Optimization of productivity and sustainability of intensive cropping systems through symbiotic nitrogen fixation in agroforestry plantations

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Present geopolitical and environmental world context:

- Rarefaction of fossil fuels
- Needs to reduce CO$_2$ emissions

➡️ Promotion of renewable energy sources

➡️ Biomass

➡️ Forest = first supplier currently

➡️ + Short Rotation Coppice (SRC) plantations on agricultural lands
Tree plantations dedicated to biomass production

Currently not attractive because not optimized
Tree plantations dedicated to biomass production

- Introduction of N fixators, woody or herbaceous

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<thead>
<tr>
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<th>Alfalfa</th>
<th>Cereals</th>
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<tbody>
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<td>Poplar</td>
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<td>Alder</td>
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- Poplar: 2.5 m x 2 m
- Alfalfa: 2 m x 2.5 m
- Cereals: 5 m
Mixture plantations introducing nitrogen fixators

Our hypotheses
Mixture plantations introducing nitrogen fixators

Our hypotheses and the ways to test them
Mixture plantations introducing nitrogen fixators

The experimental agroforestry plantation: location
Mixture plantations introducing nitrogen fixators

The experimental agroforestry plantation: layout

3.5 ha – 3500 trees – 100 tree lines
Mixture plantations introducing nitrogen fixators

The experimental agroforestry plantation: maintenance

- Instrumentation to monitor soil and weather conditions

- Protection of trees against game + mulching

- Weed control (mechanical, chemical)

- Watering during summer 2015
Mixture plantations introducing nitrogen fixators

Already some undesirable treatment effects!
Mixture plantations introducing nitrogen fixators

 Already some undesirable treatment effects!

Wheat yield in 2015

Mixture with alder: $40.3 \pm 2.5$ quintal ha$^{-1}$

Monoculture: $49.0 \pm 3.6$ quintal ha$^{-1}$
Thank you!

Questions?
Method: Symbiotic nitrogen fixation

- **Aim:** to determine the amount of nitrogen fixed by the leguminous

- **Isotopic dilution:** increase of soil $^{15}$N signal with an input of a labelled fertilisant (ammonium sulfate $(^{15}$NH$_4)_2$SO$_4$)

\[
\% \text{Ndfa} = 100 \left[ 1 - \frac{x^E_{\text{leg}}}{x^E_{\text{non-leg}}} \right] \quad \text{(Fried & Middelboe, 1977)}
\]

\[
x^E \text{ (excess in } ^{15}\text{N}) = \frac{^{15}\text{N} \times 100}{(^{15}\text{N} + ^{14}\text{N})} - 0.003663
\]

- **Transfers**

\[
P_{\text{nonleg(\neq atm)}} = 1 - \left( x^E_{\text{non-leg mixture}} / x^E_{\text{non-leg pure}} \right)
\]

\[
P_{\text{nonleg(\neq leg)}} = \left( x^E_{\text{non-leg pure}} - x^E_{\text{non-leg mixture}} \right) / \left( x^E_{\text{non-leg pure}} - x^E_{\text{leg mixture}} \right)
\]

(Chalk & Smith, 1994)

**Percentage of N derived from the atmosphere**

**Percentage of $^{15}$N in excess**

**N proportion in the non fixing species coming from the biological N fixation**

**N proportion in the non fixing species coming from the N fixing species**