Interactive effects of soil restoration strategies on ecoenzymatic stoichiometry in degraded tropical soil

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Motivation

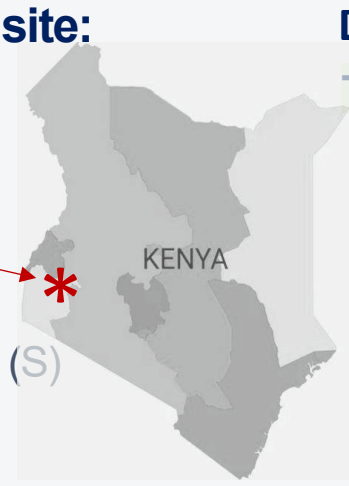
- Degraded tropical soils are highly weathered, compacted and low organic matter
- Restoration often involves tillage (to relief compaction) and organic amendments but their influence on microbial stoichio-metry is poorly understood
- Why this matter?

  Microbes mediate nutrient cycling and influence restoration succees

Methods

Experimental site:

Western Kenya: Kisumu County (Thur Gem)



Treatments

1) Soil inoculum (S)
2) Manure (M)
3) Tillage (T)

Design: Full factorial

Treatment	Description
S0M0T0	Control
S1M0T0	Soil inoculum (S)
S0M1T0	Manure (M)
S0M0T1	Tillage (T)
S1M1T0	S × M
S1M0T1	S × T
S0M1T1	M × T
S1M1T1	All three

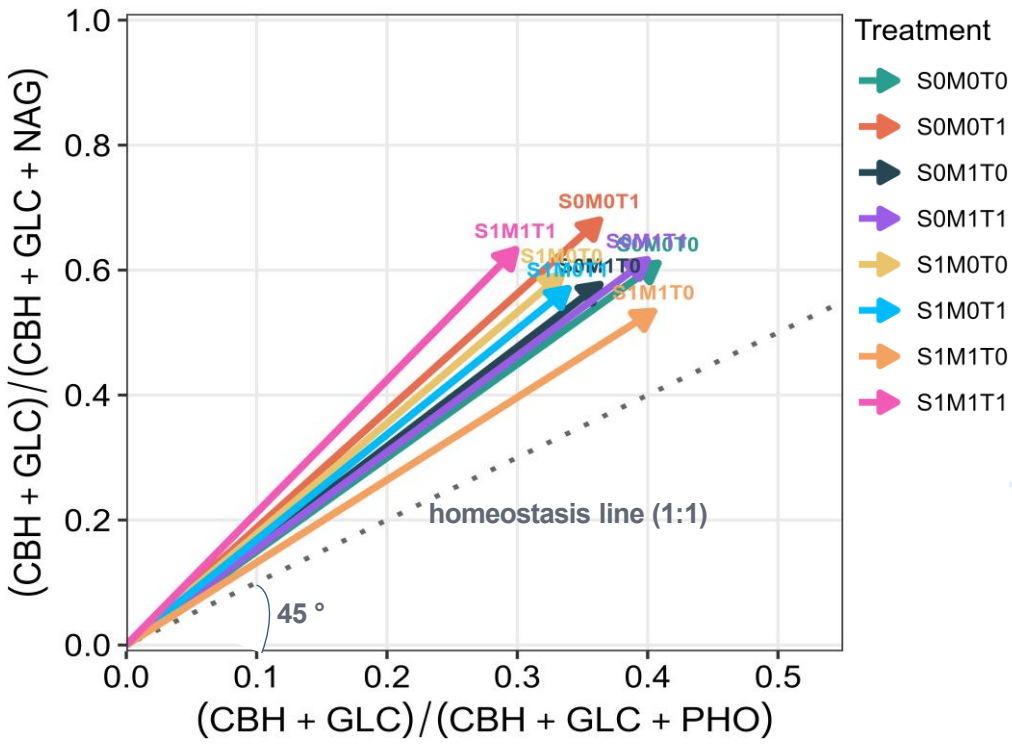
S = Inoculum (0 = absent, 1 = present); M = Manure; T = Tillage

2021: Established
2025: Sampled

Measured:
C-N-P enzymes | Soil C, N, P pools | Microbial biomass

Results

(a) Microbial nutrient status (vector analysis)

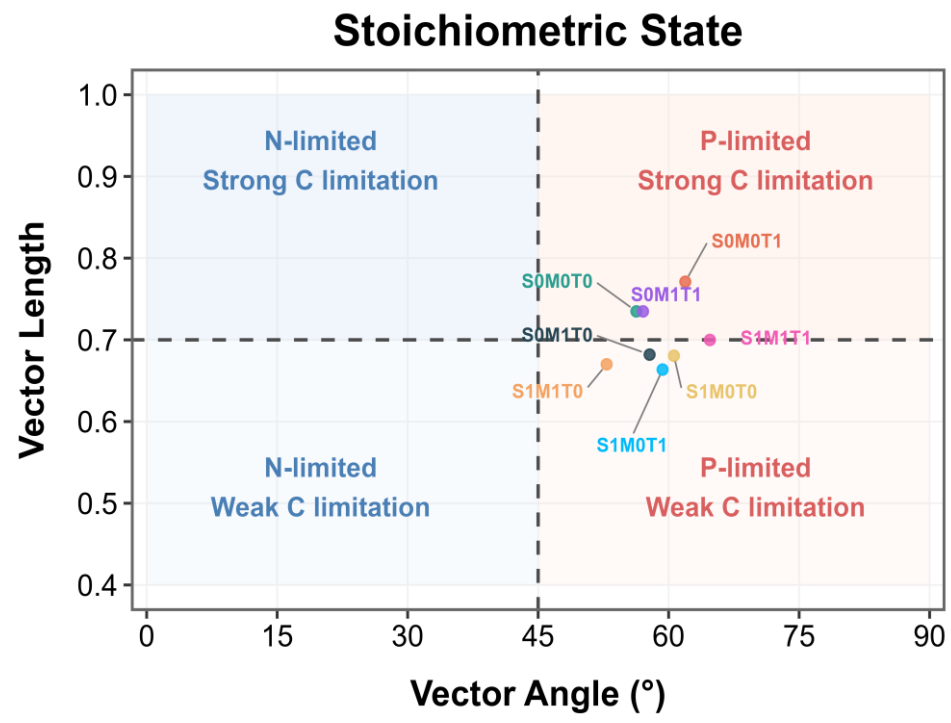


Angle > 45°
→ P limitation

Angle < 45°
→ N limitation

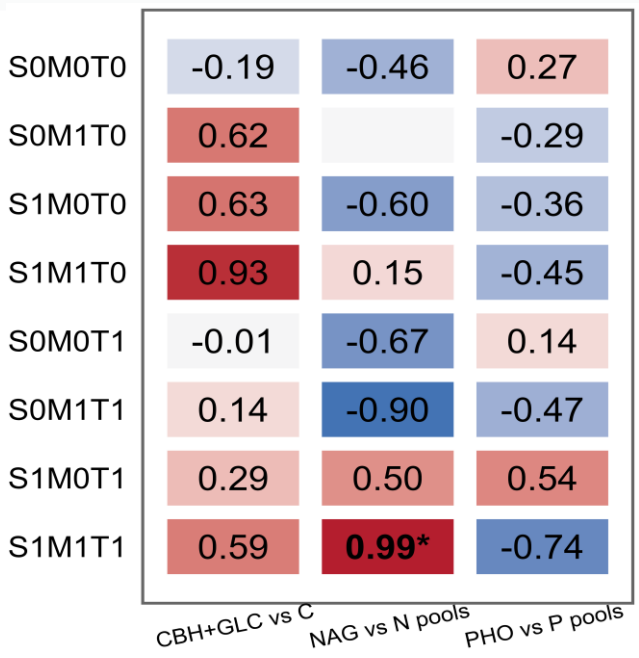
Longer vector
→ Stronger C limitation

Homoestatis line
C: N | C:P



Enzymes: CBH (cellobiohydrolase) + GLC (β-glucosidase) for C; NAG (N-acetyl-β-glucosaminidase) for N; PHO (phosphatase) for P.

(b) Microbial nutrient acquisition strategy



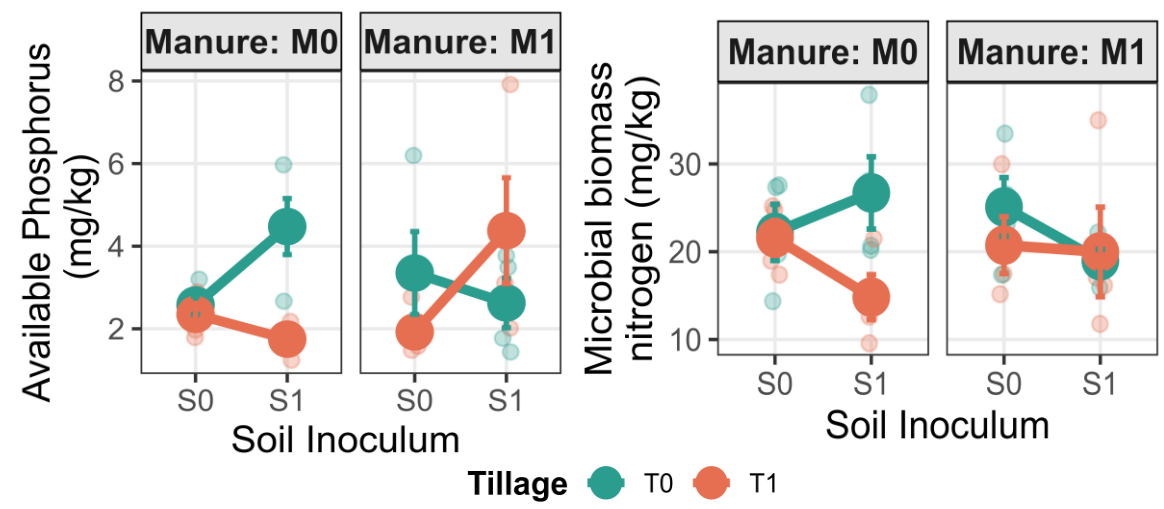
*p < 0.05; **p < 0.01; **p < 0.001

Substrate-enzyme coupling across treatments

Blue → negative correlation (mining strategy: microbes Invest more enzymes when nutrient scarce)

Red → positive correlation (substrate response: enzyme production tracks nutrient availablity)

(c) Three-way interaction effects on key variables



S1= Soil inoculum added | S0 = No soil inoculum
T1 = Tilled soil | T0 = Untilled soil
M1 = Manure applied | M0= No manure applied

Takeaways and implications

- No treatment alleviated microbial P limitation.
  Single applications are insufficient.
- Microbes shifted nutrient acquisition strategy
  Adaptation to a lower-resource equilibrium.
- Inoculum effects are context-dependent
  Depend on substrate stoichiometry and disturbance.
- Management/restoration implication
  Minimal tillage, sustained organic input, match inoculum to substrate C:N ratio, and legume-grass integration.

References

Moorhead et al. (2016) Soil Biol Biochem, 93, 1-7; Sinsabaugh et al. (2008) Ecol Lett, 11, 1252-1264; Wubs, et al. (2016) Nature plants 2.8, 16107; Six et al. (2006) Soil Sci Soc Am J, 70, 555-569; Kunito et al. (2024) Soil Science and Plant Nutrition 70(4), 246-269

Partners/funders

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