

A Comparison of Methods to Estimate N Mineralization in Soils Amended with Poultry Litter

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INTRODUCTION

The use of poultry litter (PL) as a fertilizer has the capacity to increase the organic fraction of the soil in the long-term. As a consequence, the nitrogen (N) mineralization potential (N_{min}) of the soil can potentially be increased. The process of measuring N_{min} is time consuming, as the aerobic incubation of soil takes six months to be completed. Therefore, short-term biological and chemical indexes have been developed to estimate N_{min}. The validity of these indexes has never been confirmed in soils amended with PL.

Objectives: 1) To quantify the change in N_{min} in soils amended with PL versus amended with inorganic fertilizers
2) To evaluate the validity of the use of N_{min} estimators in these soils.

RESULTS

- Differences in total C and N between treatments with PL and inorganic fertilizer varied with soil (Table 1)
- The greater the clay content, the larger the difference between inorganic and PL treatments in total C ($\Delta C = 0.0147 \times \% \text{clay} - 0.1549$, $R^2 = 0.84$) and in total N ($\Delta N = 0.0018 \times \% \text{clay} - 0.0092$, $R^2 = 0.96$; Table 1).
- The C:N ratio tended to be smaller in PL treatments, suggesting an increase in the N mineralization potential.
- Three soils amended with PL have an increased N mineralization potential when compared to the same soils that received inorganic fertilizers (Fig. 1).
- The difference was 18, 62 and 115 mg N kg⁻¹ for Delaware 2, Iowa and Georgia respectively, while no differences were observed in Delaware 1.
- The increase in N mineralization was associated with the accumulation of total N caused by PL application.

Table 1. Carbon and nitrogen concentration in four different soils after more than 10 years of inorganic or poultry litter fertilization

Soil	Treatment	C (g 100g ⁻¹)	N (g 100g ⁻¹)	C:N
Delaware 1	Inorg	1.24 d	0.076 f	16.3 a
	PL	1.17 d	0.084 f	14.0 b
Delaware 2	Inorg	1.16 d	0.110 e	10.5 d
	PL	1.34 d	0.132 d	10.1 d
Iowa	Inorg	2.30 c	0.198 c	11.6 c
	PL	2.52 b	0.236 b	10.7 d
Georgia	Inorg	2.64 b	0.248 b	10.6 d
	PL	3.09 a	0.311 a	9.9 d

- NaOH and ISNT extracted more N than the rest of the methods due to the more powerful nature of the used extractant, which hydrolyzes organic N compounds (Table 2).
- Hot KCl and ISNT presented different relationship with N_o depending on the fertilization treatment. Similar values of extracted N with either method were related to different N_o values.
- Using the relationship developed for soils receiving inorganic fertilizer would underestimate the mineralization potential of soils receiving PL
- In soil with greater clay content, where the effect of PL over C and N content was more evident, the inefficiency of the estimation methods was larger.
- From all the evaluated methods, N_{an} showed the best correlation with N_o, due to the shared biological nature of both methods, and was not affected by the fertilization treatments.

Table 2. Methods to estimate N mineralization (N_{min} estimators)

Soil	Treatment	N-PF	Hot KCl				
			Nan	NaOH	PB	ISNT	
		<i>(mg N kg⁻¹)</i>					
Delaware 1	Inorg	0.009	1.7	41.0	88.3	16.1	33.3
	PL	0.011	1.9	34.5	87.2	14.4	67.7
Delaware 2	Inorg	0.008	1.8	60.6	121.8	19.5	111.8
	PL	0.013	2.0	70.1	144.7	23.5	129.3
Iowa	Inorg	0.010	2.9	73.0	223.5	61.9	228.7
	PL	0.038	2.9	107.5	247.8	50.3	233.0
Georgia	Inorg	0.026	5.7	126.6	352.3	58.9	364.8
	PL	0.051	6.1	172.2	301.5	57.3	390.8

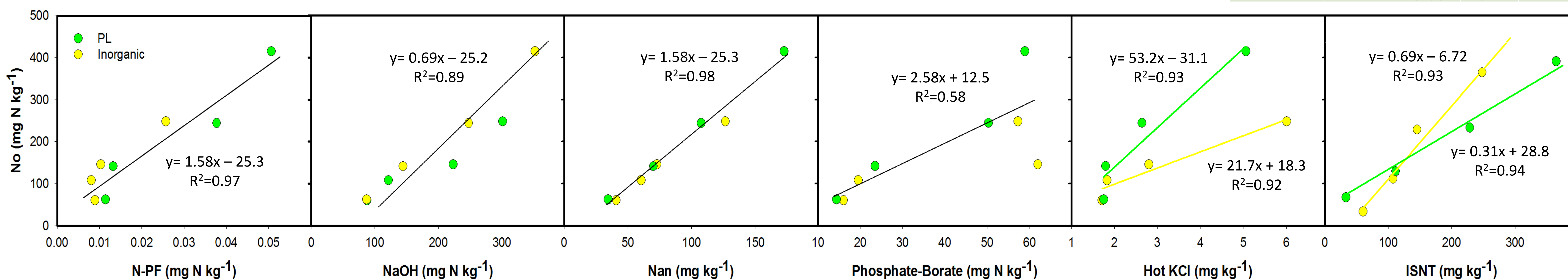


Figure 2. Relationship between N_{min} measured by long-term aerobic incubation (N_o) and N_{min} estimated by six different methods

CONCLUSIONS

The increase in C and N content in soil generated by the long-term (>10 years) application of PL was positively associated with clay content. As a result, a soil with a small % clay (Delaware 1) did not show differences in N_{min} measured by long-term aerobic incubation, while soils with more than 30% clay showed differences of up to 115 mg N kg⁻¹ soil (85% more in PL treatment compared to inorganic fertilization). Regarding the N_{min} estimation methods, some of them tended to underestimate or overestimate N_{min} in PL treatments, while others did not have a high regression coefficient with N_o.

N_{an} is recommended, as it showed the best correlation with N_o and was not affected by the fertilization treatments.

MATERIALS AND METHODS

- Soils from 3 states:
 - Delaware 1 (Ultisol, Woodstown series, pH: 6.1, 11.8% clay)
 - Delaware 2 (Ultisol, Mattapex series, pH: 6.0, 14.5% clay),
 - Iowa (Mollisol, pH: 5.5, 29.2% clay)
 - Georgia (Ultisol, Cecil series, pH: 5.46, 39.9% clay)
- Two treatments in each soil: - >10 years of inorganic fertilization and >10 years of PL application
- Soil samples mixed with sand and incubated at field capacity for 98 days with bi-weekly leaching (0.01M CaCl₂)
- Nitrate in leachate measured by ion chromatography (No).
- N_{min} estimators:** anaerobic incubation for 7 days (N_{an}), Illinois soil test analysis (ISNT) extraction with hot KCl, distillation with NaOH or phosphate-borate (PB) and quantification of N in the soil particulate fraction (N-PF).

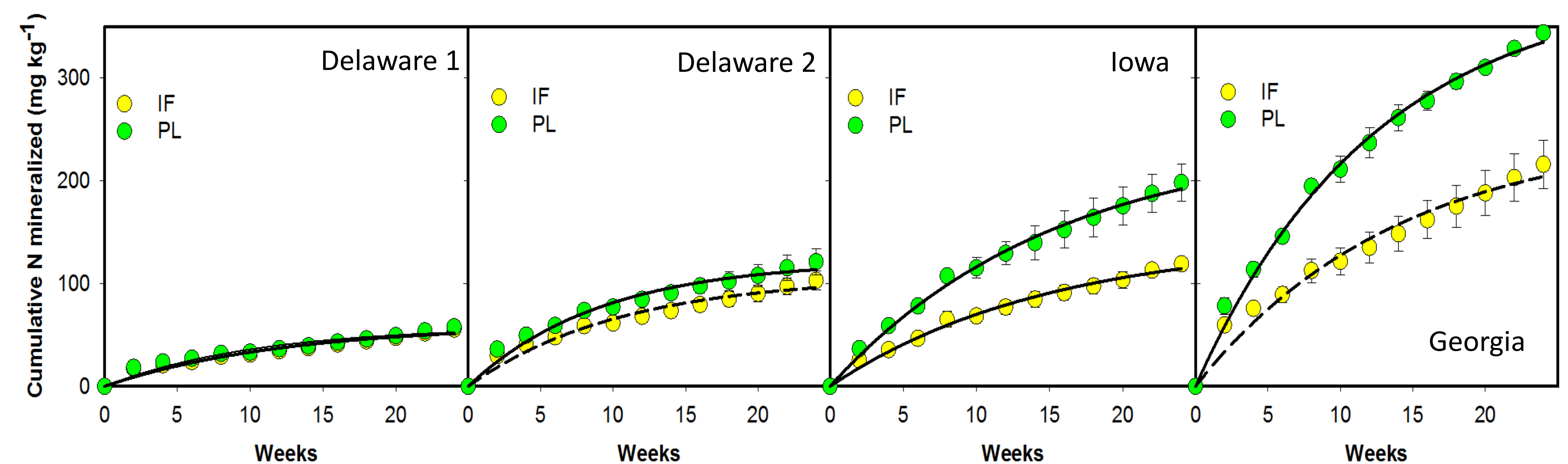


Figure 1. Cumulative N mineralized in a long-term aerobic incubation of four soils amended >10 years with PL or inorganic fertilizer.

