Impact of poplar-clover agroforestry system on root traits and microbial communities in controlled conditions

Piutti Séverine[1], Le Mouël Cédric[1], Marron Nicolas[2], Dallé Erwin[2], Priault Pierrick[2]

[1]Université de Lorraine, INRAE, UMR LAE, 54518 Vandoeuvre-lès-Nancy, France
[2]Université de Lorraine, AgroParisTech, INRAE, UMR Silva, 54000 Nancy, France

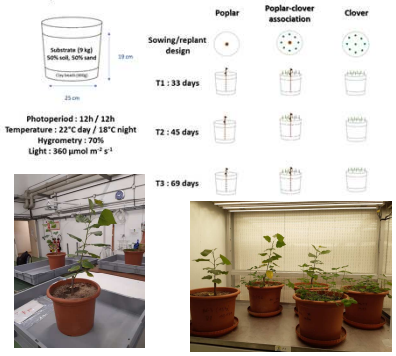
Context

The central hypothesis of agroforestry systems is based on an optimized use of environmental resources by the associated species due to a differentiation or spatial segregation of niches allowing the coexistence of associated species without competitive exclusion. Today, the mechanisms of interaction between species that determine whether agroforestry associations will be more productive than the corresponding monospecific stands are still poorly understood.
The objective of this study was to follow over a 3-month period the temporal evolution of plant above-ground biomass acquisition together with the root traits, soil organic carbon and nitrogen pools and microbial activity of the poplar-clover association grown in pots in comparison with each species in pure treatment.

Material & Methods

Experimental trial:

- 3 treatments (poplar-clover association, poplar monoculture, clover monoculture)
- 4 replicates



Plant traits (measured on clover and poplar for each treatment):

- Carbon assimilation
- Nitrogen balance index
- Shoot and root biomass
- Root architecture

Soil parameters (measured respectively on clover and poplar rhizosphere soil for each treatment):

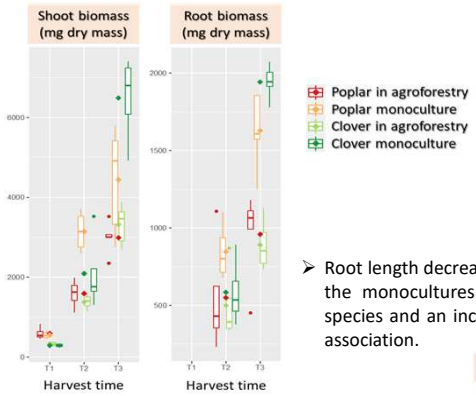
- Hot water carbon (HWC) and nitrogen (HWN) extracts
- Inorganic nitrogen ($N\text{-}NO_3^-$)

Microbial traits (measured respectively on clover and poplar rhizosphere soil for each treatment):

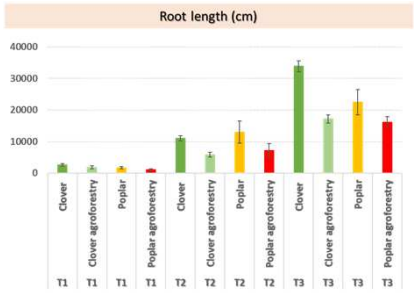
- Enzyme activities related to SOM mineralization:
  - leucine aminopeptidases (N cycle)
  - N acetylglucosaminidases (N cycle)
  - arylsulfatases (S cycle)
  - β-glucosidases (C cycle)
  - xylosidases (C cycle)
  - acid phosphatases (P cycle)

Results

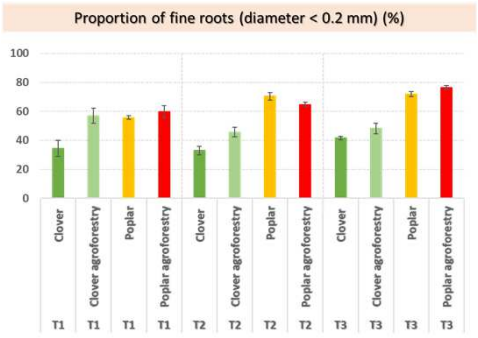
Plant traits



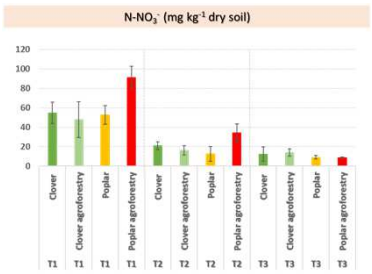
- Shoot and root biomass decreased significantly for poplar in agroforestry as compared to the monocultures at the second harvest time (45 days) and for clover in agroforestry at the third harvest (69 days).



- Root length decreased significantly in agroforestry treatments as compared to the monocultures at the second harvest with a smaller root length per species and an increase of the representativeness of fine clover roots in the association.

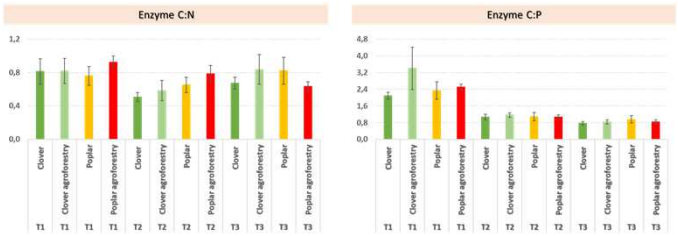


Soil parameters



- Soil hot water carbon (HWC) and nitrogen (HWN) evolved during plant growth suggesting changes in root activity but without any difference between the treatments (data not shown).
- Nitrate content decreased significantly with time with higher values in poplar rhizosphere soil in the agroforestry treatment at T1 and T2.

Microbial traits



- Enzyme stoichiometry (C:N and C:P ratios) changed significantly overtime (notably for C:P ratio) with only slight differences between treatments.

Conclusion

In controlled conditions, competition for resources led to a decrease of shoot and root biomass in clover-poplar association compared to each monoculture. In the case of clover compared to poplar, below-ground competition induced more early changes in root traits towards more acquisitive traits (i.e. finer roots) in the agroforestry association. These changes in root architecture could in turn affect microbial enzyme stoichiometry and nutrient availability.