Relationship Between Labile Soil Organic Matter Fractions and Plant Productivity

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Introduction

- Active pool of soil organic matter (SOM) is small (usually <10% of the total), but extremely important in determining the availability of nutrients that are rapidly cycled, aggregate stability, and soil C accrual.
- Permanganate oxidizable C (POXC) and mineralizable C (C-min) are the two rapid and inexpensive tests for routinely measuring the pool of active organic matter.
- However, there has been no comprehensive evaluation to assess the relationship between these two tests across a range of soils and land-use types, including what relevant ecosystem processes they reflect.

Objective: to (i) examine the relationship between POXC and C-min over a broad spectrum of soil types and cropping systems, and (ii) examine the ability of both POXC and C-min to predict crop productivity.

Materials and Methods

Over 1000 soil samples, representing a range of soil types and land use types across the US, were analyzed for permanganate oxidizable C (POXC; Fig. 1) and one-day mineralizable C (C-min; Fig. 2).

Fig. 1. POXC Procedure

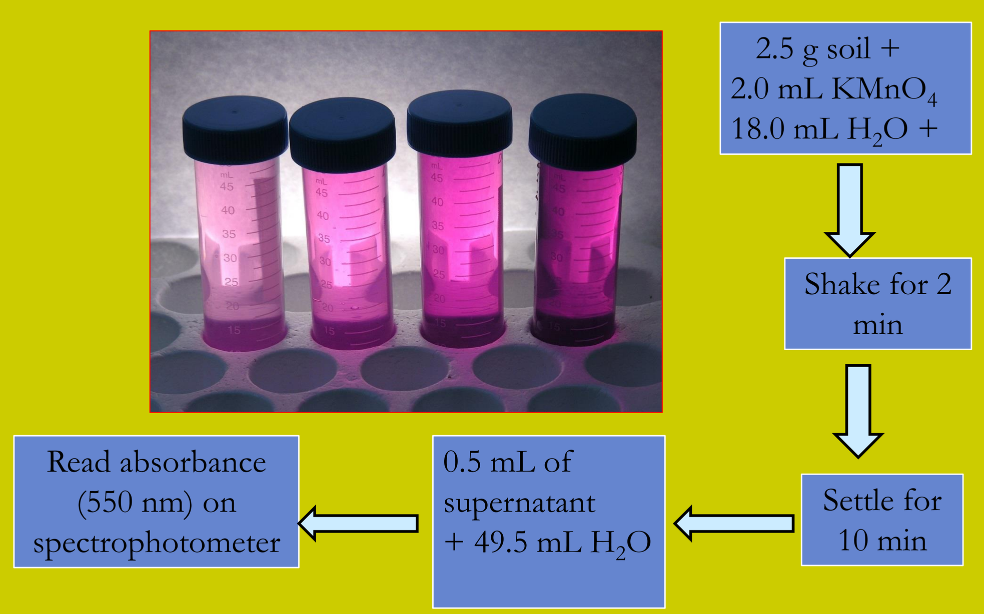
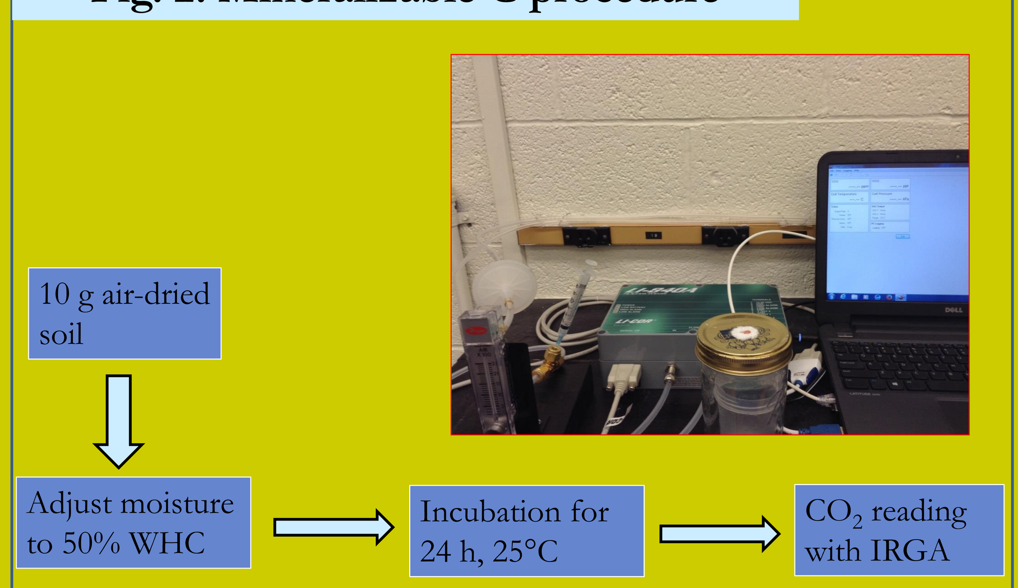


Fig. 2. Mineralizable C procedure



Data Analysis:

- To examine relationship between POXC and C-min with respect to management factors, residuals generated from linear regression models were used.
- All subset regression was used to determine the ability of these two tests to relate to plant productivity.

Results and Discussion

Relationships between soil C fractions

Table 1. Coefficients of determination (r^2) between mineralizable C and POXC, microbial biomass C (MBC), and SOC by study.

Study	POXC	MBC	SOC
FREP†	0.15***		0.07*
ICL	0.73***	0.77***	0.84***
LFL	0.35***		0.39***
Niles	0.74***	0.68***	0.70***
OUG	0.80***	0.27**	0.68**
TS†	-0.00*NS*	0.06*	0.06*
Watkinsville	0.56***	0.59***	0.62***
WORT	0.42***		0.41***

† If site were entered as covariate, improved relationship was noted between mineralizable C and POXC (r^2 = 0.57 for FREP and r^2 = 0.16 for TS), MBC (r^2 = 0.11 for TS), and SOC (r^2 = 0.59 for FREP and r^2 = 0.15 for TS).
NS = not significant.

- In all studies except for the TS study, mineralizable C was significantly related to POXC (Table 1; Fig. 3) and with other soil C fractions (MBC and SOC; Table 1).

- For multi-site studies, entering site into linear model as covariate contributed greatly to improving relationships between soil C fractions (Table 1).

Results Cont'd

POXC vs Mineralizable relationship as influenced by management

Table 2. Mean values (mg kg^{-1} soil) for POXC and mineralizable C (C-min) and residuals generated from linear models and crop yield (Mg ha^{-1})

Study	Treatment	C-min	POXC	Residuals	Corn	Tomato	Wheat
FREP	Cover crop	77.7	255.7	0.498	19.45	67.48	4.61
	Compost	87.8	496.0	-0.257	22.1	70.39	5.75
	Synthetic fertilizer	68.6	450.0	0.065	27.73	74.87	5.91
ICL	CT	130.8	464.2	0.767			2.33
	NT	173.4	575.9	-3.002			2.28
LFL	Compost	58.5	384.8	-1.840	9.72		
	Conventional	47.2	231.6	-2.898	9.55		
	Integrated	56.6	268.9	5.084	10.45		
	Continuous Corn	48.4	264.4	-3.665	9.32		
	Corn-Soy-Wheat	59.8	316.5	3.097	10.49		
Niles	NT	470.4	460.5	-18.040			
	PM	516.7	469.7	18.040			
OUG	Control	371.3	208.6	1.608		4.87	
	Compost + Biochar	1372.4	1039.1	-0.100		31.36	
	Cover crop + Biochar	954.1	955.2	-3.705		40.28	
TS	Compost	461.9	615.3	-2.150		81.0	
	Manure	438.9	498.3	3.013		87.0	
WORT	Ley	763.3	588.5	-19.211		34.1	
	Row Crop	721.7	520.9	-6.255		25.3	
	Vegetable	788.3	562.8	26.529		23.7	
	Compost	786.6	595.9	-1.889		27.7	
	Manure	785.8	553.7	31.351		32.3	
	Cover crop	704.1	524.5	-26.759		23.1	

- Residuals were generated by running linear models in which C-min was the response variable and POXC was the predictor variable; so, residuals above the best fit line (+ residuals) indicate greater C-min values and those below the best fit line (-residuals) indicate higher POXC values.
- Compost, no-till and perennial ley treatments were associated more with POXC; whereas tilled treatments, annual cropping (e.g., vegetable production), and diverse rotations with leguminous cover crops associated more with C-min.

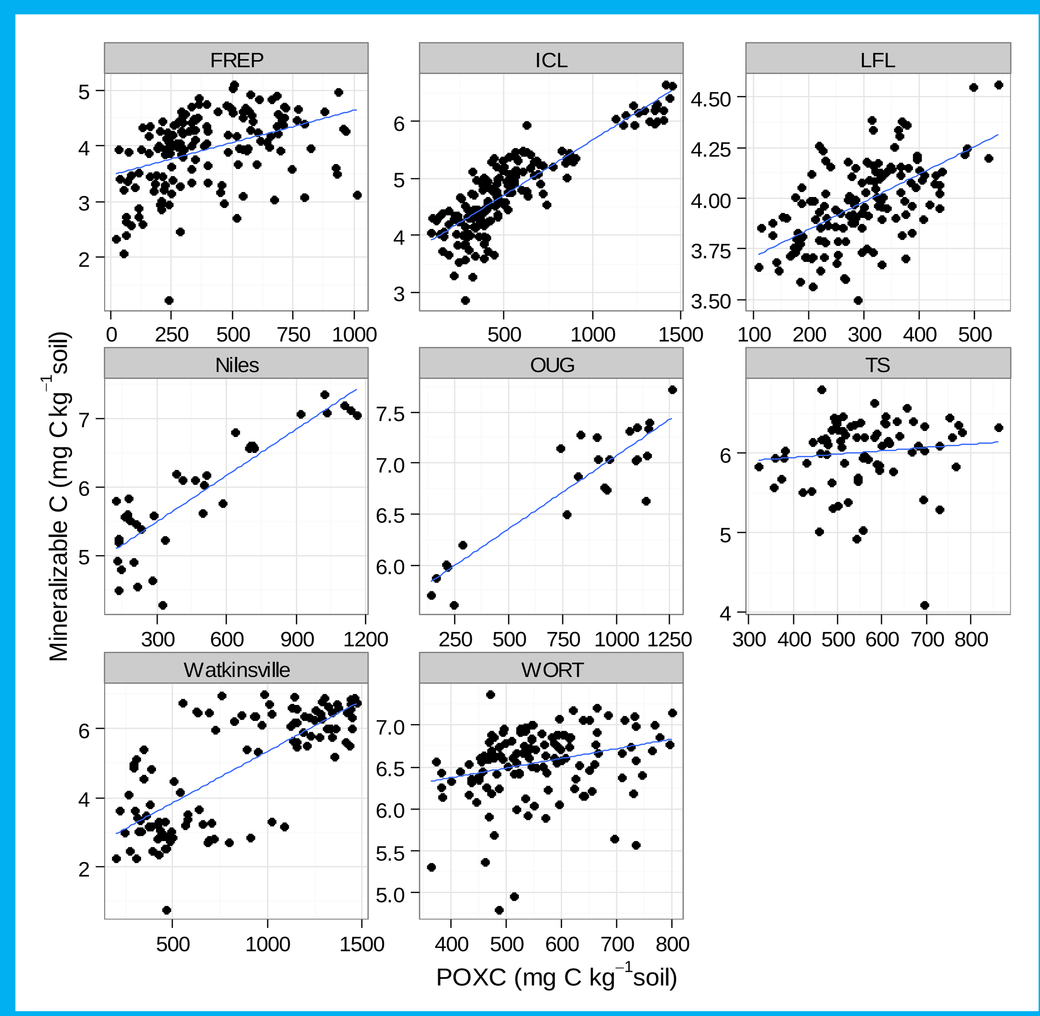


Fig. 3. Relationship between C-min and POXC by study

Ability of soil C fractions to relate to plant productivity.

Table 3. Relationship between soil C fractions plant productivity

		Rank		
Study	Crop	1st	2nd	3rd
FREP	Corn	C-min	POXC	SOC
LFL	Corn	C-min	POXC	SOC
FREP	Wheat	SOC	POXC	C-min
ICL	Wheat	POC†	POXC	SOC
FREP	Tomato	C-min	POXC	SOC
OUG	Tomato	POXC	C-min	SOC
TS	Tomato	MBC	SOC	POXC
WORT	Tomato	POXC	C-min	SOC

† POC = particulate organic matter C

- Relationships between soil C fractions and crop yields was assessed with all subset regression (Table 3).
- Overall, POXC and C-min were better predictors of crop productivity than the other soil C fractions (MBC, POC, or SOC).

Conclusions

- Results presented here show that POXC and C-min are closely related, but the relationship was shaped by management: POXC better reflects practices that stabilize organic matter and C-min better reflects practices that enhance organic matter mineralization.

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