System Report: Silvoarable Systems in Galicia, Spain

Project name	AGFORWARD (613520)
Work-package	4: Agroforestry for Arable Farmers
Specific group	Silvoarable Systems in Galicia, Spain
Deliverable	Contribution to Deliverable 4.10 (4.1): Detailed system description of a case study system
Date of report	13 January 2016
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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 a field-, farm- and landscape scale, and
4. to promote the wider adoption of appropriate agroforestry systems in Europe through policy development and dissemination.

This report contributes to Objective 2, Deliverable 4.10: “Detailed system description of case study agroforestry systems”. The detailed system description includes the key inputs, flows, and outputs of the key ecosystem services of the studied system. It covers the agroecology of the site (climate, soil), the components (tree species, crop system, management system) and key ecosystem services (provisioning, regulating and cultural) and the associated economic values. The data included in this report will also inform the modelling activities which help to address Objective 3.

2 Background

Silvoarable agroforestry consists of widely-spaced trees intercropped with annual or perennial crops on the same land unit (Graves et al. 2007). Such systems can increase productivity and profitability and, relative to arable production, provide environment benefits such as control of soil erosion and leaching, increased carbon sequestration, and increased landscape biodiversity (Palma et al. 2006, 2007).

Silvoarable systems are rare in Galicia, where they represent less than 1% of the agricultural land (Mosquera et al. 2016). One option useful for dairy cows in the Atlantic area of Europe could be the establishment of silvoarable practices with maize (*Zea mays* L.) (Graves et al. 2009). The high yields achievable with maize make it an important fodder crop (Muzaffar et al. 2014). Moreover, maize can be used to produce high quality silage for dairy cows at a lower cost than grass silage, therefore reducing the supplementation needs with concentrates while improving farm profitability (Ali et al. 2012).

Other crops such as the medical plants could be also used in the establishment of silvoarable systems. Medicinal plants are still used by 80% of the people in the world, and traditional medicines are used to treat human diseases (Rao et al. 2004). 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). In Europe, *Melissa officinalis* L. and *Mentha x piperita* L. are widely known for their medicinal properties.

Following an initial stakeholder meeting (Mosquera Losada et al. 2014), it was decided that future experimental work should focus on the use of maize as an intercrop, and the use of medicinal plants with trees.

3 Description of systems

The experiments are taking place in Boimorto (A Coruña, Galicia, NW Spain) on a plot managed by the Bosques Naturales company. The experiments are 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 timber species plantations, mainly walnut and cherry. In 2013, Bosques Naturales had 1380 ha of high value hardwood plantations, with 300,000 trees planted on farms in different locations in Spain. Table 1 provides a general description of the established silvoarable systems.

Table 1. General description of the silvoarable systems in Galicia, Spain

General description of systems	
Name of group	Silvoarable Systems in Galicia, Spain
Contact	Maria Rosa Mosquera Losada
Work-package	4: Agroforestry for Arable Farmers
Associated WP	None
Estimated area	The total area of the research site is about 456 ha.
Typical soil types	Humic cambisol
Description	In Galicia, silvoarable systems to produce quality timber are rare. However such systems are increasing in area in other parts of Europe such as France. Wild cherry (*Prunus avium* L.) for example is a productive European timber species of the Rosaceae family due to its rapid growth and its valuable timber. Wild cherry is common in Galicia, especially in the eastern half of the region. Substantial volume of maize (*Zea mays* L.) are transported around the world and the EU imports large quantities from countries like Brazil. In Galicia, maize can be used to overcome fodder shortages during the summer and winter. Medicinal plants are used by 80% of the people in the world and traditional remedies are part of Galician traditional culture. Maize and medicinal plants can be grown in silvoarable systems with, for example, wild cherry trees
Tree species	Wild cherry (*Prunus avium* L.)
Tree products	High quality timber
Crop species	Maize (*Zea mays* L.) Medicinal plants: *Melissa officinalis* L. and *Mentha x piperita* L.
Crop products	Maize can be harvested and used as fodder crop for animals or to produce high quality silage. Medicinal plants can also be harvested to be processed for human consumption.
Animal species	None
Animal products	None
Other provisioning services	Possibility of using tree prunings as livestock fodder or as firewood.
Regulating services	Trees can reduce temperature fluctuations, promote nutrient cycling, and increase carbon sequestration.
Habitat services and biodiversity	During the first years after tree establishment, weed management is required to prevent weeds from competing with the trees and invading the crop areas.
Cultural services	The establishment of silvoarable systems can increase rural employment.
Key references	See end of report

4 Update on field measurements

Field measurements described in the research and development protocol (Mosquera Losada et al. 2015) began in the spring of 2015 and will continue until the end of 2017. All measurements have been and will be conducted by researchers from the University of Santiago de Compostela with the collaboration of the "Bosques Naturales" company.

5 Intercropping with medicinal plants

A specific description of the silvoarable system with medicinal plants is provided in Table 2.

Table 2. Description of the silvoarable system established with medicinal plants

Specific description of site	
Area	0.162 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	

Figure 1. Experiments where medicinal plants are grown between wild cherry trees

Map of system

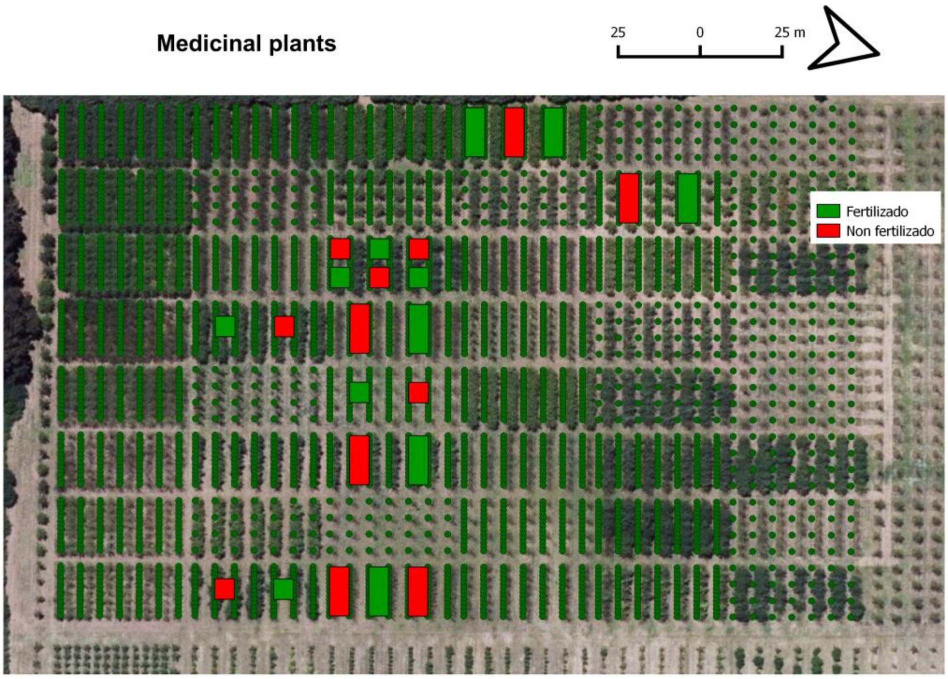

Figure 2. Location of the fertiliser and non-fertilised plots. The green area were fertilised with 5 t ha^{-1} of sheep manure and mineral fertiliser. The red areas received no fertilisation.

Possible modelling scenarios

Comparison	Technical and economic analysis of silvoarable systems versus conventional agriculture and forest systems.

Climate characteristics

Mean temperature	12.6°C
Mean annual precipitation	1898 mm
Details of weather station (and data)	"Boimorto" weather station (http://www2.meteogalicia.es/galego/observacion/estacions/estacionsHistorico.asp?Nest=19062&prov=A%20Coru%F1a&tiporede=automaticas&red=102&idprov=0#)

Soil type

Soil type	Humic cambisol
Soil depth	Over 1 m
Soil texture	Loam (42% silt, 31% sand, 27% clay)
Additional soil characteristics	soil pH (in water): 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.
Typical crop yield	
Fertiliser, pesticide, machinery and labour management	
Fertiliser	In half of the plots, 5 t ha^{-1} of sheep manure and mineral fertiliser was applied
Pesticides	Tree–understory competition was reduced with annual application of herbicides along the tree rows.
Machinery	Machinery for soil preparation, pruning and herbicides application.
Manure handling	For selected treatments
Labour	Four people to establish the experiments, two people to visit the experimental sites each week and two people to harvest and process the samples.
Fencing	Not required
Financial and economic characteristics	
Costs	Unknown

5.1 Description of tree component

The tree hedgerows of the alley cropping system consist of wild cherry (*Prunus avium* L.). The plantation densities are 6 m x 1.25 m and 6 m x 2.5 m, equivalent to 1333 and 667 trees per hectare, respectively. The trees were planted in 2008. The treatments therefore consist of two tree densities.

5.2 Crop species

The medicinal plants are planted in a randomized block design with three replicates. The plants have been planted in the 5 m alleys, leaving 1 m at the base of the trees. Each experimental plot comprises the area between 10 trees (i.e. 9 x 11.25 m^2 = 56.25 m^2 and 9 x 22.5 m^2 = 112.5 m^2).

6 Intercropping with maize

A specific description of the silvoarable system established with maize is provided in Table 3.

Table 3. Description of the silvoarable system established with maize

Specific description of site	
Area	0.668 ha
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	

Figure 3. Intercropping with maize between wild cherry

Map of system	

Figure 4. Blue, dark green, light green, and red represent the C-1, C-9, C-15 and C-G wild cherry clones, respectively. The control treatment is a conventional agricultural field adjacent to the tree experiment (out of the range of this photo)

Possible modelling scenarios	
Comparison	Technical and economic analysis of silvoarable systems versus conventional agriculture and forest systems.
Climate characteristics	
Mean temperature	12.6°C
Mean annual precipitation	1898 mm
Details of weather station (and data)	“Boimorto” weather station (http://www2.meteogalicia.es/galego/observacion/estacions/estacionsHistorico.asp?Nest=19062&prov=A%20Coru%F1a&tiporede=automaticas&red=102&idprov=0#)
Soil type	
Soil type	Humic cambisol
Soil depth	Over 1 m
Soil texture	Loam (42% silt, 31% sand, 27% clay)
Additional soil characteristics	Soil pH (in water): 5.25
Aspect	West-East
Tree characteristics	
Species and variety	Wild cherry (*Prunus avium* L.)
Date of planting	2008
Intra-row spacing	Low density: 5 m Medium 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	Maize (*Zea mays* L.)
Management	Conventional maize management with the usual ploughing
Typical crop yield	Authors as Moreno-González (1982) and Lloveras (1990) found a production of maize in Galicia around 13.4 t ha^{-1} and 14.07 t ha^{-1}, respectively.
Fertiliser, pesticide, machinery and labour management	
Fertiliser	None
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	None
Labour	Four people to establish the experiments, two people to visit the experimental sites on a weekly basis and two people to harvest and process the samples.
Fencing	Not required
Financial and economic characteristics	
Costs	Unknown

6.1 Experimental treatments

The experiment with maize has been at the same site in Sendelle as the medicinal plant experiment. The maize experiment will investigate three plantation densities (6 m x 5 m, 6 m x 2.5 m and 6 m x 1.25 m equivalent to 333, 667, and 1333 trees per hectare).

6.2 Yield measurements

Maize production per planted hectare was estimated in October 2015. It is important to be aware that in the agroforestry plots the planted maize area comprised the central 4 m of the plots (i.e. two-thirds of the total area). Figure 5 shows that maize yield values were greater for control plots (No trees) than for silvoarable plots with different tree densities (low, medium, and high density) ($p<0.001$). This result could be explained by the shade generated by the trees which could limit the maize growth (tree hedgerows were only 6 m apart). Figure 6 also shows a clear relationship between the tree density and the production of maize which decreased when the tree density was high.

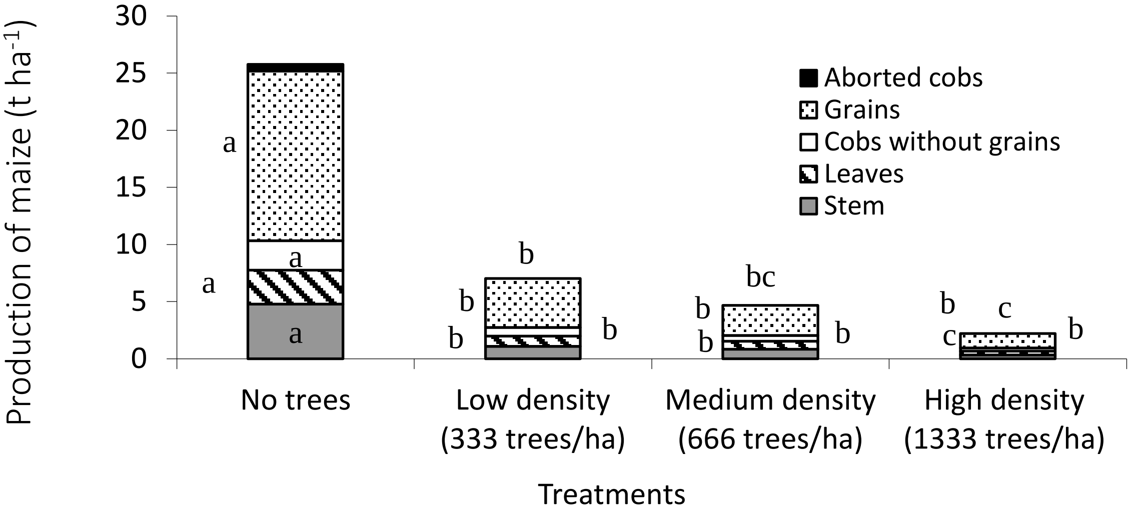

Figure 5. Production of the different components of maize (aborted cobs, cobs without grain, stems, grains and leaves) (t dry matter ha^{-1}) under the different treatments in 2015. Different letters indicate significant differences between treatments according the LSD test.

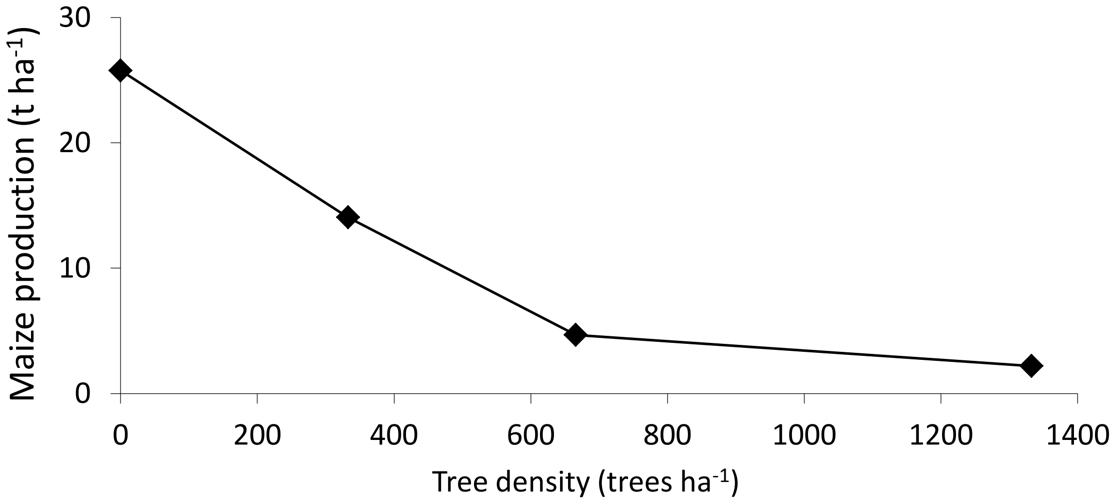

Figure 6. Relationship between the total production of maize and the tree density

7 Acknowledgements

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