# Lessons learnt: Medicinal plants in silvoarable systems in Galicia, Spain

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| Authors | María Rosa Mosquera Losada, Nuria Ferreiro Domínguez, Juan Luis Fernández Lorenzo, Pilar González Hernández and Antonio Rigueiro Rodríguez |
| Contact | mrosa.mosquera.losada@usc.es |
| Approved | Michael Kanzler and Paul Burgess (18 January 2018) |

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## 1 Context

The AGFORWARD research project (January 2014 - December 2017), funded by the European Commission, is promoting agroforestry practices in Europe that will advance sustainable rural development. The project has four objectives:

1. to understand the context and extent of agroforestry in Europe,
2. to identify, develop and field-test innovations (through participatory research) to improve the benefits and viability of agroforestry systems in Europe,
3. to evaluate innovative agroforestry designs and practices at field-, farm- and landscape scales, and
4. to promote the wider adoption of appropriate agroforestry systems in Europe through policy development and dissemination.

This report contributes to the second objective in that it contains results of the studied innovations from one of the systems being studied within work-package 4 which focuses on agroforestry for arable systems. Together with other reports, this document will contribute to Deliverable 4.11 on lessons learnt from agroforestry for arable farmers. Similar reports exist for agroforestry of high nature and cultural value, agroforestry with high value trees, and agroforestry for livestock systems.

## 2 Silvoarable systems in Galicia, NW Spain

An initial stakeholder meeting, with 14 participants, was held in 2014 (Mosquera-Losada et al. 2014). In this meeting, the stakeholders identified as the most positive aspects of the silvoarable systems the business opportunities, the originality and interest, the feasibility of the project, the diversity of products and the general environmental benefits. The negative aspects included the complexity of work, labour and management costs and losses due to wildlife. Integrating trees and medicinal plant production was identified as possible areas for research. For this reason, a research protocol developed by the stakeholder group focused on cultivation of medicinal plants between *Prunus avium* L. in Galicia was produced in 2015 (Mosquera-Losada et al. 2015). This research protocol was updated in 2016 (Mosquera-Losada et al. 2016a). In 2017, this report provides guidelines for farmers on how to combine the production of medicinal plants with the growth of *Prunus avium* L.

In Europe, silvoarable practices only occupy 360000 hectares representing less than 1% of the European land occupied by agroforestry practices (Mosquera-Losada et al. 2016b). This type of agroforestry practice is also rare in Galicia (NW Spain) and should be promoted due its economic, environmental and social advantages compared with conventional agricultural and forest systems (Rigueiro-Rodríguez et al. 2009).

Medicinal plants could be used in the establishment of silvoarable systems because the 80% of the people in the world use the medicinal plants to treat human diseases (Rao et al. 2004). Moreover, in the tropics many medicinal plants are well adapted to partial shading, allowing them to be intercropped with timber and fuel wood plantations, fruit trees and plantation crops (Vyas and Nein 1999). Medicinal plants could be intercropped with high value trees such as *Prunus avium* L. because this tree species is characterised by a low radiation interception for the understory and a fast growth rate with better financial returns (3000 € $m^{-3}$) compared with more extended used tree species in the Galicia region (Horgan et al. 2003; Chifflot et al. 2006).

## 3 Objectives

The experimental work included the objective to evaluate the effect of the tree density and the fertilisation on the yield and the concentration of active components of *Melissa officinalis* L. and *Mentha x piperita* L. established under *Prunus avium* L. in Galicia, NW Spain.

## 4 Methodology

The experiment was established in Boimorto (A Coruña, Galicia, NW Spain) on a plot managed by the Bosques Naturales company. The experiment was overseen by the University of Santiago de Compostela. Bosques Naturales is a forestry company focused on the management, maintenance, monitoring and research of high-value hardwood species plantations, mainly walnut and cherry.

The plantation of *Prunus avium* L. was established in 2008. Initially, the plantation was a mixed stand which was managed to establish *Prunus avium* L. at the final densities of 6 m x 1.25 m and 6 m x 2.5 m, equivalent to 1333 and 666 trees $ha^{-1}$, respectively. In November 2015, after the soil preparation, *Melissa officinalis* L. and *Mentha x piperita* L. were planted in-between tree rows following a randomized block design with three replicates. Medicinal plants were planted in 1.75 m-wide alleys, at 2.12 m distance from the base of the trees. Distance between plants rows was 0.7 m and distance between plants within a row was 0.4 m. Medicinal plants were planted in one of the alleys, whilst the other alley remained uncropped to allow access for machinery for annual pruning and phytosanitary application to the trees.

The total number of treatments established was eight: two medicinal plants (*Melissa officinalis* L. and *Mentha x piperita* L.) established under *Prunus avium* L. at two densities (1333 and 666 trees $ha^{-1}$) without fertilisation and with fertilisation (5 t $ha^{-1}$ of sheep manure and mineral fertiliser).

A specific description of the silvoarable system established with the medicinal plants is provided in Table 1.

Table 1. Description of the silvoarable system established with medicinal plants (*Melissa officinalis* L. and *Mentha x piperita* L.)

| Specific description of site | |
|---|---|
| Area | Total area 1620 $m^2$ |
| Co-ordinates | 42°58'30"N, 8°11'24"W |
| Site contact | University of Santiago de Compostela: María Rosa Mosquera Losada |
| Site contact email | mrosa.mosquera.losada@usc.es |
| Example photograph |  |

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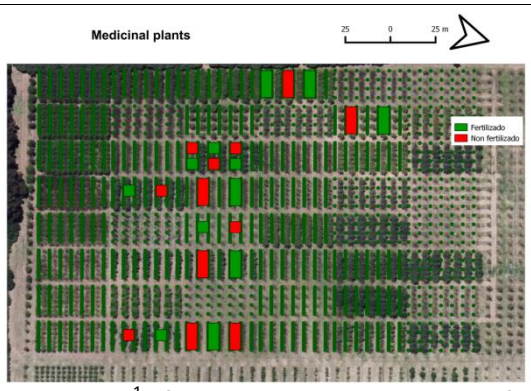
|---|---|
| Map of system |  <br>Green: fertilised with 5 t ha$^{-1}$ of sheep manure and mineral fertiliser<br>Red: no fertilisation |
| **Climate characteristics** | |
| Mean monthly temperature | 12.6 °C |
| Mean annual precipitation | 1898 mm |
| Details of weather station (and data) | "Boimorto" weather station |
| **Soil type** | |
| Soil type | Humic cambisol |
| Soil depth | Over 1 m |
| Soil texture | Loam (42% silt, 31% sand, 27% clay) |
| Additional soil characteristics | Water soil pH: 5.25 |
| Aspect | West-East |
| **Tree characteristics** | |
| Species and variety | Wild cherry (*Prunus avium* L.) |
| Date of planting | 2008 |
| Intra-row spacing | Low density: 2.50 m; high density: 1.25 m |
| Inter-row spacing | 6 m |
| Tree protection | None |
| Typical increase in tree biomass | 20 m$^3$ ha$^{-1}$ year$^{-1}$ |
| **Crop/understorey characteristics** | |
| Species | *Melissa officinalis* L. and *Mentha x piperita* L. |
| Management | Protection of the medicinal plants with a plastic mesh and application of mineral and sheep manure in half of the plots to compare with the no fertilisation treatment |
| **Fertiliser, pesticide, machinery and labour management** | |
| Fertiliser | In half of the plots were applied 5 t ha$^{-1}$ of sheep manure and mineral fertiliser |
| Pesticides | Tree–understory competition was reduced with annual application of herbicides following tree rows |
| Machinery | Machinery for soil preparation, pruning and herbicides application |
| Manure handling | Part of the treatments |
| Labour | Four people to establish the experiments, two people to visit the experimental sites all weeks and two people to harvest and process the samples |
| Fencing | Not required |

*Melissa officinalis* L. was harvested in July 2016 and *Mentha x piperita* L. in July and November 2016. During the harvest the orientation of the plants in the plot was taking into account. In each plot the central plants and the plants with North orientation (North-Center) were separated from the plants with South orientation (South). The plants were weighed fresh in the field. The mortality of the plants was also recorded.

In the laboratory, a subsample of the plants was weighed fresh, dried (36-38°C) and weighed dry to estimate the dry matter yield. The leaves concentration of rosmarinic acid was analysed in *Melissa officinalis* L. In this study, the medicinal plants yield per hectare was calculated considering the area occupied by the trees and assuming that the medicinal plants were established in all alleys of the plot.

Data were analysed using ANOVA and differences between averages were shown by the LSD test, if ANOVA was significant. The statistical software package SAS (2001) was used for all analyses.

## 5 Results

### 5.1 Yield of *Melissa officinalis* L. and *Mentha x piperita* L.

The yield of *Melissa officinalis* L. obtained in this study (0.31-0.42 Mg DM $ha^{-1}$) (Figure 1) was similar to the yield found by Mihajlov et al. (2013) (0.5 Mg DM $ha^{-1}$) in the first harvest after the establishment of this medicinal plant in a region of Macedonia. However, the yield of *Melissa officinalis* L. of our study was lower than the yield estimated by Douglas (1993) in different areas of New Zealand (0.8 Mg DM $ha^{-1}$) probably due to climatic differences between Galicia and New Zealand but also because in our experiment the land occupied by the trees was discounted.

Neither the tree density nor orientation of the medicinal plants in the plots had a significant effect on the yield of *Melissa officinalis* L. ($p > 0.05$), probably because this species tolerates a partial shade (Canter 2003). However, it seems that in the plots without fertilisation the yield of *Melissa officinalis* L. was higher at low tree density (666 trees $ha^{-1}$) than at high tree density (1666 trees $ha^{-1}$). Moreover, the yield of *Melissa officinalis* L. tended to be slightly higher for North aspect in all treatments compared with South aspect.

On the other hand, although the yield of *Melissa officinalis* L. was not significantly modified by the fertilisation ($p>0.05$), in the high tree density (1666 trees $ha^{-1}$) there was a tendency of increased yield with fertilisation; which could be explained because the yield of this medicinal plant is generally favoured by the fertilisation and the irrigation (Mihajlov et al. 2013).

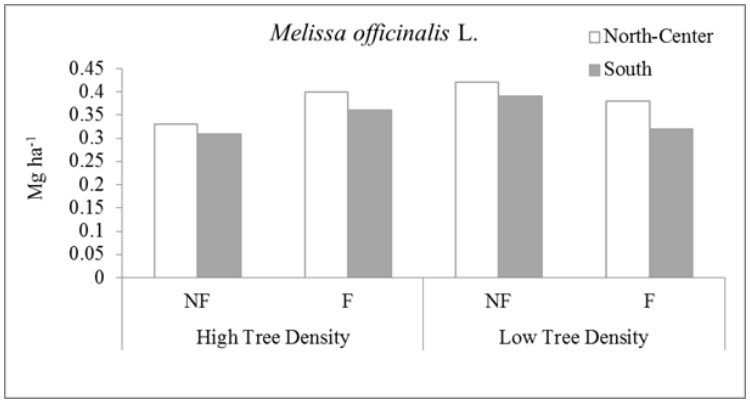



Figure 1. Yield of *Melissa officinalis* L. (Mg DM $ha^{-1}$) in a silvoarable system established in Galicia (NW Spain) under *Prunus avium* L. at different tree densities (high tree density: 1333 trees $ha^{-1}$ and low tree density: 666 trees $ha^{-1}$). NF: no fertilisation, F: fertilisation with 5 t $ha^{-1}$ of sheep manure and mineral fertiliser. North-Center and South indicate the orientation of the medicinal plants in the plots.

Figure 2 shows that the yield of *Mentha piperita* L. varied between 0.46-0.68 Mg DM $ha^{-1}$. As it was previously described for *Melissa officinalis* L., in this study the yield of *Mentha piperita* L. was not significantly modified by the tree density, the orientation of the plants in the plots and the fertilisation ($p>0.05$). However, it seems that the yield of *Mentha piperita* L. was higher at low tree density (666 trees $ha^{-1}$) than at high tree density (1666 trees $ha^{-1}$). Moreover, the yield of this medicinal plant tended to be higher in the North aspect compared with South aspect and in the fertilised plots than in the plots without fertilisation, mainly when the tree density was low (666 trees $ha^{-1}$).

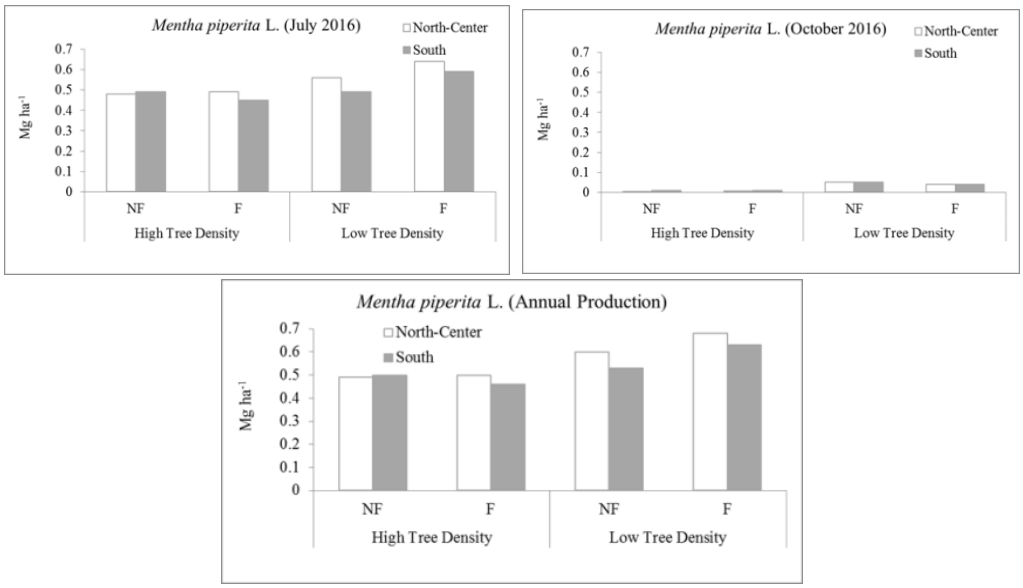



Figure 2. Yield of *Mentha x piperita* L. (Mg DM $ha^{-1}$) in a silvoarable system established in Galicia (NW Spain) under *Prunus avium* L. at different tree densities (high tree density: 1333 trees $ha^{-1}$ and low tree density: 666 trees $ha^{-1}$). NF: no fertilisation, F: fertilisation with 5 t $ha^{-1}$ of sheep manure and mineral fertiliser. North-Center and South indicate the orientation of the medicinal plants in the plots.

### 5.2 Concentration of rosmarinic acid in *Melissa officinalis* L.

In this study, the concentration of rosmarinic acid (1.28-2.78%) in *Melissa officinalis* L. was higher than the minimum required by the European Pharmacopoeia (1%) (Figure 3). Moreover, the values of rosmarinic acid found in our experiment are within the range defined in previous studies (0.5-6.8%), which indicates that the concentration of this active component in *Melissa officinalis* L. varies with the geographical area and the harvest time (Lamaison et al. 1990; Zgorka and Glowwiak, 2001; Wang et al. 2004).

Rosmarinic acid was higher in the high tree density (1333 trees $ha^{-1}$) compared with the low tree density (666 trees $ha^{-1}$) ($p<0.05$) probably due to the delay of the flowering period due to the shade conditions generated by the trees. If a delay in flowering happens generally the concentration of this active component is higher because there is more time to accumulate it.

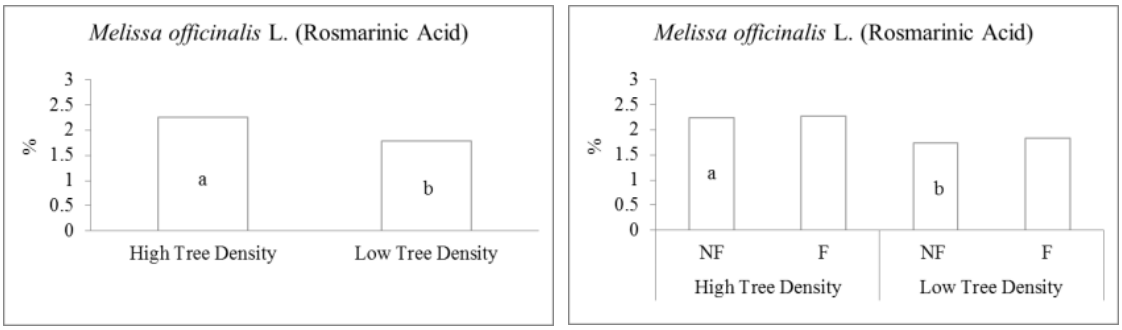



Figure 3. Concentration of rosmarinic acid in *Melissa officinalis* L. (%) in a silvoarable system established in Galicia (NW Spain) under *Prunus avium* L. at different tree densities (high tree density: 1333 trees $ha^{-1}$ and low tree density: 666 trees $ha^{-1}$). NF: no fertilisation, F: fertilisation with 5 t $ha^{-1}$ of sheep manure and mineral fertiliser. North-Center and South indicate the orientation of the medicinal plants in the plots. Different letters indicate significant differences between treatments.

## 6 Conclusions

The principal lessons learnt from the measurements and observations in the silvoarable system established with medicinal plants (*Melissa officinalis* L. and *Mentha x piperita* L.) under *Prunus avium* L. include:

- No negative effect of *Prunus avium* L. shade was found on *Melissa officinalis* L. and *Mentha x piperita* L. yield, which makes a high value tree plantation an optimum place to combine with medicinal plants yield.
- The higher concentration of rosmarinic acid in *Melissa officinalis* L. associated with the high tree density, compared with the low tree density, could be explained by the delay of the flowering period due to the shade conditions. This result can be important for farm management as the harvest period can be delayed without decreasing the concentration of active components in the medicinal plants; this creates opportunities for flexibility in labour use.

## 7 Acknowledgements

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