Lessons learnt: Weeds and silvoarable agroforestry in Northern France

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Work-package	4: Agroforestry for Arable Farmers
Specific group	Silvoarable systems in Northern France
Deliverable	Contribution to Deliverable 4.11: Lessons learnt from innovations within agroforestry for arable farmers
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Contents

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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 in that it describes the lessons learnt within the the Silvoarable Stakeholder Group in Northern France. This lesson learnt report is one of 12 within the agroforestry for arable farmers participative research and development network.

2 Background

The initial stakeholder group, focused on silvoarable systems in Northern France, identified weeds (particularly in relation to the tree rows) as a problem for agroforestry crop management. This has been identified as one of the key research topics for work-package 4 in the AGFORWARD project (Burgess et al. 2014; Cirou and Hannachi, 2014; Gosme 2014; Malignier et al., 2014; Wartelle 2014).

Research is needed because of the current lack of knowledge about weed communities in silvoarable systems. Burgess et al. (2003) reported on a study of the understory vegetation below rows of poplar and effect of weeds within arable crops in the United Kingdom. This group focused on an assessment of the impact of tree rows on weed communities and their effect on arable crops in Northern France. 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 in silvoarable systems may be different compared to weeds effect in treeless croplands.

3 System description and field measurements

3.1 System description

The general nature of silvoarable systems in the area is described in Table 1, and a description of the study site is provided in Table 2. The weed survey is described in the research and development protocol (Degrumelle 2015). It began with a first survey of six fields in the summer of 2015 and in 2016. In 2016, the weed survey was carried out between May and the beginning of June when the tree leaves were well-developed and the crops were well-established.

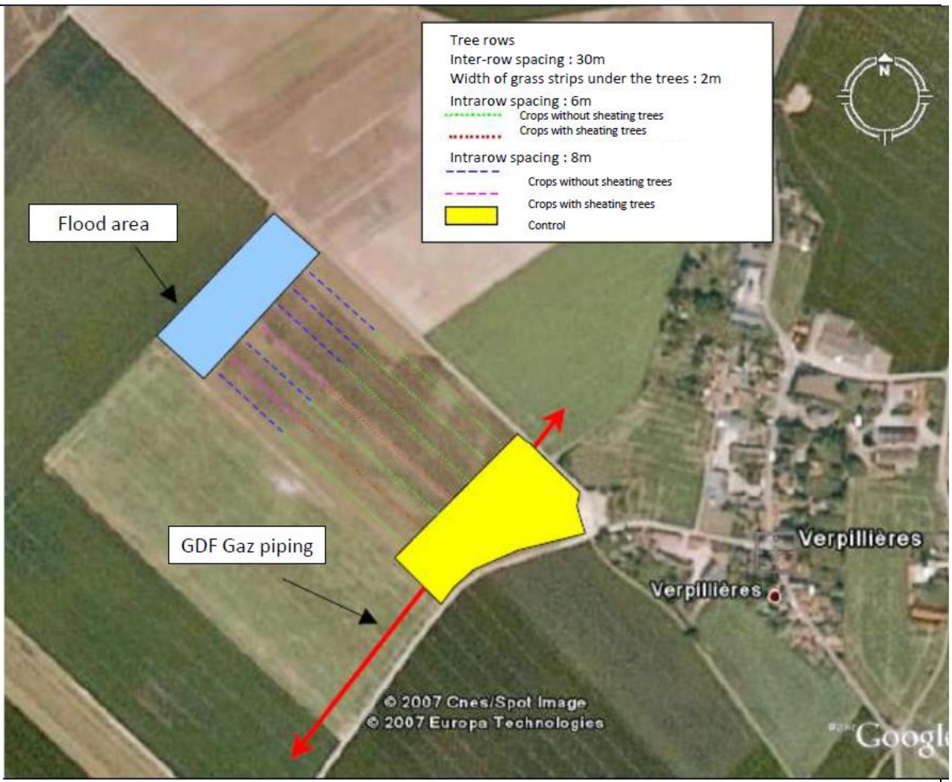
Table 1. General description of the silvoarable agroforestry case study systems

General description of system	
Name of group	Northern silvoarable systems in France
Contact	Régis Wartelle
Work-package	4: Agroforestry for arable farmers
Geographical extent	Modern alley cropping agroforestry systems are still rare, but an increasing number of farmers have been planting these systems during the last five years. The oldest Northern French field was planted in 2007 and is located in Saint-Maur (Oise, Picardie), France.
Estimated area	The total area of the silvoarable fields in Northern France is about 100 ha. Each field is about 5 to 30 ha.
Typical soil types	Luvisols, Cambisols
Description	Alley cropping agroforestry systems. Cropping system is very typical including wheat, barley, potatoes, sugar beet, and oilseed rape organically or conventionally managed with ploughing or minimum tillage. Crops are under the responsibility of local farmers. Trees are managed by the estate on the advice of Centre Regional Propriété Forestière. Fields sampled are located in Picardie - Oise (Saint-Maur and Thieux) and Somme (Lahoussoye, Bayonvillers, Verpilleres and Castel). Trees were planted in the fields between 2008 and 2014, at 26 to 50 m inter-row width (28 to 110 trees ha^{-1}), mainly with mulches (individual or straw). The understory vegetation arose from natural generation.
Tree species	Between 6 and 12 species per field, including *Juglans regia*, *Acer platanoides*, *Prunus avium*, *Sorbus torminalis, Sorbus domestica, Malus sp.* and *Pyrus sp*.
Tree products	Timber wood
Crop species	Cereals, mainly soft winter wheat (typical yield 80 to 90 quintals), potatoes, sugar beet, oilseed rape, faba bean
Crop products	Grains and other products
Regulating services	Trees may provide a microclimate which buffers from extreme values of temperature. This may increase yields by protecting crops against drought, and improve quality of crops because they suffer less thermal stress. Trees can promote nutrient cycling, increase carbon storage, and reduce nitrogen leaching in autumn-winter.
Habitat services and biodiversity	Many wild animal species can use the tree hedgerows and understory herbaceous vegetation for their habitats, resulting in an increased biodiversity.
Cultural services	Herbaceous vegetation on tree lines can host natural vegetation. Trees contribute to landscape amenities.
Key references	Degrumelle 2015.

Table 2. Description of Santerre case study system

Specific description of the site	
Area	11 ha (Established in 2008/2009)
Co-ordinates	49°40’3.96”N, 2°48’42/373”E
Site contact	Régis Wartelle
Site contact email	r.wartelle@picardie.chambagri.fr
Example photographs	 Alley-cropping system composed of sugar beet alleys and timber tree hedgerows in 2012 (3-years old) (Wartelle 2012).  Alley-cropping system composed of winter pea alleys and timber tree hedgerows in 2015 (6-years old) (Wartelle 2015)

Map of the system



Possible modelling scenarios	
Comparison	Technical and economic analyses of alley cropping vs. monoculture
Climate characteristics	
Mean monthly temperature	10.7 °C
Mean annual precipitation	669 mm
Details of weather station (and data)	Data from 1 Jan 1981 to 31 Jan 2010 (available at www.meteofrance.com)
Soil type	
Soil type	Luvisol, cambisol
Soil depth	approx. 6 m (until groundwater level)
Soil texture	Silt
Additional soil characteristics	Argile: 17.4%; Groundwater 6 to 8 m below soil surface ; Humidity : rather cool
Tree characteristics	
Species and variety	Norway maple (*Acer platanoides),* wild service tree (*Sorbus torminalis),* hybrid walnut tree (*Juglans × intermedia*), wild cherry (*Prunus avium*), wild pear tree (*Pyrus sp.*), wild apple tree (*Malus sp.*), sycamore (*Acer pseudoplatanus*), black locust (*Robinia pseudoacacia)*
Date of planting	2008-2009
Intra-row spacing	6 to 8 m
Inter-row spacing	30 m
Tree protection	Individual protection

Crop characteristics	
Species	Sugar beet (*Beta vulgaris*), oilseed rape (*Brassica napus*), potatoes (*Solanum tuberosum*), winter wheat (*Triticum aestivum*) and faba beans (*Vicia faba).* Crops grow in typical rotations: most of the time, the first crop in the rotation is oilseed rape, followed by straw cereals (wheat or barley) and then by potatoes or sugar beet.
Management	Conventional arable crop management: systematic tillage (with a mouldboard ploughing every 2 to 4 years) and chemical weed control. Organic crop management: tillage, ploughing and mechanical weed control.
Typical crop yield	Soft winter wheat typical yield 90 quintals (9 t/ha)
Fertiliser, pesticide, machinery and labour management	
Fertiliser	Assumed that this is not modified by tree hedgerows
Pesticides	Regular spraying of crops during the year to control weeds and pests
Machinery	Need for tractor access in crop alleys to allow soil preparation and spray application
Manure handling	Not necessary in field
Labour	Crops: no additional labour requirements
Fencing	Not required
Livestock management	
Species and breed	No livestock
Financial and economic characteristics	
Costs	Experimental grant for implement by Picardie Region

3.2 Weed assessment protocol

Weeds were counted at seven replicate plots (1 m^2) located in crop strips at different distances from tree rows (Q1 - Q7), as shown in Figure 1. Six fields were surveyed: four conventionally managed (AF1, AF3, AF4, AF7) and two (AF2, AF5) organically managed. AF2, AF4, AF5 are 3 to 6-years-old systems and AF1, AF 3 and AF7 are more than 6 years-old.

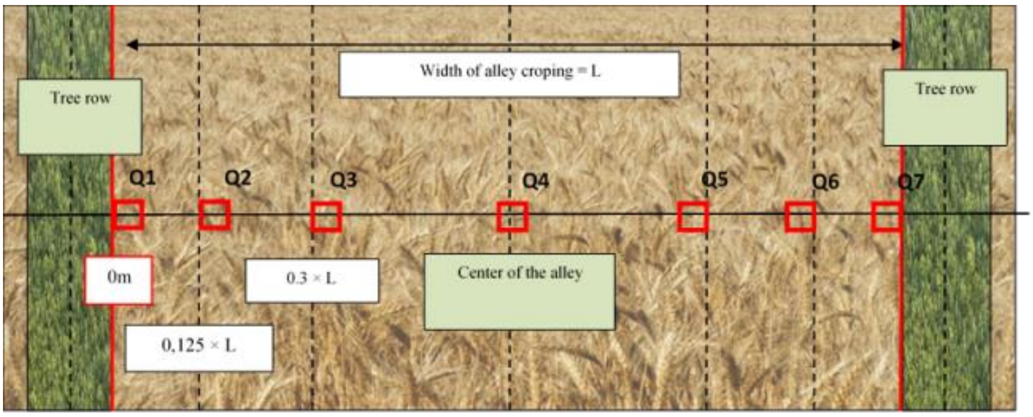
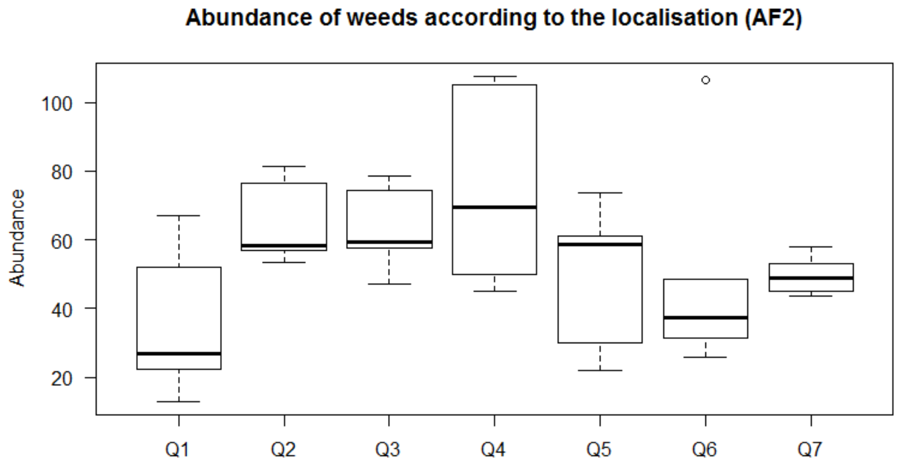


Figure 1. Schematic plan of a replicate plot found in each field - six fields were monitored

4 Results

The level of weed abundance was generally greater in the organic (AF2 and AF5) (Figure 2a) than the conventionally-managed systems (AF1, AF3, and AF7) (Figures 2b and 2c), although the weed abundance was also high in the conventionally-managed system at AF4 (Figure 2c).

Conventionally-managed alleys had higher weed abundance near the tree rows compared to the middle of the alleys (AF1, AF3, AF7) (Figures 2b and 2c), although with the winter barley crop AF4 the distribution was more even (Figure 2c). In organically-managed alleys (AF2 and AF5), where the weed abundance was higher, the abundance of weeds was similar near the tree rows and in the centre of the alley (Figure 2a).



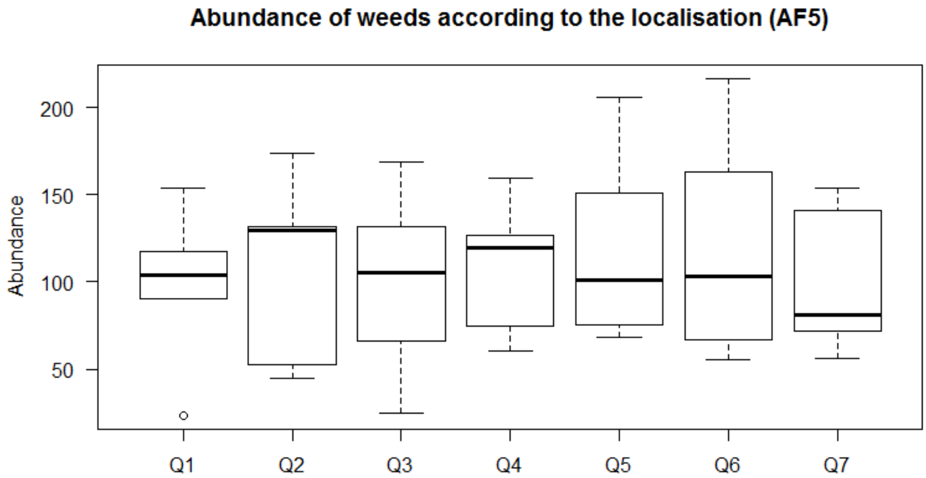
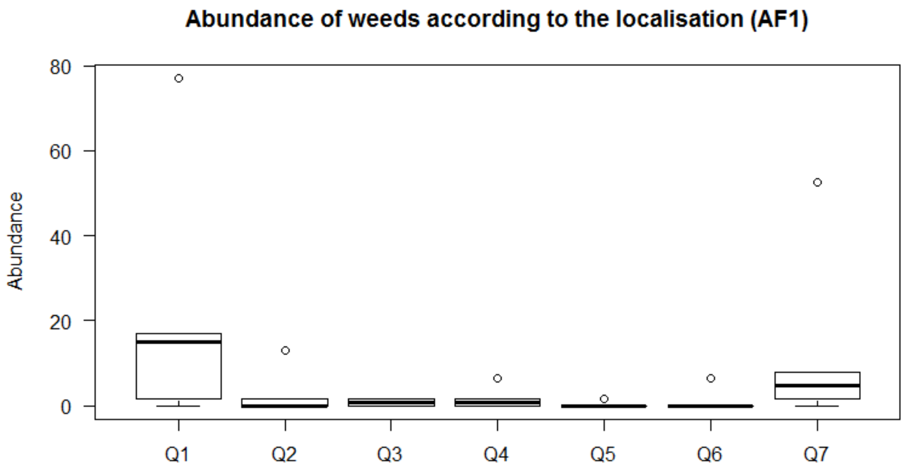


Figure 2a. Abundance of weeds at different distances from the tree rows in crop strips managed **organically** at AF2 (winter wheat) and at AF5 (triticale and faba bean mixture).

X axis: replica plots at different distances from the tree hedgerows in crop strips (Q1 and Q7 near tree row; Q4 center of the crop alley). Y axis: abundance of weeds by m² in Spring as sum of all weeds identified in a plot. This includes: *Alopecurus myosuroides, Lolium multiflorum, Bromus sterilis, Bromus erectus, Avena fatua, Cirsium arvense, Convolvulus arvensis, Cynodon dactylon, Rumex spp., Sonchus asper*, and *Sonchus oleraceus.*



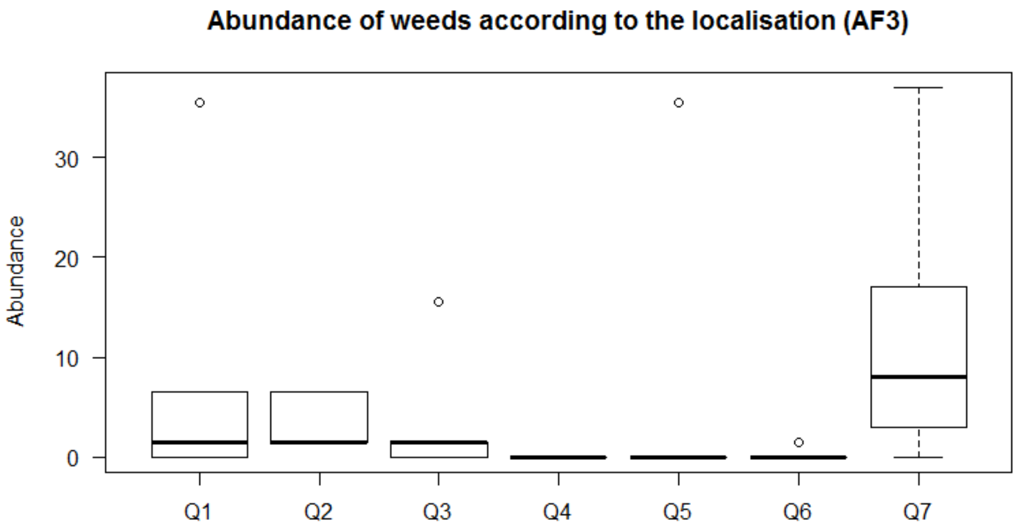
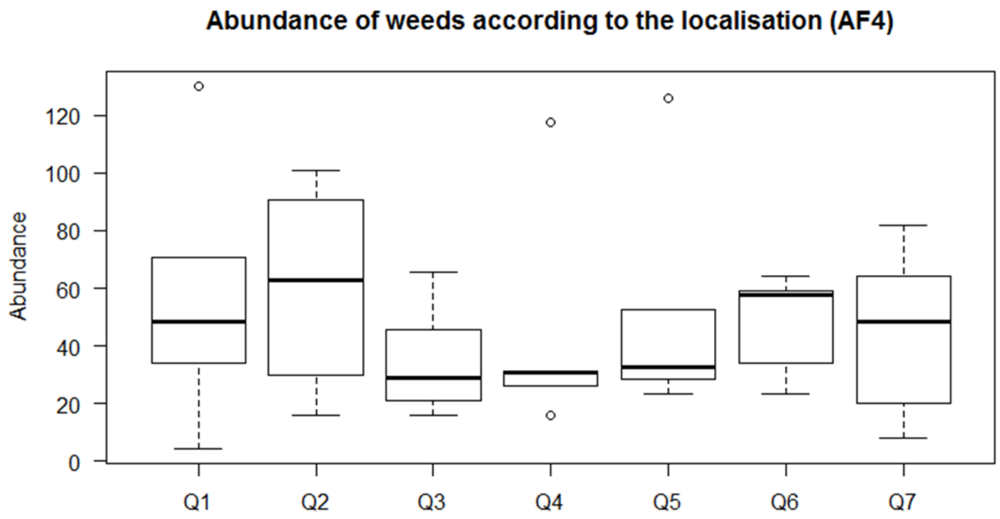


Figure 2b. Abundance of weeds at different distances from the tree rows in crop strips managed **conventionally** at location AF1 (winter barley) and at AF3 (winter wheat crop)

X axis: replica plots at different distances from the tree hedgerows in crop strips (Q1 and Q7 near tree row; Q4 center of the crop alley). Y axis: abundance of weeds by m² in Spring as sum of all weeds identified in a plot. This includes: *Alopecurus myosuroides, Lolium multiflorum, Bromus sterilis, Bromus erectus, Avena fatua, Cirsium arvense, Convolvulus arvensis, Cynodon dactylon, Rumex spp., Sonchus asper*, and *Sonchus oleraceus.*



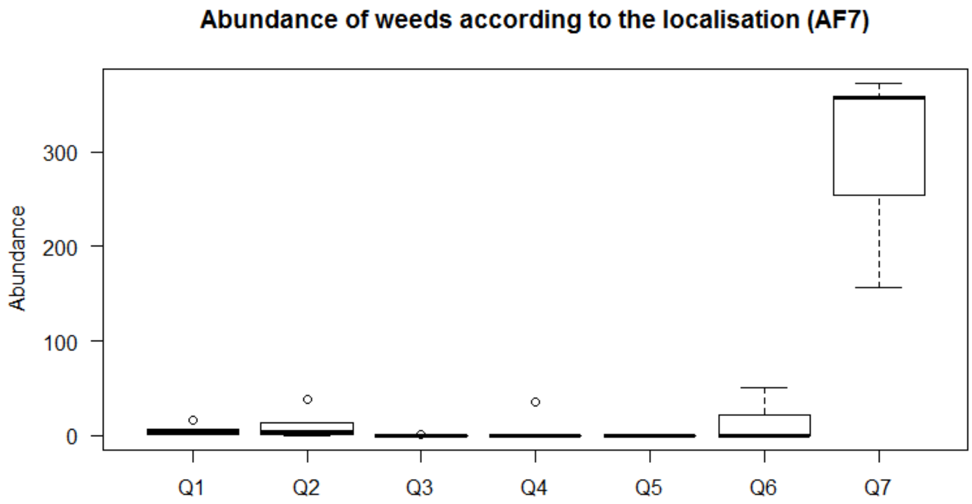


Figure 2c. Abundance of weeds at different distances from the tree rows in crop strips managed **conventionally** at the 3-6 year old AF4 system (winter barley) and AF7 (winter wheat).

X axis: replica plots at different distances from the tree hedgerows in crop strips (Q1 and Q7 near tree row; Q4 center of the crop alley)

Y axis: abundance of weeds by m² in Spring as sum of all weeds identified in a plot. This includes: *Alopecurus myosuroides, Lolium multiflorum, Bromus sterilis, Bromus erectus, Avena fatua, Cirsium arvense, Convolvulus arvensis, Cynodon dactylon, Rumex spp., Sonchus asper*, and *Sonchus oleraceus.*

One possible explanation of the even weed distribution at AF4, compared to AF1, AF3 and AF7, is the system at AF4 was only 3-6 years old, whereas the other three conventional systems were more than 6-years old (Table 3). Within the older silvoarable systems, higher weed abundance was observed near the trees than in the middle of alleys.

Although the type of crop may affect the level of weed control, it was possible to determine this from these results.

Table 3. Weed assessment analysis of conventional and organic crop management

Effect	Conventional crop management	Organic crop management
Age of system	In 3- to 6-year-old system (AF4), there were as many weeds near the tree rows as in the crop alleys. In systems more than 6 years-old, there were more weeds near tree rows.	The two organic systems were of a similar age
Weed control method	Weed control seems to be generally efficient.	The efficacy of mechanical weed control probably varies with crop type. Mulching the tree row with straw probably helps to control weeds

5 Lessons learnt

5.1 Do the understory strips affect weed dispersal in crops?

In our experiment in Northern France in 2016 and 2017, as at the Southern France Restinclières site results, cropped areas adjacent to the tree rows had higher number of weed species than areas furthest from the trees. However the number of individuals for each particular weed species did not differ much between the centre of crop strips and areas located near tree hedgerows.

The high species richness of weeds near the tree rows (up to 0.5 m away) may be partly related to the lower amounts of herbicide (applied using a spray pulverizer) reaching the edges of alleys. It is also possible that the tree row acts as a reservoir for new weed species.

In the organic fields, the abundance of weeds near the tree rows and in the centre of the crop strips was similar. This was surprising as some organic farmers complain about weed infestation from the tree row because of lower efficiency of mechanical compared to chemical weeding.

5.2 Suggestions to prevent any weed dispersal from the strip to the crops

The results provide some reassurance for organic growers, since there was no major negative effect of the tree rows on weed infestation. However, this may change with system age and may differ for systems having other tree and/or crop species, and other management tools. Therefore, farmers should monitor the dispersal of weeds into crop strips, and watch the composition and behavior of weed species in order to act before problematic situations arise. The presence of pernicious weeds such as *Alopecurus myosuroides*, *Lolium multiflorum*, *Bromus sterilis*, *Bromus erectus*, and *Avena fatua* should be monitored and controlled to avoid harmful dispersal to the crop strips. Very pernicious weeds such as *Cirsium arvense*, *Convolvulus arvensis*, *Cynodon dactylon*, *Rumex spp.*, *Sonchus asper*, and *Sonchus oleraceus* should be removed immediately.

6 Acknowledgements

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7 References

Burgess PJ, Incoll LD, Hart BJ, Beaton A, Piper RW, Seymour I, Reynolds FH, Wright C, Pilbeam DJ, Graves AR (2003). The impact of silvoarable agroforestry with poplar on farm profitability and biological diversity. Final report to DEFRA, Cranfield University, UK.

Cardinael R, Chevallier T, Barthès BG, Saby NPA, Parent T, Dupraz C, Bernoux M, Chenu C (2015). Impact of alley cropping agroforestry on stocks, forms and spatial distribution of soil organic carbon – A case study in a Mediterranean context. Geoderma 259-260, 288-299.

Cirou E, Hannachi Y (2014). Initial Stakeholder Meeting Report: Agroforestry for arable farmers in Western France. 14 November 2014. 9 pp. Available online: http://agforward.eu/index.php/fr/systemes-agroforestiers-ouest-de-la-france.html

Degrumelle G (2015). Diagnostic de parcelles en agroforesterie à l'échelle de la région Picardie. Université du Havre 111 pp.

Malignier N, Canet A, Van Lerberghe P (2014). Initial Stakeholder Meeting Report: Agroforestry for arable farmers in the South-West of France. 23 December 2014, updated 20 February 2015. 8 pp. Available online: http://agforward.eu/index.php/fr/systemes-agroforestiers-sud-ouest-de-la-france.html

Mézière D, Boinot S (2015). Research and development protocol for weed management in Mediterranean silvoarable group in France. 9 June 2015. 9 pp. Available online: http://agforward.eu/index.php/fr/systemes-silvoarables-mediterraneens-en-france.html

Wartelle R (2014). Initial Stakeholder Meeting Report: Agroforestry for arable farmers in Northern France. 16 December 2014. 10 pp. Available online: http://agforward.eu/index.php/fr/systemes-agroforestiers-nord-de-la-france.html

Wartelle R, Mézière D (2015). Research and Development Protocol for Agroforestry for Arable Farmers in Northern France. 17 August 2015. 5 pp. Available online: http://www.agforward.eu/index.php/fr/systemes-agroforestiers-nord-de-la-france.html

Wartelle R, Mézière D, Gosme M, La-Laurent L (2016). System report: Weed Survey in Northern Silvoarable Group in France. 15 January 2016. 8 pp. Available online: http://www.agforward.eu/index.php/fr/systemes-agroforestiers-nord-de-la-france.html