System Description: Walnut Trees on Arable Land in France

Project name	AGFORWARD (613520)
Work-package	4: Agroforestry for Arable Systems
Specific group	Agroforestry for arable farmers in Western France
Milestone	Contribution to Deliverable 4.10 (4.1): Detailed system description of a case study system
Date of report	18 January 2016
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Approved	Jaconette Mirck (16 February 2016) Paul Burgess (8 April 2016)

Content

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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. This report was produced in January 2016, and additional material will be presented over the remaining two years of the project.

2 Background

Trees can grow equally well when intercropped with arable crops as when grown in conventional forest environments (Balandier and Dupraz, 1998). However the work of Balandier and Dupraz related mostly to young trees aged ten years and less. Very little is known about older trees within silvoarable agroforestry systems. To our knowledge, Mr Claude Jollet owns the oldest agroforestry system on arable land in France. It is situated near the town of Eduts in Charente-Maritime in Western France. The study site provides an excellent opportunity to study the influence of old black walnut (*Juglans nigra*) trees (older than 38 years) on arable crops.

It is estimated that the area funded using EU agroforestry measures in France from 2010 to 2015 is only about 1250 ha. However those working with agroforestry in France estimate that only half of the planted agroforestry area has been funded in this way and hence the area of new agroforestry plantations may be about 2,500 hectares. Only ten regions have used the agroforestry measure and about 207 projects have been implemented. The agroforestry systems have been established using varieties and young plants in accordance with forestry regulations, having a density between 30 and 200 trees per hectare, both on meadows or on arable land.

3 Objectives of research

The research aims to address four questions:

- What is the average biomass of an agroforestry tree? Is it different from a forest tree? What is the variation of the average volume and the shape of the main stem?
- How is the aboveground biomass distributed between the trunk and the branches in agroforestry and forest trees?
- How is the biomass of the branches distributed according to diameter sizes: cutting Ø ≥ 20 cm; 20 cm > 7 cm Ø ≥ ; 7 cm > Ø ≥ 4 cm ; 4 cm > Ø ≥ 2 cm in agroforestry and forest trees?

- Are there allometric equations that can be used to predict the average aboveground biomass of agroforestry and forestry trees?

This research is being conducted by the Institute for Forest Development (IDF) in collaboration with the French Association of Agroforestry (AFAF).

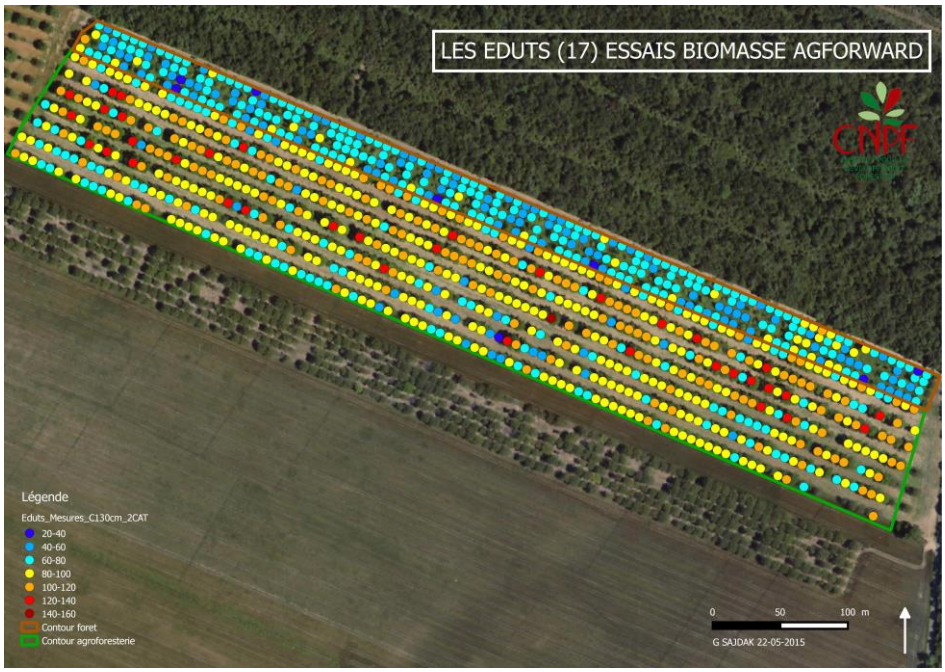
4 System description

Error! Reference source not found. provides a general description of the alley cropping system. A description of a specific case study system is provided in Table 2. Missing data will continue to be sourced during 2016.

Table 1. General description of cereal production and walnut trees association

General description of system	
Name of group	Cereal production beneath walnut in France
Contact	Nina Malignier, Philippe Van Lerberghe, Yousri Hannachi
Work-package	4: Agroforestry for arable farmers
Associated WP	3: High value trees
Geographical extent	Plantations of walnut for the production of quality timber are found in Europe, United States, China and Chile.
Estimated area	This system is only present in Charente-Maritime (on the farm of Claude Jollet) and on the experimental farm of INRA in Montpellier. The estimated area is about 100 ha.
Typical soil area	Rendosol (Baize 2009)
Description	Arable crops with walnut trees plantation are dedicated to a double production: the crops and the quality timber. The presence of trees enables soils to be more fertile.
Tree products	Those walnuts produce quality timber highly prized for its color. It is heavy and strong, yet easily worked. This timber is hard, dense, tight-grained and polishes to a very smooth finish.
Tree species	Black walnut: *Juglans nigra*
Tree products	Quality timber Wood for heating (logs or wood chips) produced by the branches, to add the value of the plantation.
Crop species	Barley *(Hordeum vulgare)*
Animal species	None
Animal products	None
Other provisioning services	Possibility of using tree products as livestock fodder or as biomass for animal litter
Cultural services	Rural employment
Regulating services	Carbon storage Temperature, water and nutrients regulation. The distance between the trees have to be well managed to avoid a diminution of crop yields (by shadow) Soil fertility improvement
Habitat services and biodiversity	Regulation of pests

Table 2. Description of the specific case study system

Specific description of site	
Area	Forest plot (reference) : 2.5 ha Agroforestry plot : 6 ha Cultural plot (reference) : 15 ha
Co-ordinates	46°00'39.32"N - 0°13'3.75"W
Site contact	Philippe Van Lerberghe
Site contact email	philippe.vanlerberghe@cnpf.fr
Example photograph	 Figure 1. View along an alley of black walnuts
Map of system	 Figure 2. Aerial view of the walnut agroforestry (to the south) and forest system (to the north)

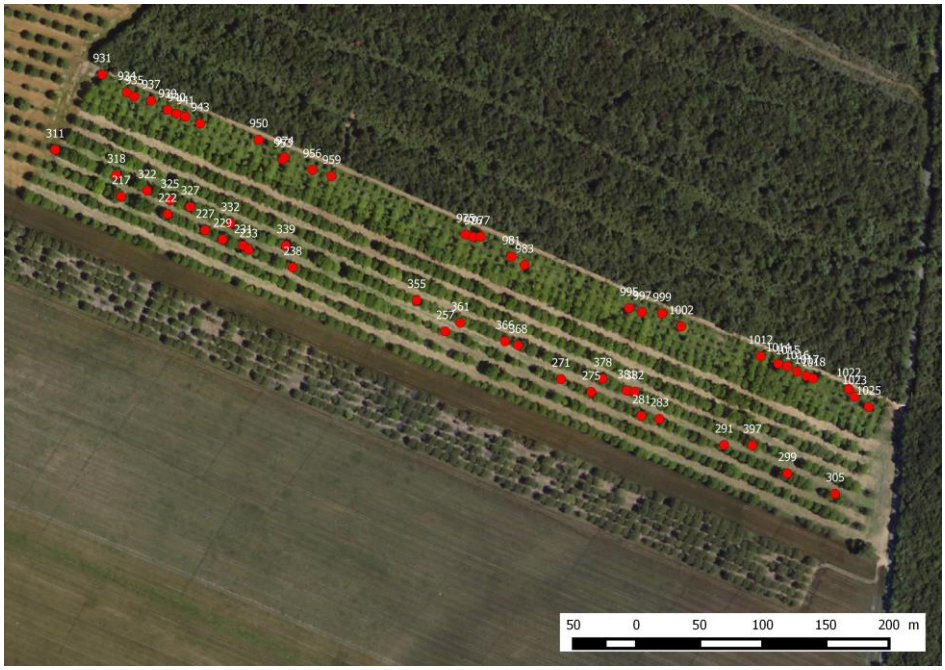


Figure 3. Aerial photograph of the walnut agroforestry (to the south) and forest system (to the north)

Possible modelling scenarios	
Comparison	Wood quantification between agroforestry plot and forest plot. Technical/economical between alley cropping and plot without trees.
Climate characteristics	
Mean monthly temperature	10.0-11.0°C
Mean annual precipitation	901-975 mm
Details of weather station (and data)	Data (1961-90) from « SILVAE – Système d'Informations Localisées sur la Végétation, les Arbres et leur Environnement » 2015
Soil type	
Soil type	Rendosol (Baize 2009)
Soil depth	15-30 cm
Soil texture	Currently being analyzed
Additional soil characteristics	For agroforestry plot: pH = 7-8 0.271 g kg^{-1} of P_2O 0.444 g kg^{-1} of K_2O 0.267 g kg^{-1} of MgO Bulk density of soil : 1.25 g cm^{-3} Organic Matter : 58.7 g kg^{-1} C : N ratio : 13.6 : 1
Aspect	North-South

Tree characteristics	
Species and variety	Black walnut (*Juglans nigra*)
Date of planting	Spring 1977
Intra-row spacing	Forest plot : 7 m Agroforestry plot : 7 m
Inter-row spacing	Forest plot : 7 m Agroforestry plot : 14 m
Hedgerow spacing	
Tree protection	None
Typical increase in tree biomass	Objective of the trial
Crop/understorey characteristics	
Species	Barley *(Hordeum vulgare* subspecies *hexastichum)*
Management	Conventional arable crop management with the usual mixture of ploughing and herbicide spraying to keep down the weeds
Typical crop yield	
Fertiliser, pesticide, machinery and labour management	
Fertiliser	On each experimental area, there will be an unfertilised part to be able to compare
Pesticides	Regular spraying of crops during the year to control weeds and pests
Machinery	Before sowing, use of a cover-crop
Manure handling	
Labour	A cover-crop was seeded in September. The field had not been cultivated for several years because of the lack of light, given that the trees were too big, and the farmer didn't want to carry out any thinning. He has changed his mind on this issue.
Fencing	Not required
Livestock management	
Species and breed	Not applicable
Financial and economic characteristics	
Costs	To be determined

5 Description of tree component

5.1 Tree species

The biomass and volume estimations will be achieved in two contiguous parcels of 40 years old black walnut (Table 1 and 2):

- Forest plantation: on a 2.5 ha plot, the trees have been installed on four lines of 700 m, 7 m spacing on the line and 7 m between planting lines. The inter-rows have included cover crops and have been weeded using disks
- Agroforestry planting: a neighbouring plot covering 6 ha; black walnut were installed on seven lines of 700 m, 7 m spacing on the line and 14 m between rows; the inter-rows were cultivated every year, most often cereals, over a width of 12 m.

5.2 Description of design

The site management parameters are described in Table 3.

Table 3. Site management parameters

Feature	Average value
Distance between rows (inter-row tree spacing)	14 m
Tree distance within a row (intra-row tree spacing)	7 m
Crop width	10 m
Number of trees per hectare	116
Mean breast diameter (1.3 m)	95 cm
Rotation	40 years
Planting date	1997
Harvest date	2016 and after

5.3 Tree allometric equation measurements

Studies of tree biomass partitioning (including the weight of branches) in a temperate climate are rare (Lotfi 2008). The steps include 1) felling a tree without leaves, 2) cutting the trunk and branches into small manageable pieces, 3) drying the wood in an oven, and 4) careful weighing (Walker et al. 2011). This destructive method is then used to develop allometric relationships. An above-ground biomass allometric equation is a statistical model relating the components of a tree to parameters such as diameter at breast height (DBH), height of the tree (Feldpausch et al. 2011), or the height of the crown (Chave et al. 2005).

The collection of field and laboratory data necessary for quantifying the ground biomass of trees takes place in three phases (Bauwens and Fayolle, 2014):

Phase 1 is an exploration phase, which is comprised of the geographic locator trees approached to locate trees corresponding to a previously defined circumference;

Phase 2 corresponds to the collection of field data, a series of measures to be taken before and after tree harvest. Tree will be harvested one at a time.

Phase 3 corresponds to the collection of laboratory data, for this purpose various measurements will be carried out on subsamples (aliquots) from trees sampled in the field. These samples will be weight before and after drying in a hoven at 105°C until a constant weight. The analysis of the data will also be conducted during Phase 3.

5.4 Tree diameter measurements

Tree circumferences at breast height were measured in April 2015. On December 2015, 30 trees were harvested in each plot (total = 60 units). The 60 trees were selected randomly in each stand.

The protocol of data collection in the field and establishing tree biomass allometric equations are based on work done in tropical Africa (Bauwens and Fayolle 2014; Picard et al. 2012). Details of the measurements are described in Table 4. They include total height, the diameter at a height of 1.3 m (DBH), and every 50 cm from ground to top of the trunk. The ground projection of the crown, and the weight of the trunk and branches were also measured.

The statistical analysis still needs to be done, the results are expected soon.

Table 4. List of measured and calculated tree variables

Variable	Abbreviation and formula	Unit
Tree		
[f] Reference circumference	C_{ref}	m
[f] Reference circumference height	H_{ref}	m
[f] Total height	H_{tot}	m
[c] Total woody aerial biomass	$B_{tot} = B_{Sa} + B_{La} + B_{Ba}$	kg
Stump		
[f] Stump height	H_S	m
[c] Stump surface	S_S	m^2
[l] Wet stump sample biomass	m_{Sw}	kg
[l] Dry stump sample biomass	m_{Sd}	kg
[c] Water content of stump wood	$WC_S = (m_{Sw} - m_{Sd})/m_{Sw}$	%
[c] Dry stump biomass	$B_{Sa} = V_{Sw} \times ID_S$	kg
Log		
[f] Length of piece$_i$	l_{pi}	m
[f] Wet biomass of piece$_i$	m_{pi}	kg
[f] Top diameter of piece$_i$	d_{ti}	m
[f] Butt diameter of piece$_i$	d_{bi}	m
[c] Log length	$L_L = \Sigma_i\, l_{pi}$	m
[c] Wet log biomass (if weighing)	$B_{Lw} = \Sigma_i\, m_{pi}$	kg
[l] Dry log sample biomass	m_{Ld}	kg
[c] Water content of log wood	$WC_L = (m_{Lw} - m_{Ld})/m_{Lw}$	%
[c] Dry log biomass	$B_{La} = V_{Lw} \times (1 - WC_L)$	kg
Branches		
[f] Length of piece$_j$	l_{pj}	m
[f] Top diameter of piece$_j$	d_{tj}	m
[f] Butt diameter of piece$_j$	d_{bj}	m
[c] Wet branches biomass	B_{Bw}	kg
[l] Wet branches sample biomass	m_{Bw}	kg
[l] Dry branches sample biomass	m_{Bd}	kg
[c] Water content of branches wood	$WC_B = (m_{Bw} - m_{Bd})/m_{Bw}$	%
[c] Dry branches	$B_{wBa} = B_{wBw} \times (1 - WC_B)$	kg

Letters [c], [l] and [f] respectively indicate that the variable is calculated, measured in the laboratory or measured in the field.

6 Acknowledgements

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