



Research and Development Protocol for Cereal Production beneath Walnut in Spain

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Specific group	Cereal production beneath walnut in Spain (cross-links with WP3: Grazing and Intercropping of Plantation Trees in Spain)
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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 the second objective. It contributes to the initial research and development protocol, [Milestone 16 \(4.3\)](#), for the participative research and development network focused on the use of agroforestry in arable systems.

2 Background

During the 2010s, intensive hardwood plantations, using chemical inputs and high levels of energy inputs to reduce the rotation length, have substantially increased in many Spanish regions. Periodical harrowing, irrigation and the use of herbicides and mineral fertilizers are controversial management practices because of the high costs and their impact on soil and water pollution (Babcock et al 2003; World Bank, 2008). Agroforestry could help to reduce the economic costs of these plantations and improve the delivery of environmental services (Rigueiro-Rodríguez et al. 2009; López-Díaz et al. 2011).

This research and development protocol relates to an intensive plantation of walnut for the production of quality timber located in Toledo (Spain) owned by the company Bosques Naturales S.A. This company owns 1300 hectares in Spain for quality timber production with forestry certification of FSC.

3 Objective of experiments

The objective of this experiment is to test different cereals beneath walnut plantations under intensive management for quality timber production. The initial hypotheses are:

- There is not significant competition between trees and crops by soil water: because root of both strata are developed at different depths and their water requirements are separated in time.
- Tree growth is not reduced by crops due to nutrient or water competition.
- Agroforestry systems reduce nitrogen contamination. Trees in silvopastoral systems develop deeper root systems that reduce nitrate lixiviation.
- The establishment of silvopastoral systems increases carbon sequestration of the system, as a result of increased productivity of the system.

4 System description

The experiment was carried out in Toledo (Spain) (Figure 1) in a 8- year old hybrid walnut (*Juglans major x nigra*) plantation, with a density of 333 trees ha⁻¹ owned by the company Bosques Naturales S.A

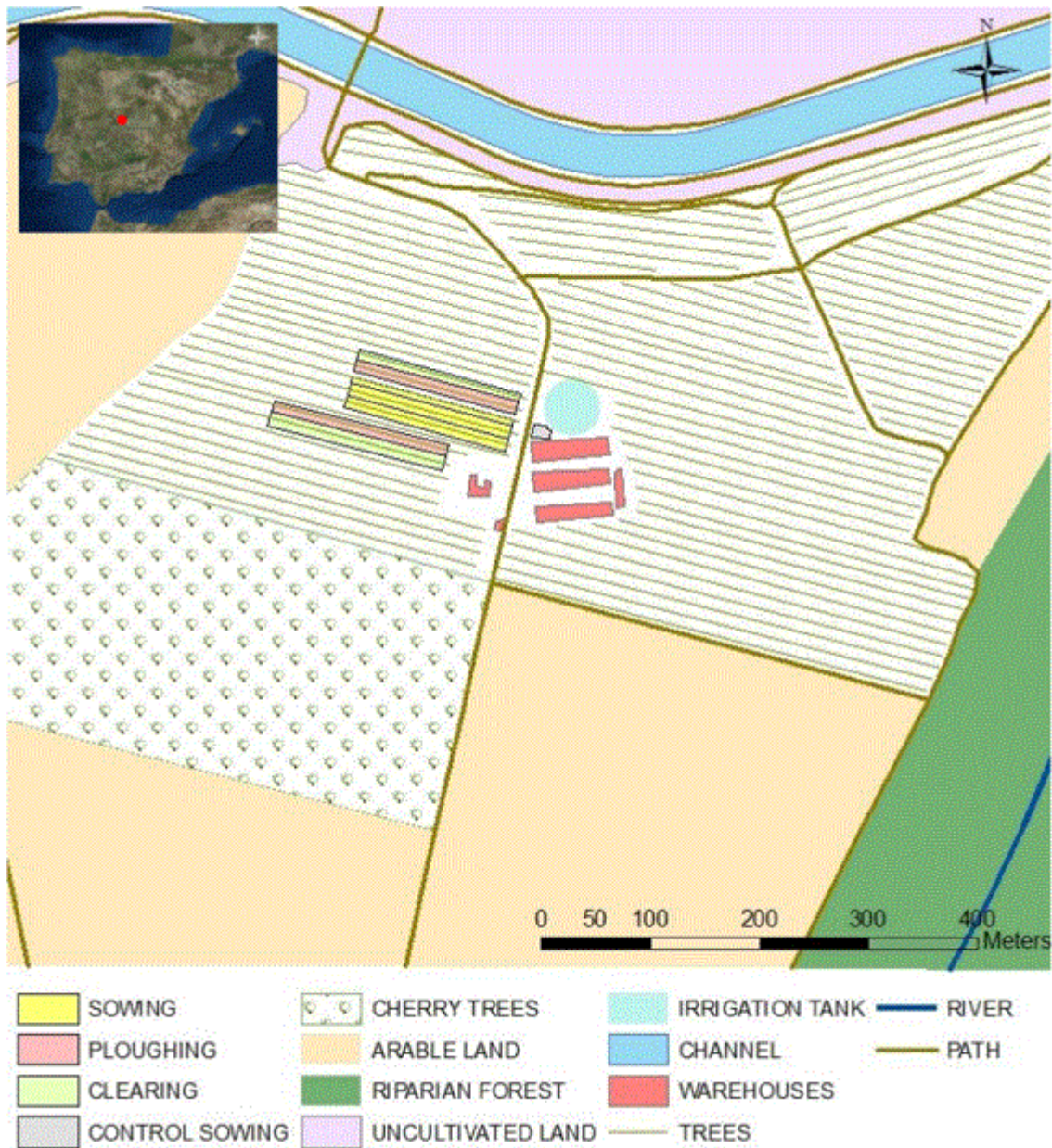


Figure 1. Map of situation and distribution of plots in the essay with different vegetation systems and treatments.

Table 1. Description of the site, with soil, tree, understorey, livestock, and climate characteristics

Site characteristics	
Area (ha):	0.5
Co-ordinates UTM:	ETRS89 huso 20: X:374.444 Y:4.411.877
Altitude	411
Slope	<5%
Site contact:	Gerardo Moreno
Site contact email address	gmoreno@unex.es

Soil characteristics	
Soil type (WRB classification)	Fluvisols
Soil depth	>140 cm
pH	5-6
Soil texture	Sandy loam

Tree characteristics	
Tree species	<i>Juglans major x nigra</i>
Tree density (spacing)	5 x 6 m
Mean breast diameter (1.3m)	16.08 cm
Tree protection	None

Understorey characteristics	
Species	Cultivated cereal species and cultivars
Coverage	100% in 4 m-width alleys among walnut rows separated by 6 m (66.6 % of the soil cultivated)

Climate data	
Mean monthly temperature	15.3°C
Mean annual precipitation	437 mm

5 Experimental design

5.1 Conceptual design

Two vegetation systems are being tested: an agroforestry system and an agricultural system with cereals grown in an open area. In each vegetation system, different treatments were installed, as Table 2 indicates.

Table 2. Treatments and plot characteristics

	Forestry control (F)	Agroforestry system (AF) Intercropped cereal	Agricultural control (C) Cereal cultivated in open area
Treatments	Two method to control weeds to be compared with intercropped walnuts * Ploughing * Clearing	3 varieties of wheat: CCB Ingenio, Sublim, Nogal 4 varieties of barley: Basic, Lukhas, Hispanic, Rgt Dulcinea 1 variety of triticale: Verato	3 varieties of wheat: CCB Ingenio, Sublim, Nogal 4 varieties of barley: Basic, Lukhas, Hispanic, Rgt Dulcinea 1 variety of triticale: Verato
Plot size	20 m x 4 m	20 m x 4 m	2 m x 2 m
Replicates	3 replicate plots	3 replicate plots	3 replicate plots
Trees	<i>Hybrid walnut (<i>Juglans major x nigra</i>)</i>		None

5.2 Description of design

The experiment was established in Autumn 2014 (Figure 2). There were five replicates of each treatment. In October 2014, all experimental plots were fertilized with 600 kg ha⁻¹ of 8:12:12 N:P:K. In the Spring, 120 kg ha⁻¹ of urea (46%) will be applied. The “forestry” plots are maintained by ploughing and controlling weeds (Figure 3).

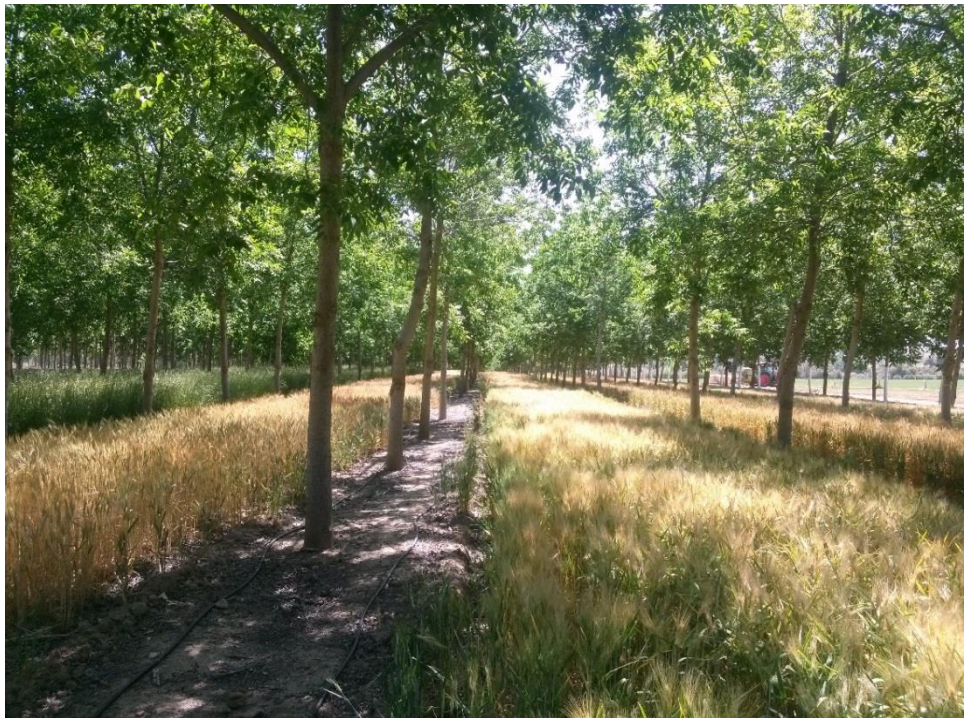


Figure 2. View of the agroforestry plot: walnut with cereals



Figure 3. View of “forestry” plots with control of weeds by clearing

5.3 Measurements

Crop yield is measured in each cereal variety and replicate plot. Nine random samples of 50 cm x50 cm will be taken, three located in the centre of the alley, three in the south border of the alley, and three in the north border of the alley. In each sample, the number of cereal plants, the height of the plants, the number and biomass of spikes, and the number and biomass of grains will be recorded. Hemispherical pictures to assess the solar radiation available for the crop, and soil samples to assess the nutrient availability (mineral N, P and P) will be taken at the same points.

Tree diameter growth is monitored every year (December) with a calliper in all trees of the experiment. In a selection of them (9 per treatment and replicate plot) leaves are taken in July to assess the leaf nutrient content.

6 Acknowledgements

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