Hybrid walnut wood quantity and quality: Agroforestry vs. Forestry systems.

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Agroforestry for the transition towards sustainability and bioeconomy
Abstract
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Abstract

On an agroforestry plot, the services provided by trees are numerous, especially on the economic front since they help to improve the business model of the farm by diversifying activities and income for the farmer.

However, agroforestry trees grow in very different conditions than forestry trees mainly because of their higher exposure to wind and light, specific competition for water availability, strong interactions with annual crops, numerous human operations on branches (pruning) and root systems (due to the tillage). Production level and quality such as anatomical, chemical and technological properties of wood coming from agroforestry systems have not yet been studied. Such results could provide many interesting data to the farmers to promote access of agroforestry wood to conventional and/or niche markets.

This work started in January 2020 and is divided into two main axes: on one hand, we aim to understand how agroforestry trees adjust to their specific growing conditions, and on the other hand, we aim to study how these growing conditions affect the quality of the wood. As well as the annual wood productivity level, the notion of wood quality, which is very important because it influences the potential valorisation ways of the woods, may allow to improve their economical values. In our study, the wood quality will be addressed by considering the two following aspects: the mechanical performances and the biochemical composition. Two species are studied: hybrid walnut (*Juglans x regia x nigra* NG 23xRA) for the high aesthetic value in the wood market and poplar (*Poplar sp*) for the packaging and building market. The work is conducted by comparing, for each species, the growth and quality of wood from agroforestry trees with that from trees grown under more conventional conditions in terms of stand densities.

In this presentation, we focused on hybrid walnut trees growing into the Restinclières Agroforestry Platform (RAP), near Montpellier, France, managed by UMR ABsys INRAE team (https://umr-system.cirad.fr/en/the-unit/research-and-training-platform-in-partnership/restinclieres-agroforestery-platform-rap). Two plots with 25 years old walnuts are studied: an Agroforestry plot (AF, with 140 walnuts) and a Forestry Control plot (FC, with 235 walnuts).

Initially the planting density in both plots (AF and FC) was identical. A thinning in 2004 reduced the density of the AF plot to 100 trees/ha and walnut trees were spaced 4, 8, 12 or 16 m on a same planting line. Between each line, winter cereal crops were cultivated. In FC plot, the walnut tree density was almost 200 trees/ha and were mixed with alders (*Alnus cordata*). In both plots, tree rows were north-south oriented. In the agroforestry stand, the annual crop was fertilized with approximately 150 kg N ha^{-1} yr^{-1}, except when it was a leguminous, and the soil in the inter-row was usually ploughed to 20 cm depth every year before the crop was sown. In the forest control plot, half of the trees were fertilized until 2010 and the other half not.

Dendrometric measurements have been recorded by UMR ABSys since 1995 for the height and 1998 for the circumference at 1.30 m height and allow the comparison of wood production between agroforestry and forestry walnuts. Our first results show that radial growth of the stem in AF plot was greater than in FC plot, with mean values of circumference of 95 cm and 63 cm, respectively in 2017 (Figure 1 - left). The height of walnut trees in AF plot was also more important than those of trees from FC plot with average values of 12.8 m and 11.5 m high, respectively (Figure 1 - right).

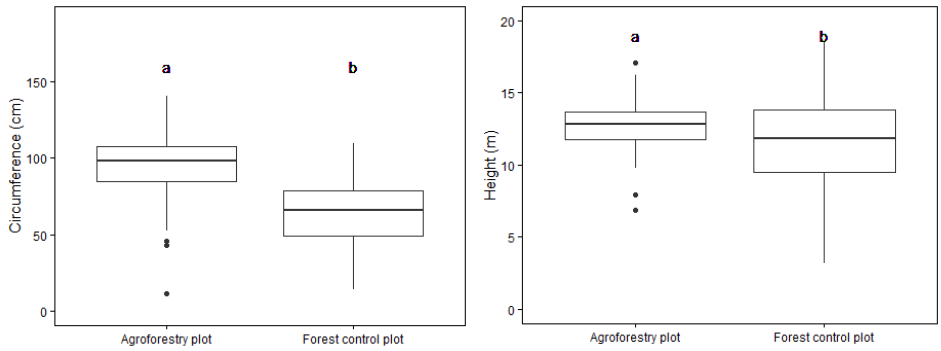

Figure 1. Left: Circumference at 1,30 m height of AF walnuts and FC walnuts, *p-value = 2.2e-16 (2018)* / **Right:** Total height of AF walnuts and FC walnuts, *p-value = 0.00012* - (2017)

Concerning radial growth, our results are in agreement with observations made on the impact of stand density on growth. In forest stands, density has significant effects on radial tree growth and crown size. Low stand density leads to the formation of trees with larger diameters than trees planted at higher densities (Jiang et al. 2007). In addition, Cabanettes et al. (2004) showed that tree spacing in agroforestry systems favored radial growth. This could be explained by the higher availability of water, light and enhanced by a higher mechanical stimulation due to the wind (Bonnesoeur et al. 2016 ; Niez et al. 2019). Concerning height growth, our results show the AF walnuts are taller than FC walnut, which differs from other studies indicating that agroforestry trees are usually smaller than forest tree (Cabanettes et al. 2004) and that axial growth could be reduced by higher mechanical stimulations due to wind (Niez et al. 2019).

After this first quantitative approach on agroforestry walnut wood, all the other experiments aim at investigating the qualitative aspects of these specific woods; in particular the duraminisation kinetic reactions, the mechanical properties and the peeling ability for an industrial target. These experiments are currently in progress.
The continuation of the study on the growth of agroforestry trees will focus on the agroforestry poplar, its mechanical properties and its aptitude for peeling. We will also focused on the impact of wind on the primary and secondary growth dynamics of the trees and on the juvenile/adult transition of the wood whose age of establishment influences the mechanical quality of the wood produced by the tree.
In parallel to these two main studies, the effect of wind on tree growth (thigmomorphogenesis) is studied on young Black Locust trees (*Robinia pseudoacacia*) in an experimental agroforestry system in South of France, in order to distinguish the effects of water, nutriments and light resources from the impact of higher exposure to wind.

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