC 4.8 cmol (+) kg^{-1}.
- Manures or NH_4NO_3 were mixed in soil at a constant N rate of 143 mg N kg^{-1}. Aliquots of 2.0 kg soil were placed in 6-inch diameter plastic containers, brought to 60% wfps, and packed to 1.2 Mg m^{-3}. Sudangrass was planted in the amended soils and grown in a greenhouse in Orono, Maine for 16 weeks, with aboveground biomass harvested by cutting about every 5 weeks (***Figs. 2 and 3***).
- Activities of **acid phosphomonoesterase (ACP)**, **alkaline phosphomonoesterase (ALP)**, and **phosphodiesterase (PDE)** were determined in soil at planting and after 16 weeks of plant growth (Tabatabai and Bremner,1969) (***Fig. 4***)
- Modified Morgan P was determined in soil at planting and after 16 weeks of plant growth (***Fig. 5***).

TABLE 2. **Selected properties of 13 OD manures and a CD manure.** There was a wide range in C:N and C:P ratios of OD manures.

Manure	*% DM*	*C (%DM)*	*N (%DM)*	*C:N*	*P (g/kg)*	*C:P*	*NH_4^+-N (g/kg)*
OD1	24	38	2.8	14	19	20	12
OD2	22	30	1.7	17	4.5	66	4.0
OD3	19	40	2.1	19	5.4	74	5.4
OD4	19	42	1.5	30	5.8	72	4.2
OD5	16	42	1.5	28	4.4	94	5.7
OD6	21	35	1.8	19	5.2	67	3.3
OD7	30	45	0.9	52	2.0	227	3.7
OD8	23	41	1.5	28	2.6	159	3.0
OD9	20	42	1.4	29	4.5	92	1.0
OD10	20	42	1.4	29	3.4	124	2.9
OD11	20	43	1.3	34	3.5	123	2.5
OD12	19	43	1.4	30	4.9	88	6.3
OD14	20	40	2.4	17	2.4	168	7.9
Mean(SD)	21(3)	40(4)	1.7(0.5)	27(10)	5.2(4.2)	106(54)	4.7(2.7)
CD	15	37	1.3	27.5	6.9	53	4.1





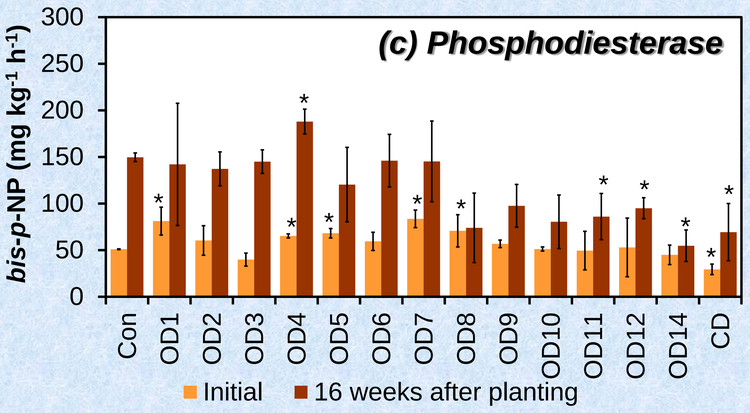


Fig. 4. **Effects 13 OD manures, CD manure, and inorganic fertilizer (Con) on activities of (a) ACP, (b) ALP, and (c) PDE. Asterisk (*) indicates significant difference from Con at that specific time point.**

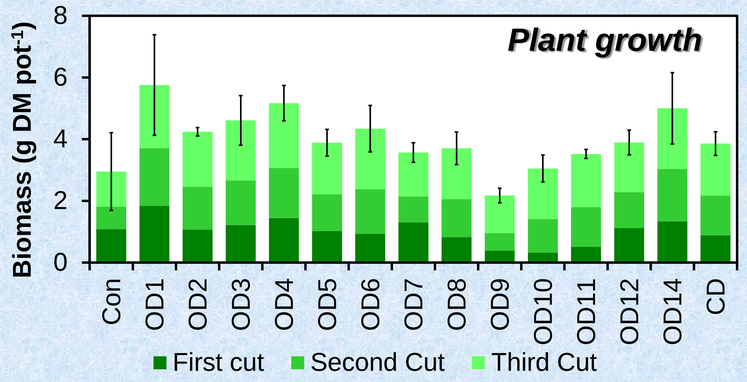


Fig. 3. **Aboveground biomass production by plants fertilized with OD manure, CD manure, or inorganic fertilizer (Con).**

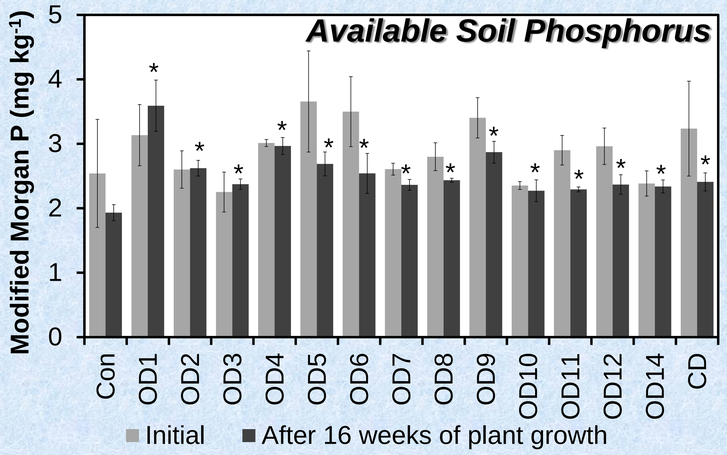


Fig. 5. **Effects of OD manures, CD manure, or inorganic fertilizer (Con) on available soil P.**

CONCLUSIONS

- There was no difference ($p > 0.05$) in growth of sudangrass fertilized with equivalent N rates from OD manure, CD manure or inorganic fertilizer (***Fig. 3***) However, there was a wide range in biomass production with OD manure, which was negatively correlated to manure C:N and C:P ($p < 0.05$) ratios.
- After 16 weeks, soils that received OD manure had higher modified Morgan P concentrations than soils that received inorganic fertilizer ($p < 0.05$), but there was no difference between OD and CD manured soils ($p > 0.05$) (***Fig. 5***).
- Of the three major soil phosphatases, ACP activity was highest, and increased following OD manure amendment, in a manner similar to CD manure (***Fig. 4a***)
- There was a negative correlation ($p < 0.01$) between ACP activity and OD manure C:P ratios, suggesting that **high C content in manure influences P cycling and may reduce P availability in soils amended with OD manure**, in a manner similar to CD manure.