AGFORWARD
Agroforestry for Europe

System Report: Weed Survey in Mediterranean Silvoarable Group in France

Project name	AGFORWARD (613520)
Work-package	4: Agroforestry for arable farmers
Specific group	Mediterranean silvoarable systems in France
Deliverable	Contribution to Deliverable 4.10 (4.1): Detailed system description of a case study system
Date of report	15 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

The initial stakeholder group, which focused on silvoarable systems, mentioned weeds as an issue for crop management, and unravelling the impact of trees on weed infestations in silvoarable systems has been identified as one of the key research topics for work-package 4 (Burgess et al. 2014; Cirou and Hannachi, 2014; Gosme 2014; Malignier et al., 2014; Wartelle 2014). Because of an obvious lack of knowledge about weed communities in these systems, further research is required. Some studies have described weed composition and abundance in both the alley cropping systems and the understory vegetation (e.g. Burgess et al. 2003). It is expected that weed communities in silvoarable systems are modified because of i) the tree understory at the edge of cropped alleys, and ii) competition with the trees for light and water. Consequently the effects of weeds on crops may be different compared to weed communities of arable crops without trees.

3 Update on field measurements

Weed survey described in the research and development protocol (Mézière and Boinot 2015) began by a first survey at the end of March 2015 and will continue until the end of 2016. Each year the weed survey is carried on three dates: 1) at the onset of spring vegetation and before tree budbreak (ca. February-April), 2) after budbreak when tree leaves are well developed and when crops are flowering (ca. May-beginning of June), and 3) in autumn before crop sowing.

Two fields were surveyed in 2015. Only one field (see Field A, described in Mézière and Boinot, 2015) will be surveyed in 2016 as the farmer gives up the other field (because the 15-years poplars shade out the crop, see Field B described in Mézière and Boinot, 2015).

4 System description

Table 1 provides a general description of the silvoarable agroforestry systems established in Restinclières estate (South of France). A description of the specific case study system (Field A in Mézière and Boinot, 2015) is provided in Table 2.

Table 1. General description of the silvoarable agroforestry system

General description of system	
Name of group	Mediterranean silvoarable systems in France
Contact	Lydie Dufour
Work-package	4: Agroforestry for arable farmers
Associated WP	6: Field- and farm-scale evaluation of innovations
Geographical extent	Modern alley cropping agroforestry systems are still few, but an increasing number of farmers are planting since the last 5 years). The oldest French Mediterranean fields are 20 years old now and are located in the experimental site conducted by INRA in Restinclières estate, Hérault, France.
Estimated area	The total area of the agroforestry experiments in the Domain site is about 40ha.
Typical soil types	Silty deep alluvial fluvisols with 25% clay and 60% silt
Description	Alley cropping agroforestry systems. Cropping system is very typical: a legume followed by two straw cereals, conventionally managed with superficial tillage and mouldboard-ploughing every 3 years. Crops are under the responsibility of a local tenant farmer. Trees are managed by the estate on the advice of INRA research team. Fields were planted between 20 and 15 years ago, at 13m inter-row width.
Tree species	Poplar (*Populus spp*), walnut (*Juglans nigra x regia*), sorb (*Prunus domestica*), ash (*Fraxinus excelsior*), maple (*Acer spp.*), hackberry (*Celtis australis*), and wild pear tree (*Pyrus pyraster*)
Tree products	Timber wood
Crop species	Straw cereals, legumes, oilseed rape, alfalfa
Crop products	Grains
Animal species	None
Animal products	None
Other provisioning services	Some energy crops (alder, poplar)
Regulating services	Trees provide a microclimate which buffers daily temperature variations and protects from extreme values of temperature, which may increase the quantity of harvest by protecting crops against drought, but may also improve the quality of harvest production by protecting crops against thermal stresses. Trees can promote nutrient cycling, increase carbon storage, and reduce nitrogen leaching in autumn-winter.
Habitat services and biodiversity	Many animal species can use the trees and the herbaceous vegetation in the tree lines for habitat resulting in increased biodiversity. In addition, the herbaceous diversity on the tree lines itself.
Cultural services	Herbaceous vegetation on tree lines can host patrimonial vegetation. Trees contribute to landscape amenities.
Key references	Cardinael et al. (2015); Andrianarisoa et al. (2016) and unpublished results produced on alley cropping agroforestry systems of Restinclières estate.

Table 2. Description of the specific case study system

Specific description of site	
Area	4 ha
Co-ordinates	43°43′ N, 4°1′ E
Site contact	Lydie Dufour
Site contact	dufourl@supagro.inra.fr
Example photograph	 Figure 1. Harvesting of the alley crop in July 2015 © C. Dupraz  Figure 2. Growth of the alley crop in May 2015 © D. Meziere

Map of system

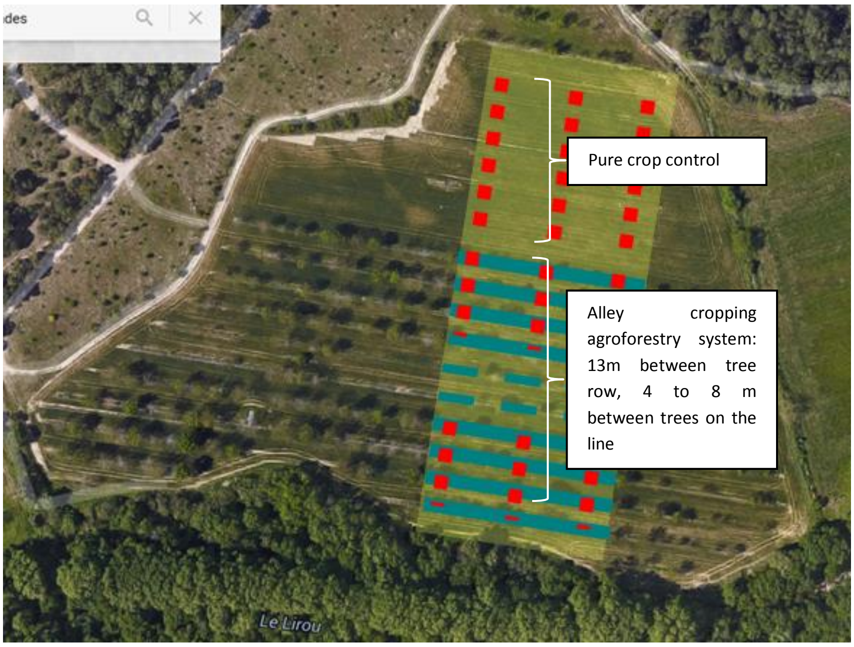

Figure 3. Schematic map of the alley cropping system (Source: Google map, 2015). In red, the 3 transects along for weed survey. In blue, the tree lines (in the middle of the agroforestry part, the two pollard-tree lines (blue dash lines) were not studied for the weed survey).

Climate characteristics	
Mean monthly temperature	14.2 °C
Mean annual precipitation	851 mm
Details of weather station	Data from 2011-2013 (Campbell station on site)
Soil type	
Soil type	Silty deep alluvial fluvisol
Soil depth	Deep
Soil texture	Silty clay limestone
Additional soil characteristics	Carbonated soil
Aspect	Flat
Tree characteristics	
Species and variety	Hybrid walnut (*Juglans nigra x regia cv. NG23*)
Date of planting	1995
Intra-row spacing	4 to 8 m (4 m at planting, but half of the trees were thinned out in 2003)
Inter-row spacing	13 m
Tree protection	None
Crop understory characteristics	
Species	Typical arable crop rotation: winter pea (*Pisum sativum*)/winter durum wheat (*Triticum turgidum* subsp. *durum*)/winter barley (*Hordeum vulgare)*. Winter barley in 2015, winter pea in 2016
Management	Conventional arable crop management with mouldboard-ploughing every 3 years.
Typical crop yield	Winter barley: typically 5-6 t ha^{-1} but 6.5 t ha^{-1} in 2015

	Winter pea: 2 t ha^{-1} Winter wheat: 4.5 t ha^{-1}
Fertiliser, pesticide, machinery and labour management	
Fertiliser	Mineral nitrogen (common amount), Sulphur. None for pea.
Pesticides	Conventional herbicide programme. Herbicides: anti-grass + anti-broad-leaf herbicides (diclofop methyl, fenoxaprop-p-ethyl, metsulfuron methyl or substitutes depending on crop species) No insecticide. Seed-protection fungicide for cereals
Machinery	Need for tractor access in crop alleys to allow soil tillage, sowing, input applications and harvesting
Manure handling	None
Labour	Normal
Fencing	None

5 Description of tree component

The Restinclières estate site comprises 40 ha under agroforestry, divided in about 15 fields. About 30 species of trees were planted in 1995, and new planting occurred in 2000 on some fields to replace non-adapted tree species (*Paulownia tomentosa*) composed of two agricultural plots. The field used for the weed survey, and described in Section 4, was planted in 1995 with one tree species (hybrid walnut) at 200 trees per hectare. In 2003, a thinning was performed to remove half of the trees, resulting in a final density of 100 trees per hectare. Because thinning was made by selecting the best quality trees, some trees are still separated by 4 m on the tree line, whereas some others are at 12 m. The trees were pruned at 4 or 6 m.

6 Description of crop component

The crop rotation involves durum wheat as the main cash crop. The first crop in the rotation is typically a legume (*Pisum sativum*), although oilseed rape (*Brassica napus*) is sometimes used. This is followed by two cereal crops such as durum wheat (*Triticum turgidum* subsp. *durum*), but in 2015 the second cereal was barley (*Hordeum sativum*). Production potential is high for the region, because of the deep soil and the shallow water table.

Preliminary results from 2015

The objectives of the first weed survey in alley cropping agroforestry systems were (i) to compare the composition, abundance, and spatial distribution of arable weed communities in agroforestry vs. pure crop control, and (ii) to assess the effect of the distance to the tree line and the effect of light competition with trees on the structure of weed communities within the crop alleys. Weed communities were studied in experimental fields A and B. (See the detailed protocol in Mézière and Boinot, 2015). The contrasting levels of shade in the alley cropping system and in the crop control field (without tree nor herbaceous strips within the field but the same cropping system) are shown in Figure 1.

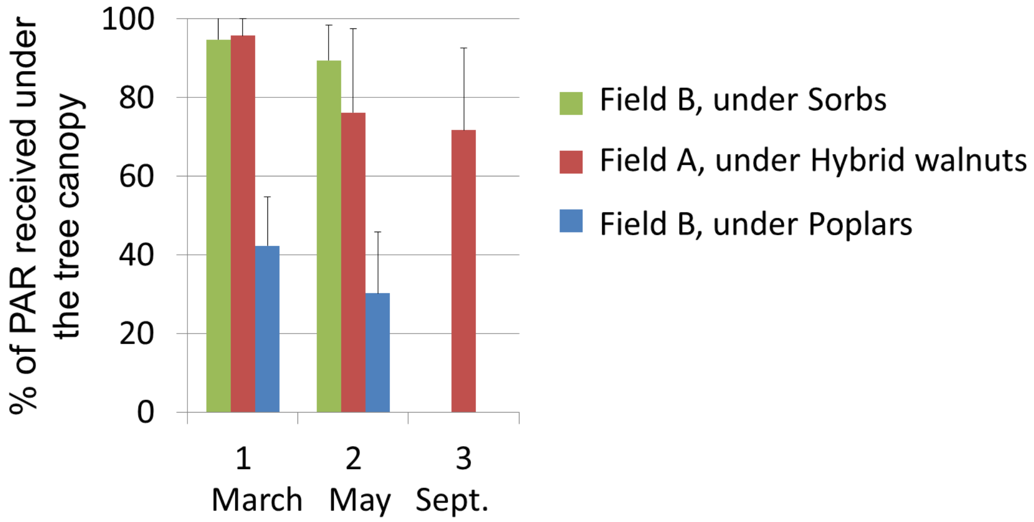

Figure 1. Proportion of Photosynthetically Active Radiation (PAR) received under the tree canopy compared to the pure crop control situation for the three weed survey sessions in March, May and September 2015

The results from March and May 2015 showed a lower ($p < 0.01$) weed density and a significant different composition in agroforestry compared to the pure crop control (Principal Coordinates Analysis performed on the similarity Jaccard index matrix) (abundance and composition in Figure 2).

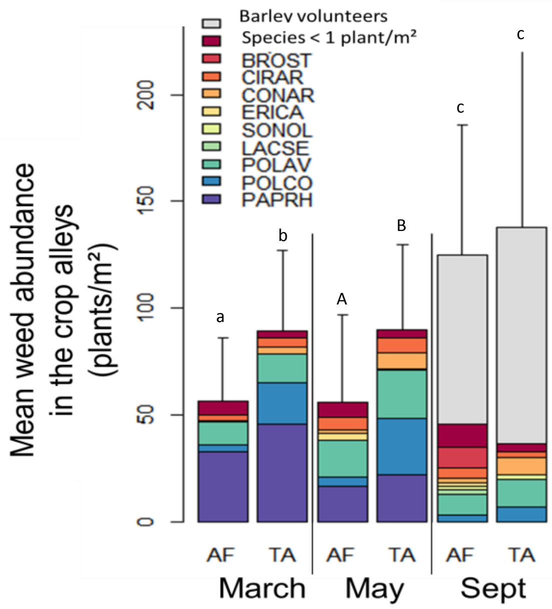

Figure 2. Specific and total abundances of flora at quadrat scale in Field A for the three sessions. AF=agroforestry system, TA=pure crop control. BROST: *Bromus sterilis*, CIRAR: *Cirsium arvense*, CONAR: *Convolvulus arvensis*, ERICA: *Conyza canadiensis*, SONOL: *Sonchus oleraceus*, LACSE: *Lactuca serriola*, POLAV: *Polygonum aviculare*, POLCO: *Fallopia convolvulus*, PAPRH: *Papaver rhoeas.* Different letters above the bars indicate significant difference between groups (α=1%, general linear mixed models performed for each session).

The number of species per m² (alpha diversity) was similar in agroforestry and pure crop control, however the total number of weed species over all samples of a given field (gamma diversity) was higher in agroforestry (samples taken within the crop alley only) than in the pure crop field. There was no observable increase in weed density close to the tree row, however there were significantly more species ($p < 0.01$) there compared to the centre of the alleys (Figure 3).

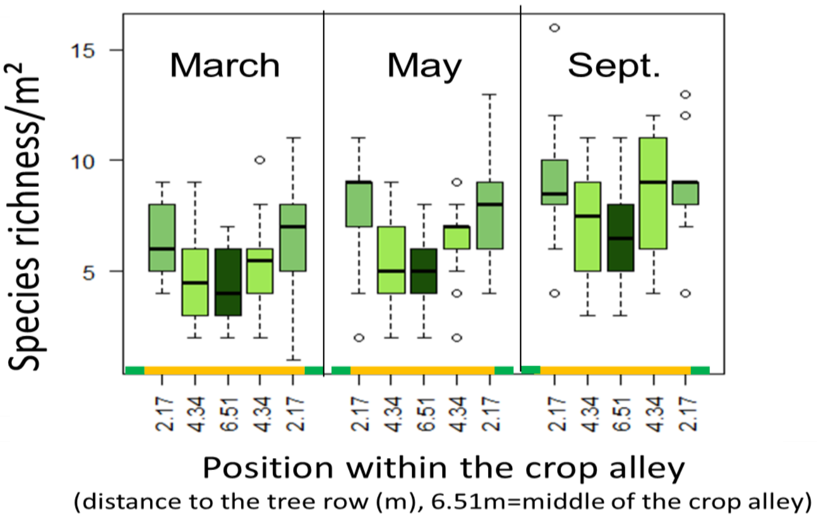

Figure 1. Distribution of the species richness at quadrat scale (alpha-diversity) as a function of the position in the crop alley in the agroforestry part of Field A. Each boxplot is the distribution of the richness for the 6 alleys x 3 transects = 18 quadrats.

7 Acknowledgements

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