GENERAL INFORMATION

author(s)	Beckers G
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MATERIALS & METHODS

Different from Muys_etal_2003_Pedobiol

not in Muys_etal_2003_Pedobiol

study area	stand 5l: small cut in stand of *Quercus rubra* & *Fagus sylvatica* with lightly degraded sandy loam soils and soil compaction because of recreation pressure
time period	1992–2002
goal	study ash mortality, vitality, and growth and the potential for autogenous soil regeneration for three planting techniques
set-up	- planting in 1992, *1.5 x 1.5 m, nursery plants 1.5 m tall, spiral protection against rabbits* - **195** *Fraxinus excelsior* in 4 blocks (45 trees x 4 = 180???) - block = 3 experimental groups, 15 trees/group, control – fertilizer – fertilizer+earthworms - fertilizer (P, K, Ca, Mg): 500 g dolomite, **200 g** slags, 100 g kieserite – mixed with the soil from the planting pits - introduction earthworms: 40 adults = 20 anecic (10 *Lumbricus terrestris*, 10 *Nicodrilus longus*) + 20 endogeic (**caught in grasslands: mainly *Nicrodilus caliginosus caliginosus*** = *Aporrectodea caliginosa*, mix of **mainly** *Aporrectodea rosea*, **little** *Allolobophora limicola* and *A. chlorotica*) - plants with naked roots, pits ø 40 cm, 40 cm depth - 1 m² around each ash = soil sample plot: 2 nested subplots of 0.5 m² (sampling in and outside of the planting pit)
data collection	TREES - *vitality in 2002: number of dead trees, injury, leaf decoloration, crown damage* - **between 1992-2001: growth = length last growing shoot (except in 1999) + total height in 1998, 2000, 2001** - 2002: 2 random trees harvested per treatment and block (24 trees in total) – *on 16-17/07, 02/08, 27/08* – aboveground biomass: leaf, branch, stem – nutrients in leaves upper third crown/lower 2/3 crown SOIL/LITTER - herb layer removed - ectorganic layer gathered

	- stability aggregates: sampling upper 10 cm in the 2 subplots - soil samples 0-10 cm, 10-40 cm, 40-70 cm EARTHWORMS (bemonstering volgens ethofysische methode) - part 1: sorting of the ectorganic layer - part 2: formaline solution on the 2 subplots (2 x 10 l 0.05 % solution, 2 x 10 l 0.1 % solution, time interval = 10 min) - part 3: soil sample of 20 dm³, 48 h in ~~a solution of 10 l water +~~ 100 cm³ Natriummetaphosphate ($Na_6(PO_3)_6$) + 800 ml **formol**, wet sieved - biomass earthworms (g/m²) = 10 m_1 + 2 m_2 + 10 m_3 - juveniles, non-identifiable earthworms or part sorted into the other species groups pro rata (CHEMICAL) ANALYSES - leaf samples and litter dried and ground - total N: Kjeldahl - nitrate-N/ammonium-N: colorimetric after extraction with 1 % KCl - pH_{KCl}: glass electrode in 1 mol/l K Cl solution (wrong??? See comment in the thesis on p 22) - concentration K, Ca, Mg, Na: Varian SpectrAA 220 spectrophotometer – ~~exchangeable after extraction with 0.1 mol/l $BaCl_2$ – total after destruction with H-perchlorate~~ – Ca with N2O-acetylene flame / rest with air-acetylene flame – solution with 10 % CsCl – *5 g sample satiated and extracted 3 times with 0.1 mol/l $BaCl_2$ (leaf + litter) – 5 g sample solved in Ammoniumlactate + activated carbon solution in Ammoniumlactate + activated carbom (soil)* - concentration total P: ~~colorimetric~~ *method of Scheel (leaf) – cf. Ca e.a. for the exchangeable fraction, but with colour reagens (soil)* - OM: Walkley & Black + Kalra & Maynard - Stability aggregates: sieve 10 mm, air-dry – aggregates sieved on 2000 µm, 250 µm, 53 µm (*60 g sample*, 5 minutes soaked in demineralised water) – manual sieving (50 x 3 cm up and down in 2 minutes) – remaining soil dried at 60°C and weighted - *sand fraction: 10 g sample + 33 ml dispersal agent (solution of hexametaphosphate), 18 u shaked, sieved at 53 µm*
remarks	scheme set-up p 18

RESULTS

TREES

- *vitality: after 4 years, the trees in the control plots were dead; after 10 years, the trees in the treated plots were vital*
- Height growth:
  - control: little growth in year 1&2, dead afterwards
  - fertilizer (+worms): good growth, fertilizer better in the first 2 years, + worms afterwards (significantly better only in year 4&5)
  - *total tree height in 2001: interaction between block and treatment (in block III, there is a significant difference between fertilizer & fertilizer+worms)*
- biomass after 10 year
  - higher for fertilizer+worms, not significantly
- leaf nutrient concentration
  - N, P, Na, K larger for fertilizer+worms, not significantly
  - Ca, Mg lower for fertilizer+worms, not significantly

ECTORGANIC LAYER

- control plots: no difference in pH or concentration in or outside planting pit
- pH
  - higher in treated plots (in and outside pit)
  - pH higher in planting pit than outside for fertilizer and fertilizer+worms

- nutrient concentration
    - no significant difference between treatments in the planting pit
    - oustide the pit: Mg sign higher in treated plots, K sign higher in fertilizer compared to control (fertilizer+worms intermediate)
    - concentration in > concentration outside pit for Mg (fertilizer, fertilizer+worms), Na (fertilizer)

<u>SOIL: total concentration</u>

- 0–10 cm
    - control plots lower conc P, Ca, Mg + smaller pH (in the pit)
- 10–40 cm
    - control plots lower conc Ca, Mg + smaller pH (in the pit)
- 40–70 cm
    - control plots smaller pH (in the pit)
- no significant differences outside the planting pit
- differences between in and outside the planting pit
    - no differences for the control plots
    - fertilizer
        - 0–10 cm: **pH higher** in the pit
        - 10–40 cm: OM, N, Ca, Mg, **pH higher**
        - 40–70 cm: P, Mg, **pH higher**
    - fertilizer + worms
        - 0–10 cm: **Ca**, Mg, **pH higher**
        - 10–40 cm: N, Na, K, **Ca**, Mg, **pH higher**
        - 40–70 cm: N, **Ca**, **pH higher**

<u>SOIL: exchangeable concentration (in the planting pit)</u>

- Ca, Mg lower in control
- NO_3-N lower in fertilizer than in control, intermediate in fertilizer+worms
- Na higher in fertilizer than in control, intermediate in fertilizer+worms

<u>SOIL: aggregates</u>

- fractions do not differ between treatments (in and outside the planting pit)
- larger fraction of large aggregates oustide the planting pit, smaller aggregates more in the pit

<u>EARTHWORMS</u>

- 4 species after 10 years
    - epigeic species
        - *Dendrobaena octaedra*: treatment/control, in/out planting pit
        - *Lumbricus rubellus*: treatment, in/out planting pit
    - endogeic species
        - *Aporrectodea caliginosa*: treatment, in planting pit
        - *Octolasion cyaneum*: 2 pits of the fertilizer treatment
- In the planting pit: BM significantly larger in the treated plots
- BM in the fertilizer plots significantly larger in the pits

CONCLUSONS

- <u>*Outside the planting pit, only the litter layer shows differences between the treatments. Inside the planting pit, several effects are found.*</u>
- Adding fertilizers in the planting pit enables planting ash in acidified forest soils. ~~(Nonetheless, the concentrations of P, K, Ca in the ash leaves are suboptimal, which might be negative for the survival of the trees in the long run.)~~
- The additional introduction of earthworms might prolong and intensify the positive effect of the fertilizers. (Initially, N might be fixed because of the development of the earthworm population; afterwards, the nutrients might be better accessible and a larger soil volume can be used by the roots.)

- Adding fertilizers increases the concentrations of Ca and Mg, and the pH. No additional effect of the addition of earthworms.
- Adding earthworms did not affect the soil structure (possibly because of the low number of endogeic species and the absence of anecic species).
- A higher earthworm biomass in treated plots. ~~Absence of anecic earthworms possibly because of low initial pH: *Nicodrilus longus* (min pH 4.91), *Lumbricus terrestris* (min pH 3.93). Biomass larger in the planting pit in the fertilizer treatment. Adding relatively acid-tolerant endogeic species may be more successful than adding less acid-tolerant anecic species.~~
- Soil-improving effect of ash not visible after 10 years (ash litter production marginal when compared to the litter of the surrounding species).