

Soil Health in Agroforestry Systems: Results from the REFOREST projectand beyond...

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What we will cover

- 1.Introduction to the REFOREST project & the Living Labs
- 2.Some theory how might trees affect soil health?
- 3.Review of the evidence from REFOREST and beyond
- 4. Discussion and questions

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What is <u>REFOREST</u>?

- Horizon Europe project - Agroforestry at the forefront of farming sustainability in multifunctional landscapes in Europe (2022-2026)
- 14 partners from 10 European countries



- Agrisilvicultural/silvoarable/silvo horticulture (trees + crops)
- Silvopastoral (trees + livestock)
- Agrosilvopastoral (trees + crops + livestock) systems



What is <u>REFOREST</u>?

- Focussed on "innovation, knowledge exchange and creating novel solutions to empower farmers in Europe and associated countries to deliver on multiple objectives: food production, carbon capture, and biodiversity development"
- Which means…tools for facilitating the transition – decision support tools, models, remote sensing; evidence
- shared on the <u>engagement platform</u> and knowledge inventory

DIGITAL TOOLS: Definitive Guide



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Introducing the Living Labs "real-li

"real-life examples of environmental sustainability & successful business models"

8 living labs consisting of networks of farms and stakeholders within a country

Belgium (Flanders)

- INAGRO research institute
- Mixing walnuts with vegetables and arable crops
- Alley cropping design
- Established 2023





research & advice in agriculture and horticulture

Agroforestry design at the INAGRO site



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Agroforestry design at the INAGRO site



Keep up with developments on a regular basis

Digging Deeper: A closer look at laymen in agroforestry

Through the '**Digging Deeper**' series, you can follow the developments and results of Inagro's own agroforestry plot from the front row. Last month and a half was dominated by the planting of leek as intermediate crop. **In this edition**, you can read more about the first practical experiences and, together with Inagro's cultivation manager, we take a closer look at growing leek in agroforestry.

Germany

- Hoflebensberg Farm
- Following principles of regenerative agriculture
- Two systems
- Nut trees (est 2020/21);
 Fruit trees (est 2022)
- 15 m between rows; 3 m within rows



es fruits, bread, eggs, milk and more

able boxes as a subscription





UK

- Ings Farm Biohub
- Circular regenerative demonstrator farm
- Focus on a diversity of fruit trees: pears, plums, apples, medlar, damsons, hazel, mulberry, elderberry, walnuts and more!

UK

- Gibside Community Farm
- 5 m wide tree alleys, 21 m growing area
- Alliums, brassicas, potatoes in the alleys





Let's think about some theory…How might trees affect soil health?

Effects on soil health will depend on system design & environment

- Local environment (Excess moisture? Drought? Excess heat? Cool growing season?)
- Objectives cash crop, microclimate, soil improvement
- Tree species selected
- Planting design



Nutrient cycling from deeper soil layers/litter deposition (natural process)



Fahad et al. Agroforestry Systems for Soil Health Improvement and Maintenance. Sustainability 2022, 14, 14877. https://doi.org/10.3390/su142214877

Abatement of agrochemical pollution



Figure 3. Absorption and immobilization of leached chemicals in agroforestry systems.

Fahad et al. Agroforestry Systems for Soil Health Improvement and Maintenance. Sustainability 2022, 14, 14877. https://doi.org/10.3390/su142214877

Enhanced nutrient cycling from deeper soil layers using – ramial wood chips (RCW)

- Fresh, un-composted woodchip from small diameter tree branches (<7 cm diameter)
- Chipped or crushed in winter and spread on the land
- Promotes rapid breakdown by soil organisms; minimize nitrogen immobilisation

Westaway 2020 Ramial woodchip in agricultural production. WOOFS Technical Guide 2. Organic Research Centre, UK.



RCW application rates reported in previous studies vary from 10 tonnes/acre (roughly equivalent to 60 m³ /ha)to 150-200 m³ per ha in the first year for the regeneration of degraded soils with much lower follow up application rates of 10-20 m³ by the fourth year.

Nutrient cycling especially if trees are N fixing



Increased soil organic matter for many reasons



Evidence for soil C sequestration Mayer et al 2022, global meta-analysis



Fig. 2. : Comparison of SOC (t ha⁻¹) in AFS and its corresponding control sites. Significance level is $\alpha = 0.05$, applied statistical test and p-value are indicated (data is paired), triangle indicates mean value.

Evidence for soil C sequestration Mayer et al 2022, global meta-analysis

Why?

- Higher above- and belowground C input – pruning residues, litterfall, root turnover, rhizodeposition (focused in area of tree row)
- 2. Deeper tree roots building soil C further below-ground



Understorey vegetation may also build soil C



Importance of trees species for soil C sequestration Mayer et al 2022, global meta-analysis

Deciduous trees – larger, deeper root systems; higher above-ground biomass produces more C that is pumped belowground; high quality litter decomposes faster, feeding the soil foodweb





Importance of system design for soil C sequestration Mayer et al 2022, global meta-analysis

Higher rates of soil C sequestration in hedgerow systems compared to alleys and silvopasture, but...

"There is also a lack of common methodological standards for these type of studies as soil sampling distance from tree rows varied between 0.4 and 12 m distance, 5 m intervals, random distribution, grid sampling or no information at all. It was thus impossible to estimate the effects of tree distance on SOC stocks based on the variety of sampling designs in existing studies."

Key outcome "Further studies are needed that systematically investigate SOC storage in the agriculturally used components of AFS in various distances from tree components"



Influence on soil biota providing resources through litter fall and root exudates (hedgerow example)

- Differences in biological communities
- Slightly more earthworms than arable, but not as much as grass or pasture
- Differences in arbuscular mycorrhizal fungi communities, but not clear if better
- Higher microbial biomasses under trees (a general outcome of agroforestry studies)



Holden et al. 2019. The role of hedgerows in soil functioning within 26 agricultural landscapes. Agr Ecosys Env 273: 1-12



Microclimate effects indirectly influencing soil biological processes

- Shade trees affect
 microclimate by lowering
 the incoming radiation,
 reducing the maximum
 temperatures, decreasing
 the temperature amplitude,
 and increasing the minimum
 temperature
- In hot climates this can be beneficial for soil biological activity…but in cooler climates, it may slow down processes if too cool and wet

Influence on soil biota the mycorrhizal

- question
 - Mycorrhizae are fungi which live in association with plant roots
 - AMF live in association with roots of many trees
 - There may be transfer of resources between crops and trees via these networks!





Assessing soil health in the REFOREST living labs

Study design



Figure 3 A schematic example of an alley cropping agroforestry system showing proposed sampling strategy for Baseline Site Characterisation. There are four transects (<u>A,B</u>,C,D). Each one is 26 m long. Point A-1 is in the middle of the tree row, A-2 is 6.5 m from A-1; A-3 is 13 m from A-1 and A-4 is 26 m from A-1.

Results so far…in general tree rows have higher soil organic matter than alleys



Results so far...some effects for distance from the tree row – Gibside, UK



Organic carbon increases with distance from the tree…why??

Declines in available P with distance from the trees. Are tree leaves adding P to the soil??



Results so far...some effects for distance from the tree row – Gibside, UK



No patterns for infiltration rates…confirming that they are very difficult to measure and variable in the field! Possibly more biomass further from the trees...competition for resources?



Summary Points

- In general, trees can improve soil health, but design will determine these effects (tree type, layout, management)
- Impacts will vary depending on distance from the tree row
- Active use of the trees for soil improvement through growth of N fixing trees and harvesting ramial woodchips will maximise benefits





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Any questions?



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