Alfalfa to get back into planetary boundaries

2025 world alfalfa congress
FRANCE REIMS-CHÂLONS

Alfalfa and soil quality

Sokolovic D. & Stepic M.

Parallel session 2

FROM 03 › TO 06
nov. 2025

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Alfalfa age and soil management as drivers of mycorrhizal colonization and agronomic performance

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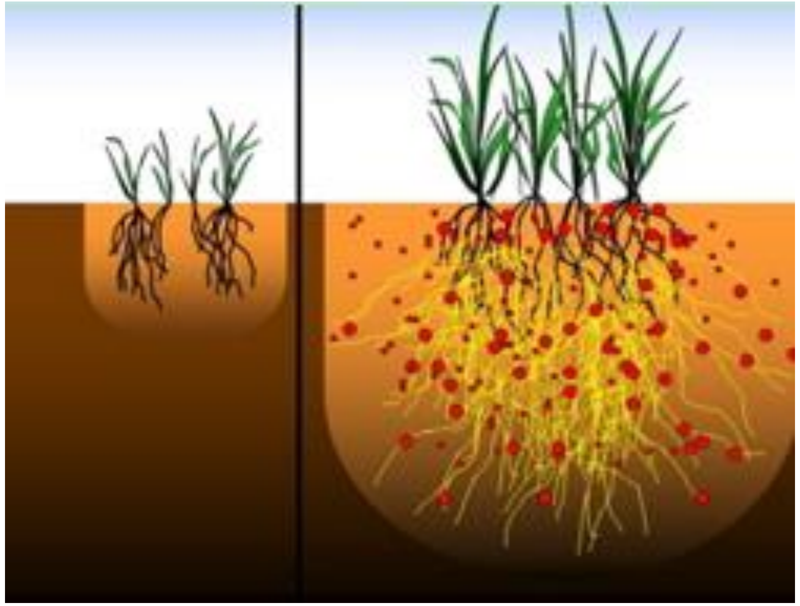
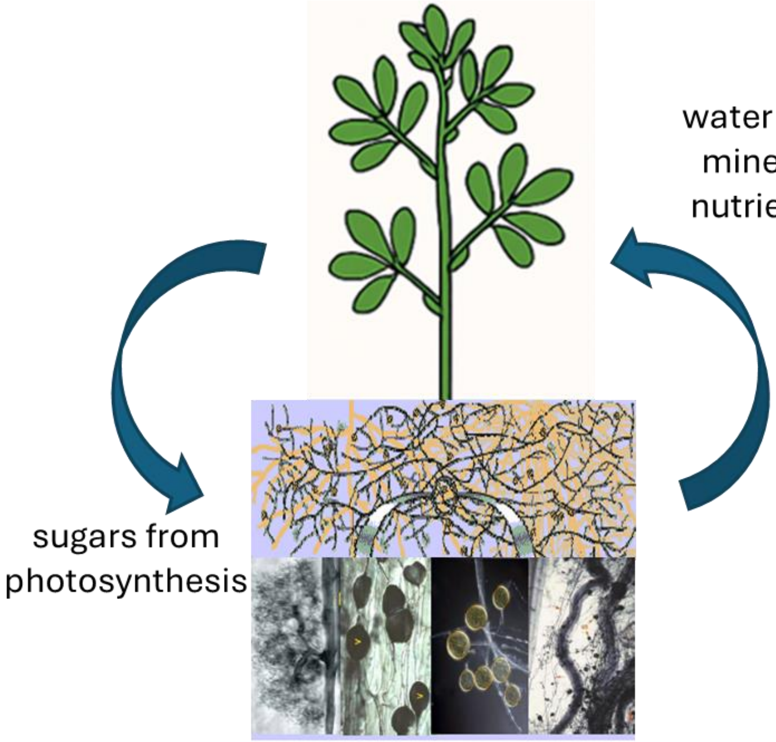
Context

- Alfalfa (*Medicago sativa* L.) is a key perennial legume in temperate regions.
- Provides high-protein forage, nitrogen fixation, and soil fertility benefits.
- Alfalfa supports sustainable livestock systems and contributes to soil fertility through symbiotic nitrogen fixation (Thiébeau et al., 2023).
- Strategic crop for agroecological transitions and soil sustainability (Schneider & Huyghe, 2015)

Mycorrhizal Symbiosis in Perennial Legumes

- Arbuscular mycorrhizal fungi (AMF) form symbioses with most crops, including alfalfa.
- Benefits: enhanced P uptake, drought tolerance, and improved root architecture.
- In perennial systems, multi-year stands favor stable AMF networks (Robdrup et al., 2024)
- Limited field-based data on AMF dynamics in alfalfa.



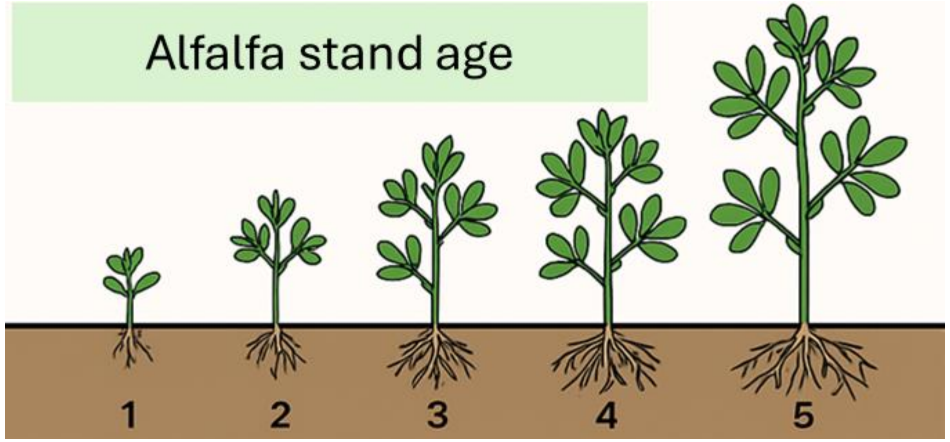


Understanding the « Age × Tillage » Interaction

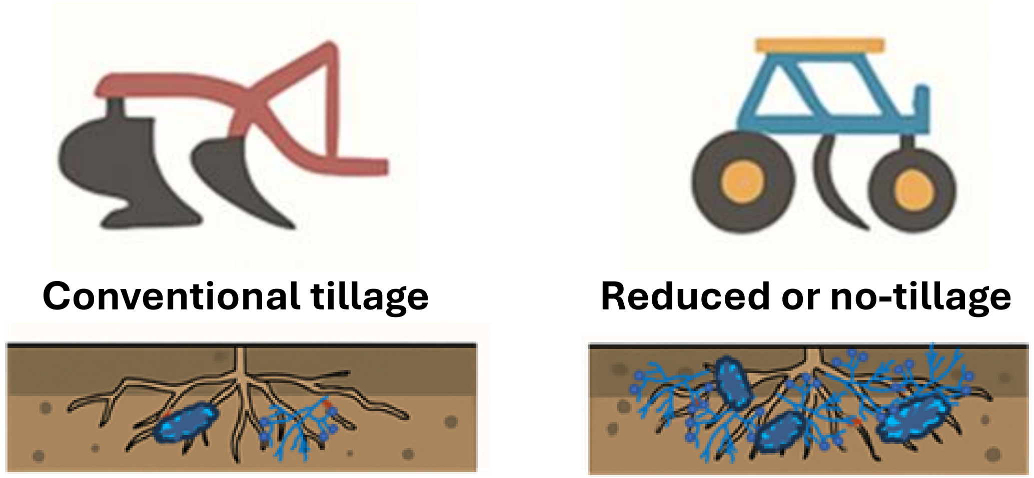
- Colonization dynamics of AMF in perennial crops (Alfalfa) are poorly documented under field conditions.

- Tillage intensity and stand age strongly affect AMF dynamics.

- Influence of stand age on AMF colonization and persistence.
- Effect of tillage practices on AMF colonization.
- Combined impacts on plant growth and productivity.



AMF colonization and its functional benefits vary with stand age?



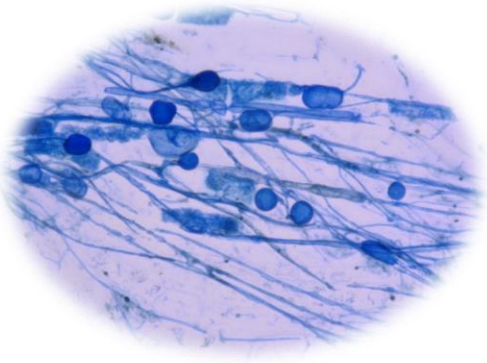
Reduced tillage promotes AMF colonization by preserving hyphal networks?

Objective

❖ Assess how alfalfa stand age and tillage practices influence AMF colonization and plant performance in alfalfa.

Specific Objectives

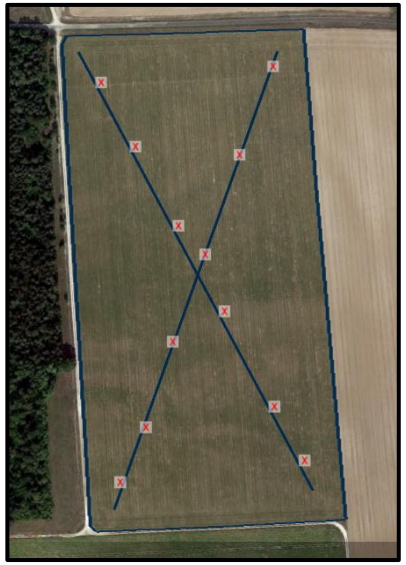
- Evaluate effects of alfalfa stand age and tillage on AMF colonization.
- Examine relationships between AMF colonization and agronomic parameters (root biomass, root density, average plant weight).



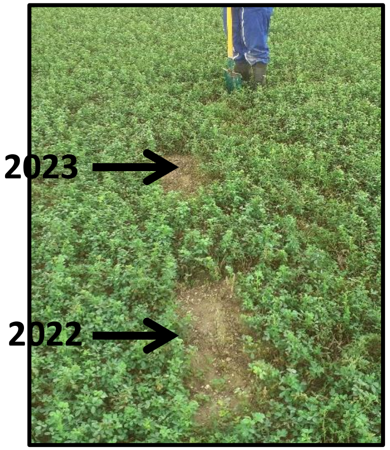
Materials & Methods

❖ Study site & Experimental design

- Main alfalfa-producing area (10 farmers' fields in northeastern France, Reims)
  - ➢ 5 fields - **conventional ploughing**
  - ➢ 5 fields - **Simplified Cultivation Tech. (SCT)**
- Period sampling: Autumn 2022 & 2023.
- Alfalfa stand ages: 1 – 5 years.
- Six subplots per field.



Satellite view of a 13-ha field



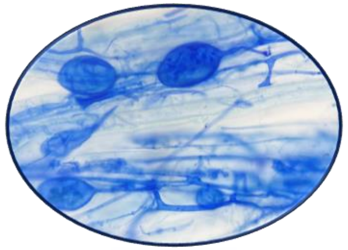
Temporal monitoring

Alfalfa roots

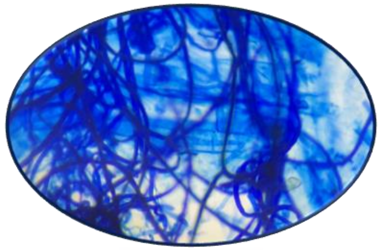
❖ Measurements

- root density (plants.m^2)
- biomass (g DM.m^2)
- average plant weight(g DM.plant)

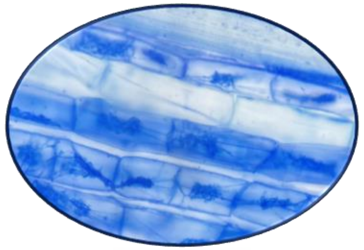
- Mycorrhizal intensity (%)
- Arbuscule abundance (%)



Vesicles



Hyphae



Arbuscules

Trouvelot et al., 1986

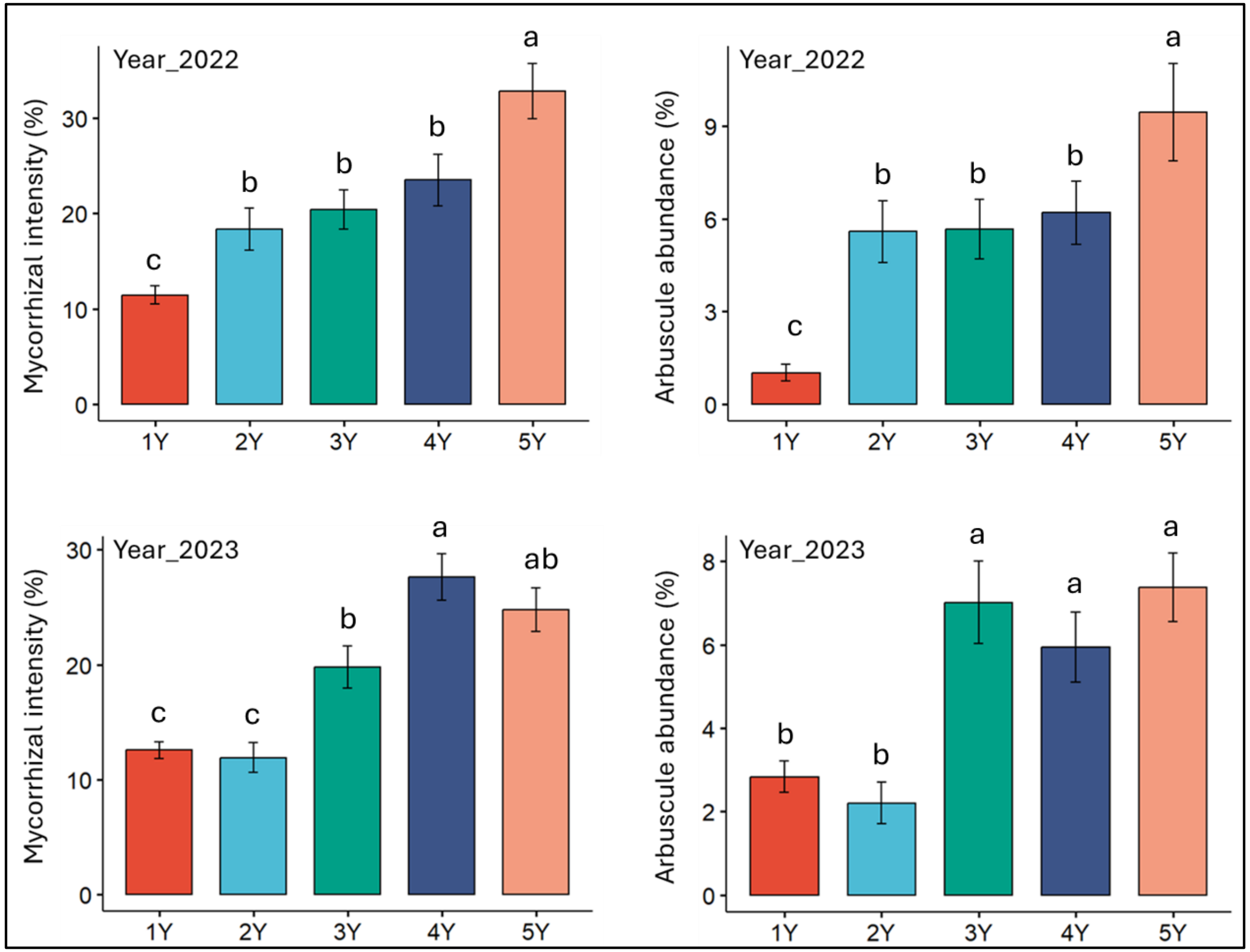
❖ All analyses performed with R v4.2.0

Effect of age on Alfalfa mycorrhization dynamics

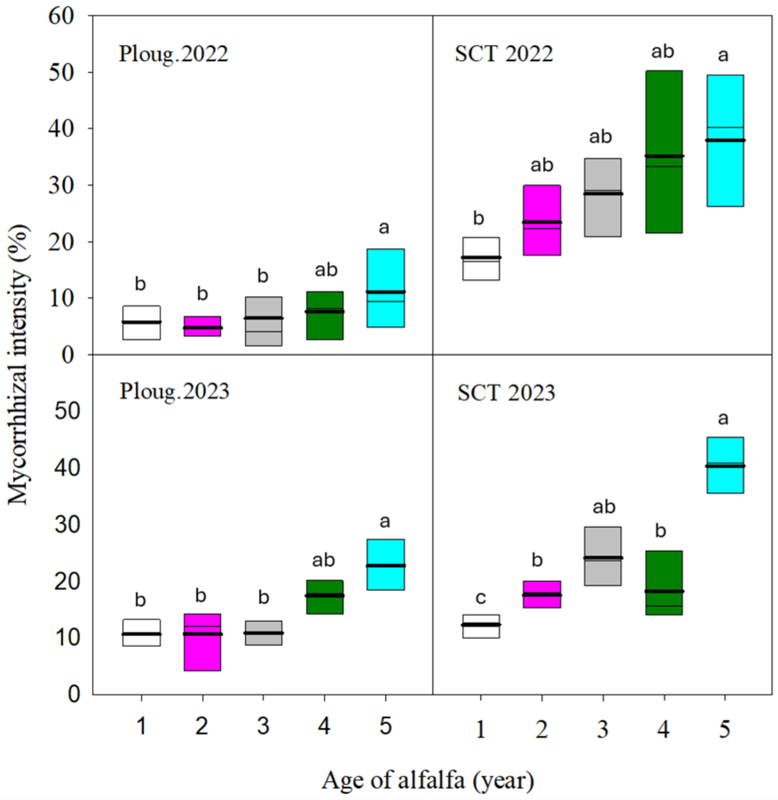
❖ **Positive effect on mycorrhization,** with a linear increase in both mycorrhizal intensity and arbuscule abundance over time.

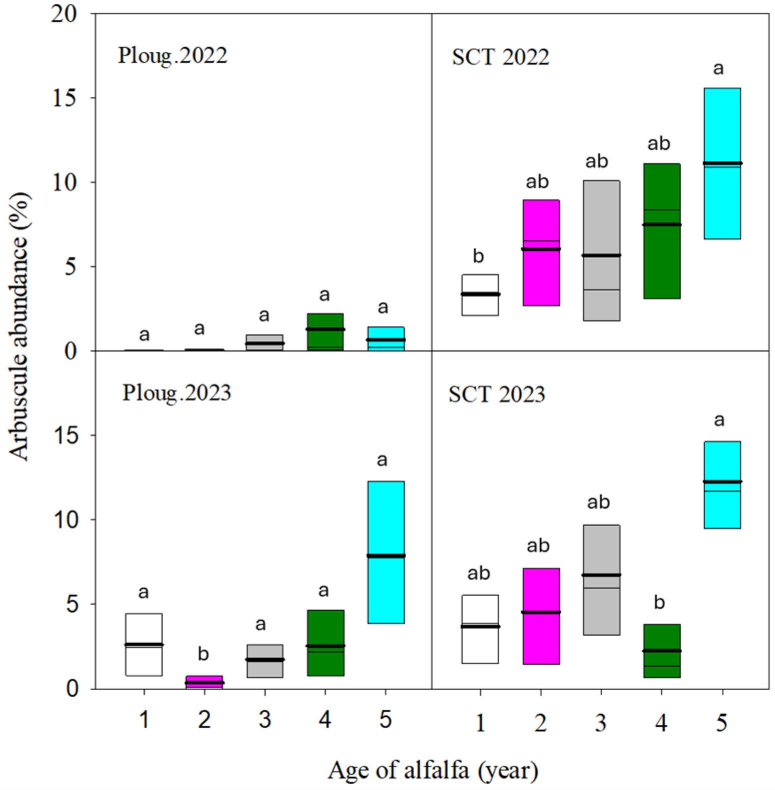
❖ **Peak mycorrhization at 4 to 5 years of age:**

- In 2022, maximum mycorrhizal intensity (35%) and arbuscule abundance (9%) were observed at 5 years old.
- In 2023, the peak occurred at 4 years old (27% intensity), also significantly different from ages 1, 2, and 3.



Effect of soil tillage on age-related mycorrhization dynamics in Alfalfa



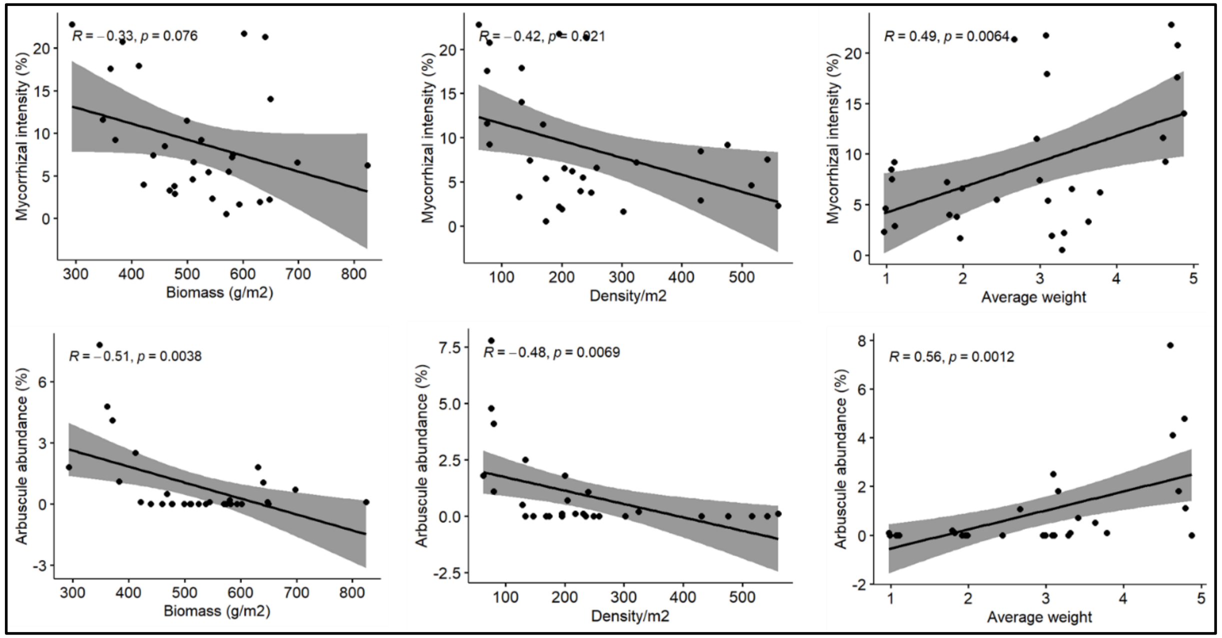


Boxplots created using SigmaPlot 12.0

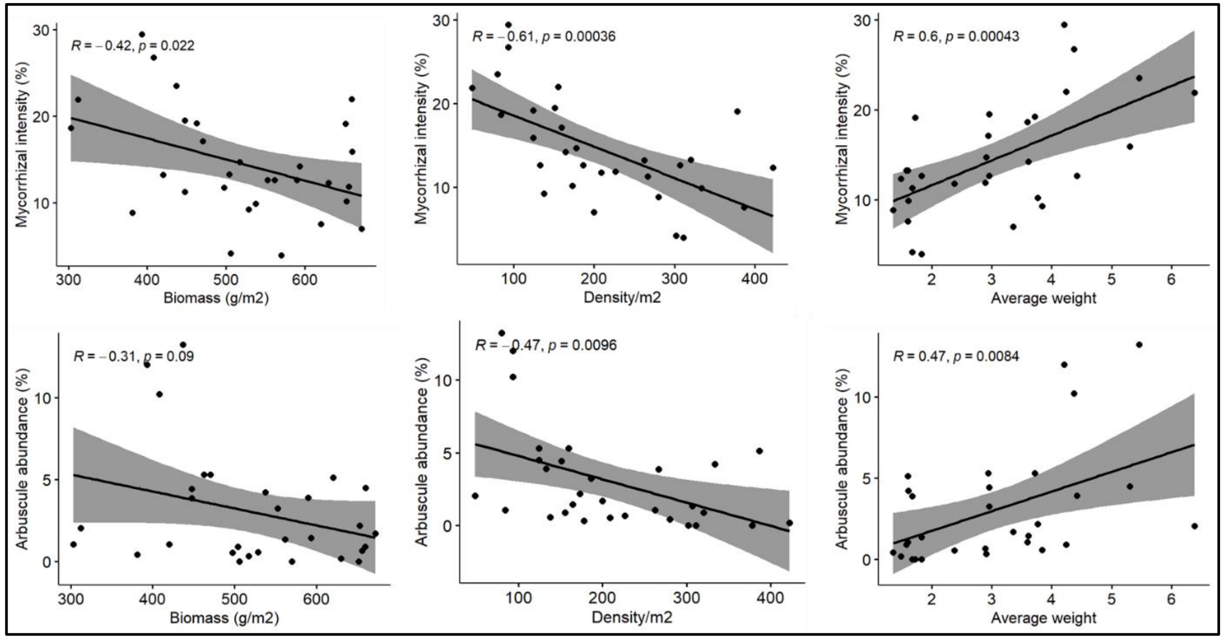
- **Age positively influences mycorrhization (under Reduced Tillage):**
  - Mycorrhizal colonization increases with alfalfa age under both ploughing and SCT in 2022 and 2023.
- **SCT greatly enhances mycorrhization:**
  - <u>In 2022</u>, mycorrhizal intensity reached 40% at 5 years under SCT, compared to only 10% under ploughing at the same age.
  - <u>In 2023</u>, the trend persisted, with 41% at 5 years under SCT, versus 22% under ploughing.

Relationship between mycorrhizal colonization and agronomic parameters of alfalfa under Conventional Ploughing (2022–2023)

Ploughed fields 2022



Ploughed fields 2023

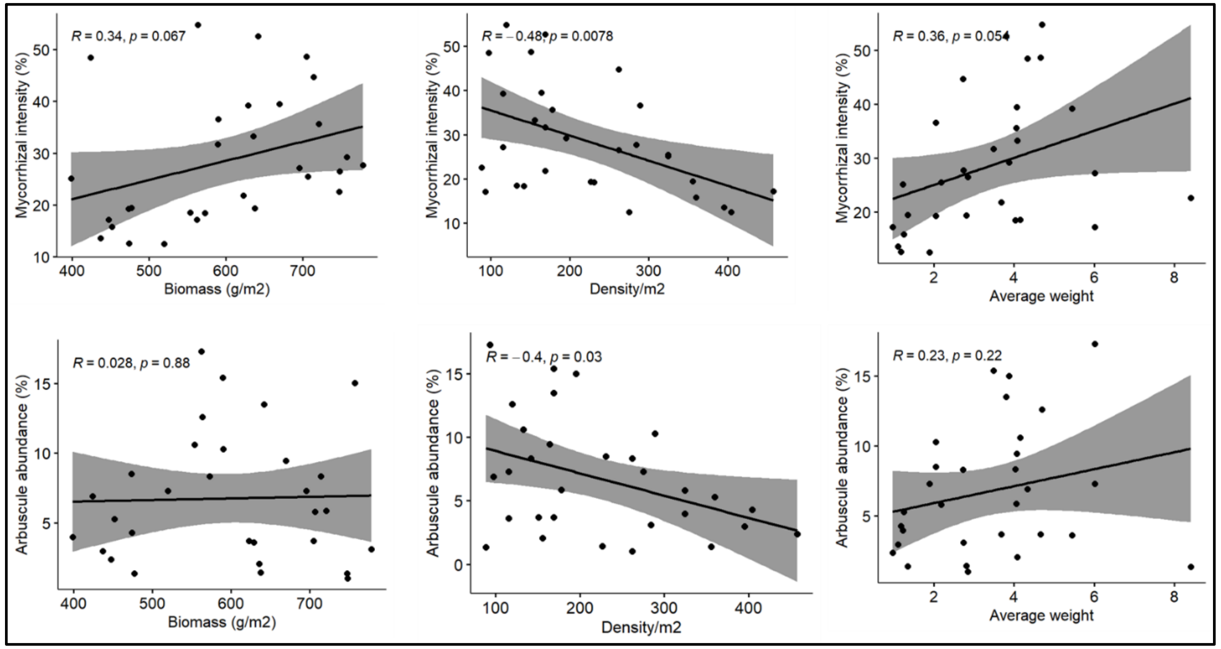


- Negative correlations between AMF parameters and root biomass ($p < 0.05$), plant density ($p < 0.05$)
- Positive correlations with average plant weight:
  - Mycorrhizal intensity ($p < 0.05$)
  - Arbuscular abundance ($p < 0.05$)

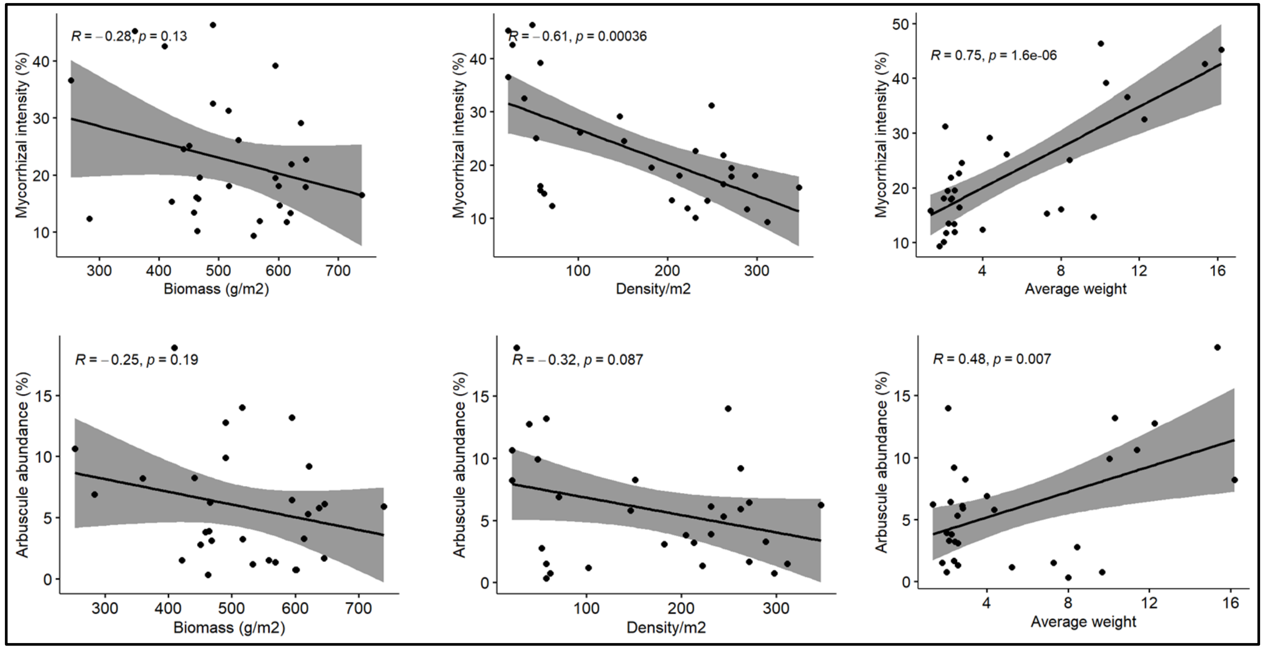
→ AMF colonization supports individual plant vigor, even when overall stand density is high.

Relationship between mycorrhizal colonization and agronomic parameters of alfalfa under SCT (2022–2023)

SCT fields 2022



SCT fields 2023



- Correlations generally weaker and more variable:
  - Biomass vs AMF: weak positive or negative (depending on year).
  - Plant density vs AMF: negative in both years.
  - Average weight vs AMF: positive but moderate.

→ AMF–alfalfa relationships are less sensitive to SCT management but still linked to individual plant performance.

Conclusion

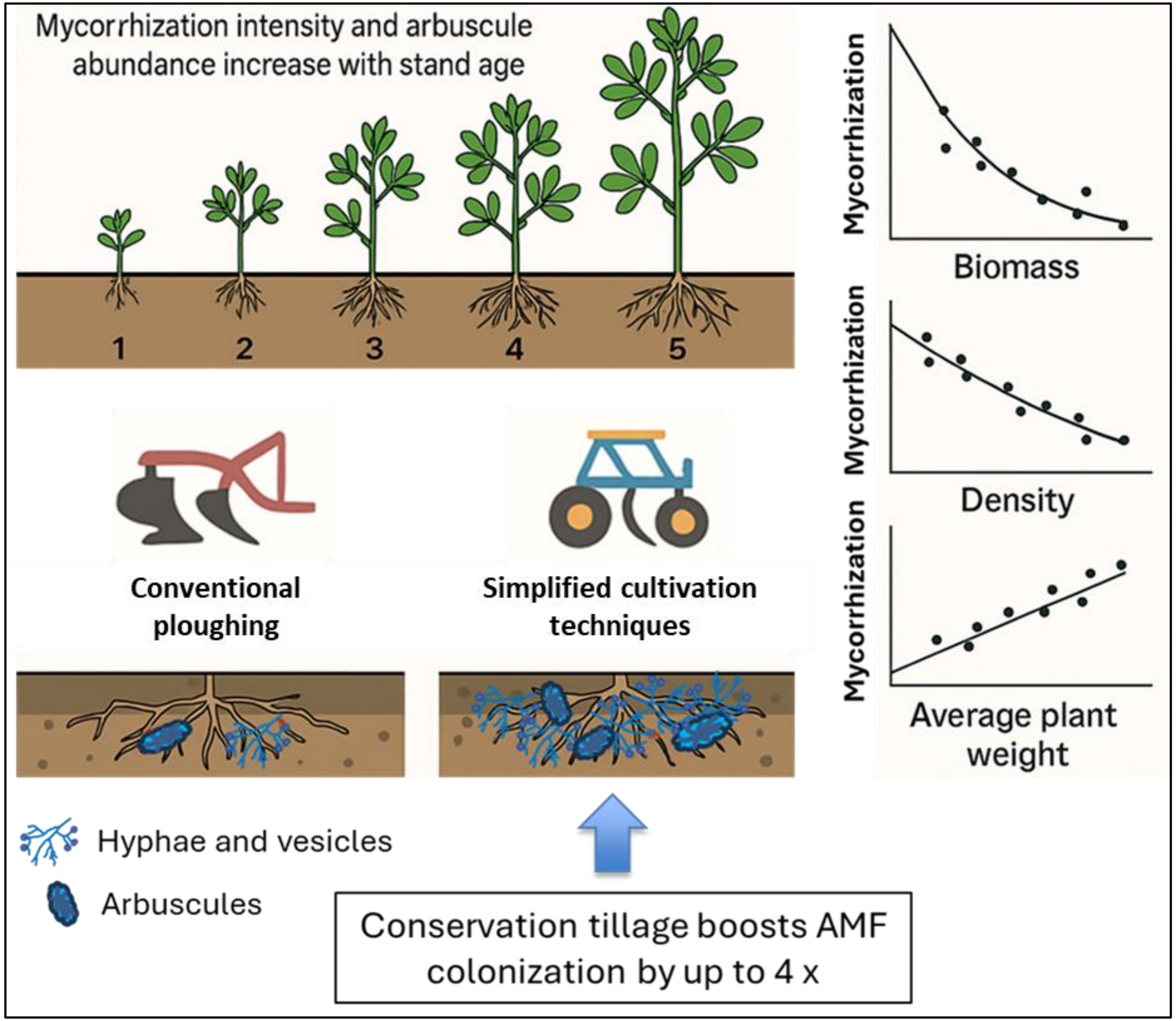
- Strong influence of stand age and soil tillage on the dynamics of arbuscular mycorrhizal symbiosis in alfalfa.

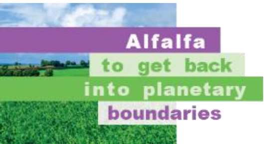
- Mycorrhizal colonization increases with alfalfa stand age ➡ gradual establishment of stable AMF networks

- Soil tillage strongly affects this dynamic:
  - *Ploughing* reduces mycorrhization
  - *SCT* enhances and maintains AMF activity

- Older alfalfa stands under SCT show the highest mycorrhizal colonization

- Positive link between mycorrhization and plant vigor





Thank you for your attention

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