Soil nitrogen mineralization under long-term farming systems in North Carolina

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Background

- Soil health is highly dependent on successful N cycling to provide continuous supply of inorganic N to agricultural crops
- How soil is manipulated in the laboratory to estimate N mineralization can be important in predicting field N supply

Hypotheses

- Simplifying and standardizing soil handling in the laboratory will be an efficient strategy to understand soil N mineralization
- Soil depth is a more important characteristic of N mineralization than lateral spatial distribution

Methods

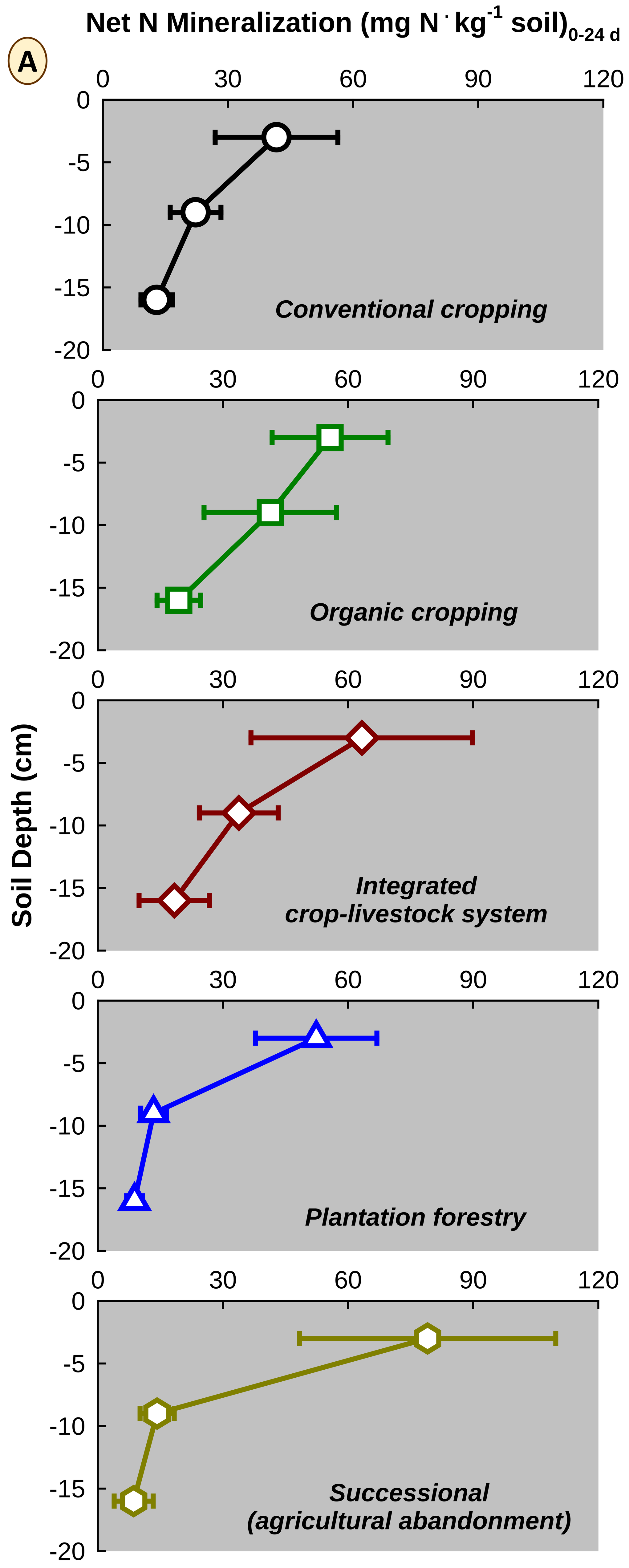
- Field experiment established in 1998 at the Center for Environmental Farming Systems (CEFS) in Goldsboro NC – eastern Coastal Plain physiographic region
- Five main farming system treatments (3 replicate plots of 14 sub-treatments):
  1. Conventional cropping (BMP approach) with two sub-treatments of (a) disk tillage and (b) no-tillage
  2. Organic cropping with four sub-treatment rotations of (a) 3-yr crop/3-yr hay, (b) 3-yr rotation of corn-soybean-cover, (c) 3-yr rotation of corn-soybean-sunflower with conventional tillage, and (d) 3-yr rotation of corn-soybean-sunflower with reduced tillage
  3. Integrated crop-livestock system with three sub-treatments of (a) 3-yr hay rotated with 3-yr cropping, (b) 6-yr grazing rotated with 6-yr cropping, and (c) 6-yr cropping rotated with 6-yr pasture
  4. Plantation forestry with four sub-treatments of (a) green ash, (b) bald cypress, (c) longleaf pine, and (d) black walnut
  5. Successional (abandoned cropland)

- Soil sampled with three approaches:
  1. Five diagnostic sites sampled individually within each of 42 plots at 0-15-cm depth; soil dried (55 °C)
  2. Pooling of five sites within a plot and sampling at 0-6, 6-12, and 12-20 cm depths; soil dried (55 °C)
  3. Pooling of five sites within a plot and sampling at 0-6 cm depth; soil kept moist

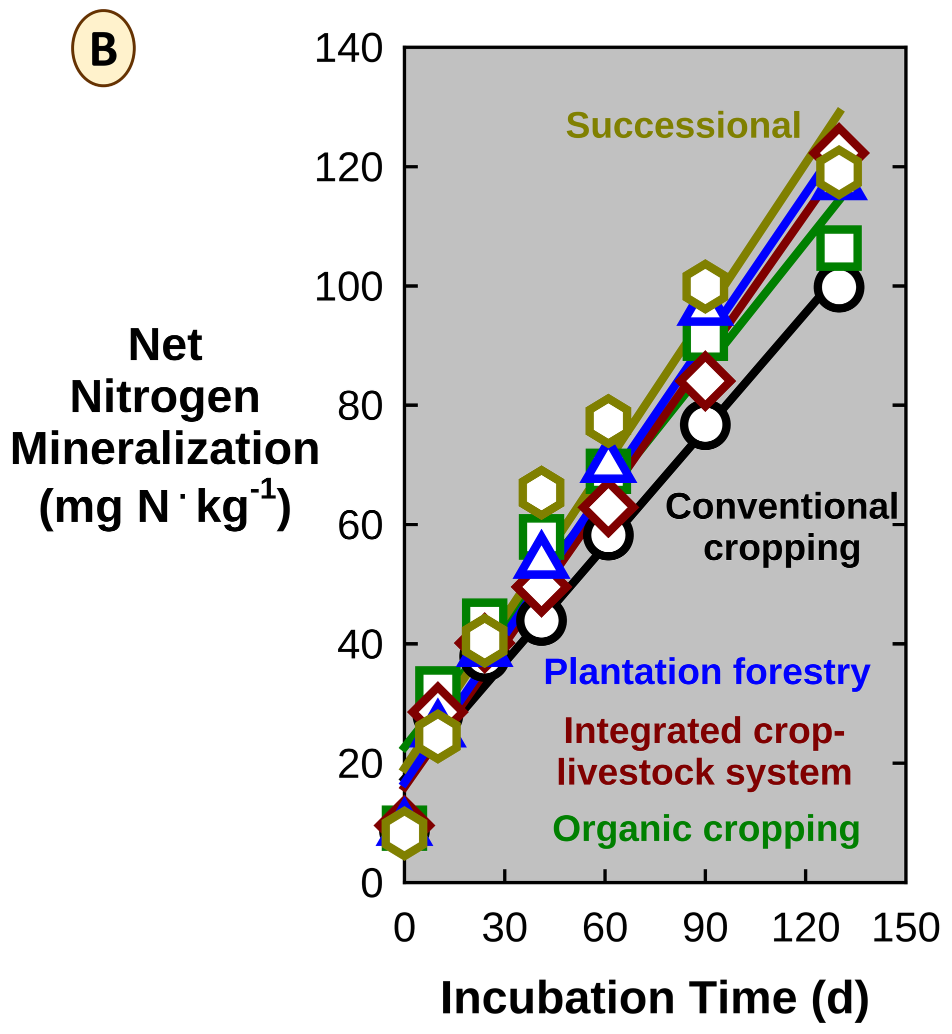
- Surface residue N and total soil N determined with Leco TruMac dry combustion
- Incubation of soil at 50% water-filled pore space and 25 °C
- Simultaneous determination of C and N mineralization from alkali trap and inorganic N accumulation, respectively
- Soil-test biological activity as flush of CO_2 following rewetting of dried soil during first 3 days
- Mean, root mean square error, and standard deviation calculated

Results and interpretations

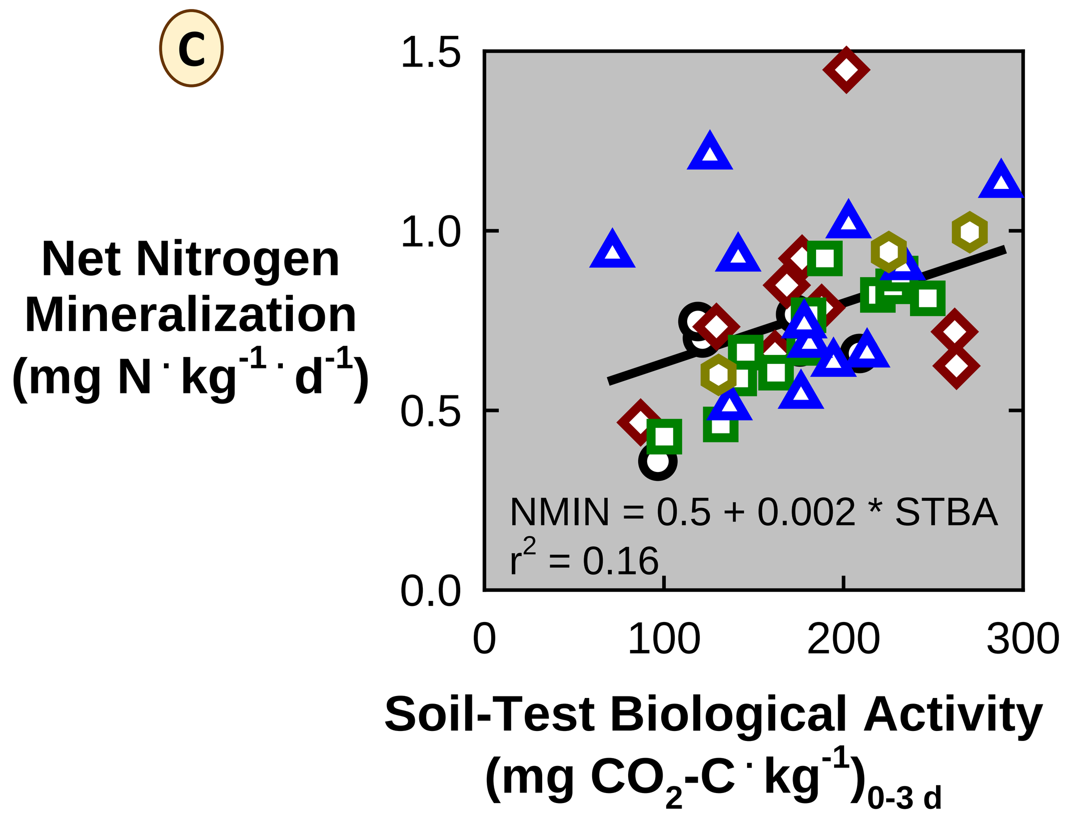
Dried (55 °C) and sieved (4.75 mm) soil



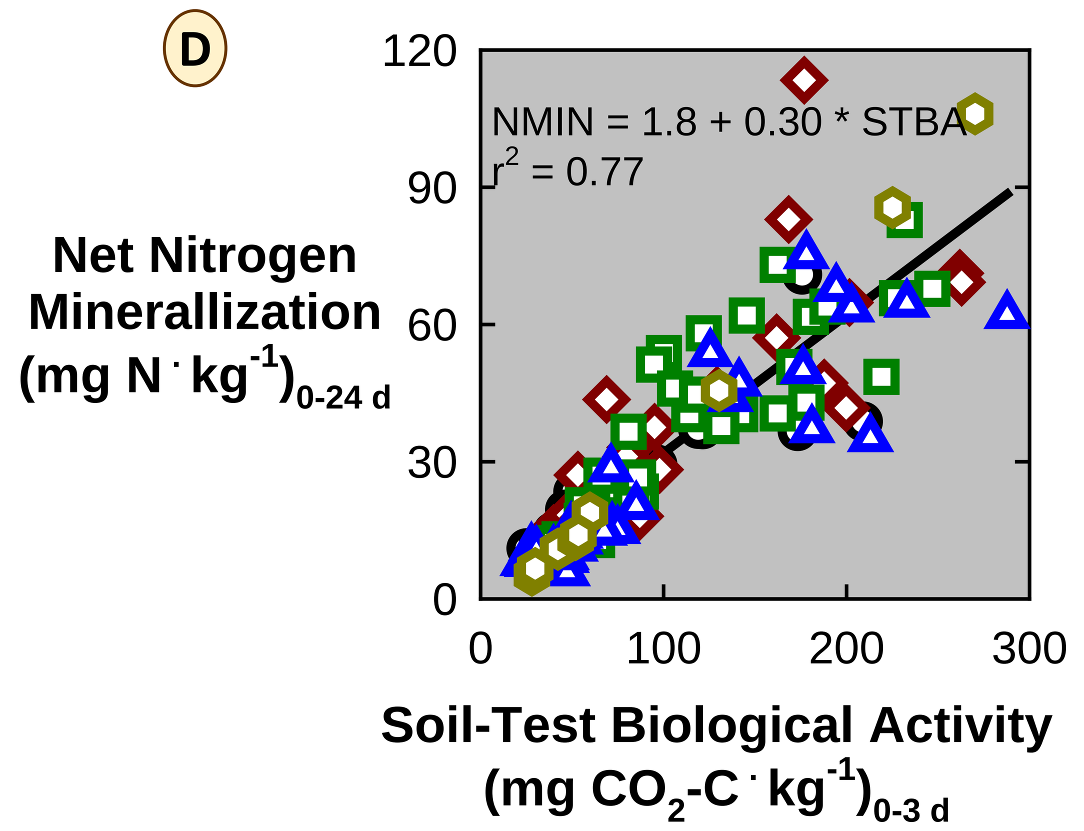
Field-moist and sieved (4.75 mm) soil
[0-6-cm depth]



Field-moist soil for NMIN and dried soil for STBA
[0-6-cm depth]



Dried (55 °C) and sieved (4.75 mm) soil
[0-6, 6-12, and 12-20 cm depths]



A. Net N mineralization declined dramatically with depth in several farming systems
B. When kept moist, net N mineralization increased steadily, but not differently among treatments
C. When kept moist, net N mineralization was only weakly related with soil-test biological activity
D. When soil was dried, net N mineralization was highly related with soil-test biological activity
E. Farming systems were only weakly differentiated by soil-test biological activity at 0-15-cm depth
F. Total N stocks had significant contributions from surface residue and soil at 0-6-cm depth

E Soil-test biological activity (STBA; mg CO_2-C kg^{-1} 3 d^{-1}) at depth of 0-15 cm from five sub-plots within a plot (n=42)

Farming system	Mean STBA	RMSE (sub-plot)	RMSE (plot)
Conventional cropping	120	23	72
Organic cropping	130	19	76
Integrated crop-livestock system	138	25	84
Plantation forestry	132	36	87
Successional	145	33	93

F Total N stocks (kg/ha) of different soil components as affected by farming system

Soil component	Conventional cropping	Organic cropping	Integrated crop-livestock system	Plantation forestry	Successional
Surface residue	79 ± 27	114 ± 43	139 ± 45	189 ± 77	234 ± 68
Soil (0-6 cm)	847 ± 194	890 ± 188	952 ± 272	742 ± 122	843 ± 71
Soil (6-12 cm)	575 ± 109	788 ± 155	680 ± 199	397 ± 67	468 ± 140
Soil (12-20 cm)	538 ± 90	682 ± 131	647 ± 189	418 ± 74	501 ± 96
Total N	2040 ± 277	2474 ± 401	2417 ± 642	1746 ± 261	2046 ± 368

Conclusions

Lab handling approach was a key factor in declaring differences in N mineralization among farming systems

- Pooling soil within large plots did not sacrifice sensitivity and increased lab resource efficiency, while allowing evaluation of more depth increments that revealed important stratification
- Net N mineralization was effectively associated with soil-test biological activity, but only when soil was dried and not kept moist

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