Nitrogen availability as result of interaction between fertilizer and soil properties

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Background and objectives

Soils have a highly varied ability to release nutrients, especially nitrogen (N). Organic fertilizers can exhibit very different rates of N release at different locations. The aim is to understand N release from organic fertilizers and its interaction with soil properties and land use management, as essential for estimating N mineralization potential, improving nutrient management in organic vegetable production and reducing negative environmental impacts.

Methods

We conducted incubation (18°C, 50% WC, 35-90d) and greenhouse experiments (18-24°C, 67% WC, 27-42d) with different soils to study the impact of soil clay content and carbon to nitrogen (CN) ratios of organic fertilizers on N mineralization and plant nitrogen availability (N_{min}, plant growth and N uptake).

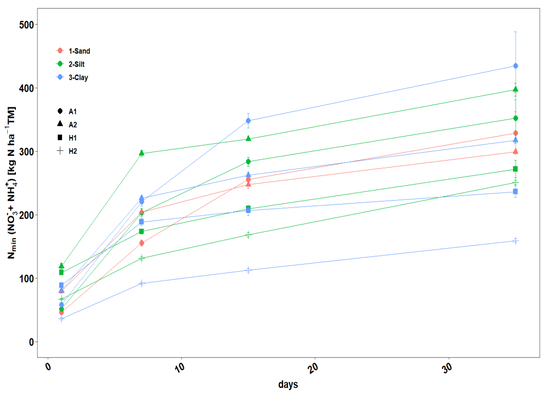
- 4 sites: A1, A2, H1, H2
- 2 management systems: agricultural (A) and horticultural (H) soils
- 3 groups of clay contents: ~14% (sandy loam: „sand“)
  ~22% (silt loam: „silt“)
  ~31% (clay loam: „clay“)
- Fertilizers: C/N 3-28

Hypotheses

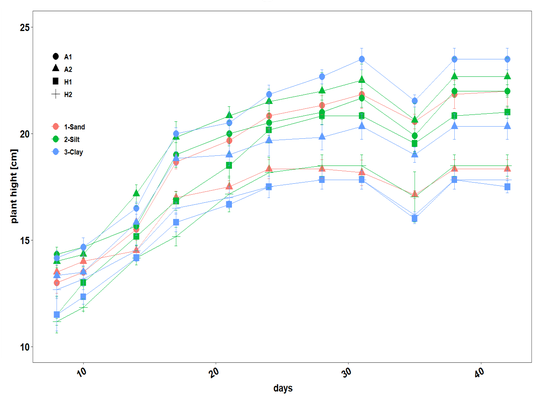
- Higher clay content results in lower relative soil N mineralization
- Net N mineralization is independent from clay content
- Horticultural soils release more N than agricultural soils

Results

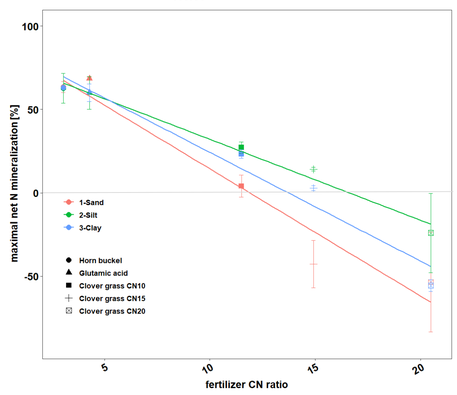
Soil N mineralization



Plant growth



Net N_{min} vs fertilizer CN

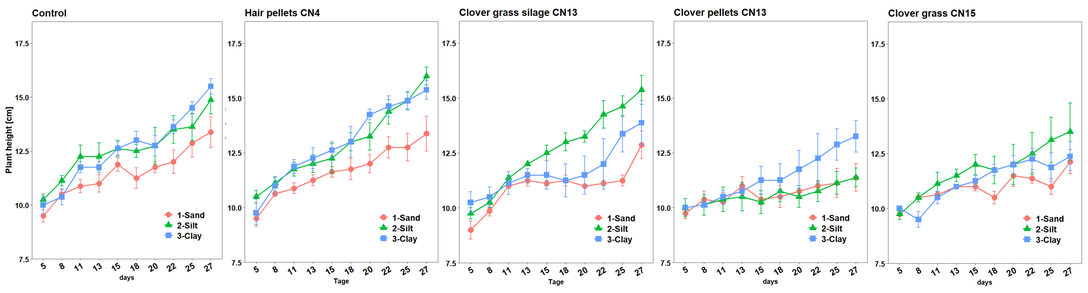


A1, 66d
- Clay content ($F = 6$; $p < 0,01$)
- Fertilizer CN ($F = 36$; $p < 0,001$)
- Lower mineralization at greater CN ratio
- N immobilization at CN > 10 (Net N_{min} < 0)

- Differences between and at site (N_{min}: $F = 29$; $p < 0,001$); A1 > A2 > H1 > H2
- Site x clay content interaction (N_{min}: $F = 2,5$; $p < 0,1$; Plant height: $F = 74$; $p < 0,01$)

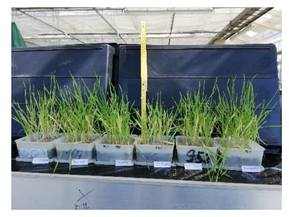
Net N mineralization

A1, 88d
- Fertilizer ($F = 6$; $p < 0,001$)
- Clay content significant at fertilizer CN 11-15 (max. net N_{min}, $F = 4$; $p < 0,05$)
- Partly, (initial) immobilization processes (net N_{min} < 0) and no re-mineralization with fertilizer CN > 15 within 88d
- Higher final mineralization at higher clay content

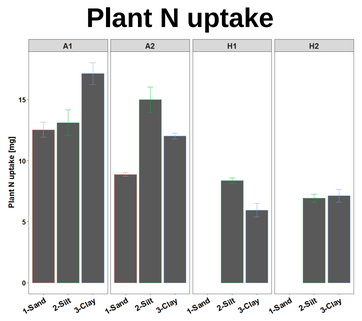


Plant growth

A2, 27d
- Growth rate differentiation after ~2 weeks
- Lower growth on sand
- Fertilizer x clay content interaction resulted in growth differences and partly negative fertilizer effects
- Slower growth with clover grass silage on clay and sand → N availability of fertilizer after 3-4 weeks
- Reduced growth with clover grass and clover pellets



Plant N uptake



42d

- Plants on agricultural sites took up more N in total ($F = 69$; $p < 0,001$) and in dependence of clay content ($F = 7$; $p < 0,01$) compared to horticultural sites
- Agricultural soils: site ($F = 14$; $p < 0,01$), clay content ($F = 15$; $p < 0,001$) and interaction ($F = 12$; $p < 0,01$)
- Horticultural sites: clay content ($F = 7$; $p < 0,05$) and interaction with site ($F = 9$; $p < 0,05$)

Plant net N uptake

3.6 = Hair pellets; 10.8 = Field bean meal; 13.1 = Clover pellets und 15.1 = Sunflower seeds press cake

- Site ($F = 32$; $p < 0,001$),
- Clay content ($F = 29$; $p < 0,001$)
- Fertilizer ($F = 6$; $p < 0,001$)
- Site x clay content ($F = 13$; $p < 0,001$),
- Site x fertilizer ($F = 2$; $p < 0,05$)
- Site x clay content x fertilizer ($F = 4$; $p < 0,001$) → no clay content x fertilizer interaction across sites
- Greater N uptake on horticultural soils
- Partly negative fertilizer effect on agricultural soils
- Fertilizer effect overall: GB1 > GB2 > AB1 > AB2
- Fertilizer effect lower on clay soils, though, only significantly higher with hair pellets
- Individual fertilizer effect by site, varying with fertilizer x clay content interaction

Summary

- Relative soil N mineralization was higher at higher clay contents and tends to higher mineralization rates of fertilizer N
- Agricultural soils had greater N mineralization than horticultural soils
- Plants on un-fertilized agricultural soils took up more N in total and dependent on clay content
- Greater fertilizer effect on horticultural sites
- Net N mineralization was site-dependent on clay content
- No uniform interaction of clay content and fertilizer across sites

Conclusion

- Plant-based fertilizers with CN ratios greater than 10 may not suit short cultivation periods and thus applicability in organic vegetable production
- Site-specific management history influences N mineralization greater than soil clay content and fertilizer CN ratio
- Importance of the specific investigation of management history for further understanding and improving of fertilization efficiency

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