System Report:
Olive Agroforestry in Kassandra, Chalkidiki, Greece

Project name	AGFORWARD (613520)
Work-package	3: Agroforestry for High Value Tree Systems
Specific group	Olives intercropped in Chalkidiki, Greece
Deliverable	Contribution to Deliverable D3.7 (3.1): Detailed system description of a case study system
Date of report	1 December 2015
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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 3.7: "Detailed system description of case study agroforestry systems". This report was produced in 2015, and additional material will be presented over the remaining two years of the project.

2 Background

It is estimated that olive groves cover an area of 600,000 ha in Greece (Schultz et al. 1986) and that about 124,300 ha have an understorey of various crops or pasture (Papanastasis et al. 2009). According to Schultz et al. (1986) olive (*Olea europea*) is the most widespread cultivated tree in Greece. Olive trees alone or in orchards are found in all parts of the country which have a mild Mediterranean climate. The olive tree is considered as one of cultivated trees with the lowest demand for soil nutrients. This is why it can survive and be productive in poor, rocky areas with soils mostly derived from hard limestone. A large proportion of the olive groves are found on steep mountain slopes which have been terraced with stone walls to hold the soil.

Olive trees are the only tree component in typical olive systems. Quite often, however, other trees are found as well, including carobs (mainly in Crete), almonds, walnuts, apricots, fig, poplars, and plums. These trees are grown either with the olive trees or along the boundaries of the olive orchards. In the traditional systems, practically all olive trees are formed from grafted wild plants.

Edible olives and olive oil are the main products of olive trees, while secondary products include fodder for animals and firewood. In some places, exquisite furniture and handicrafts are made of olive wood. Under the olive trees it is possible to rear grazing animals (e.g. sheep, cattle, goats, pigs or chickens) or crop such as wheat or other cereals, corn, alfalfa, or grape vines, vegetable crops (e.g. potatoes, melons, tomatoes, beans, onions, or fava beans) or wild herbaceous vegetation which may be edible. Animals may graze on the naturally regenerating vegetation or on planted crops.

Meetings of the 'Intercropping of olive groves in Greece" stakeholder group were held on 27 June 2014, at which the group identified examples of interesting or best practices that involved the intercropping of olive trees and leguminous crops for animal feeding and soil amelioration or cereals for grain production (Pantera, 2014).

3 Update on field measurements

Field measurements described in the research and development protocol (Mantzanas et al. 2015) began in April of 2015 and will continue until the end of 2016. All measurements have been and will be conducted by researchers from the TEI Stereas Elladas in collaboration with Aristotle University of Thessaloniki, Greece.

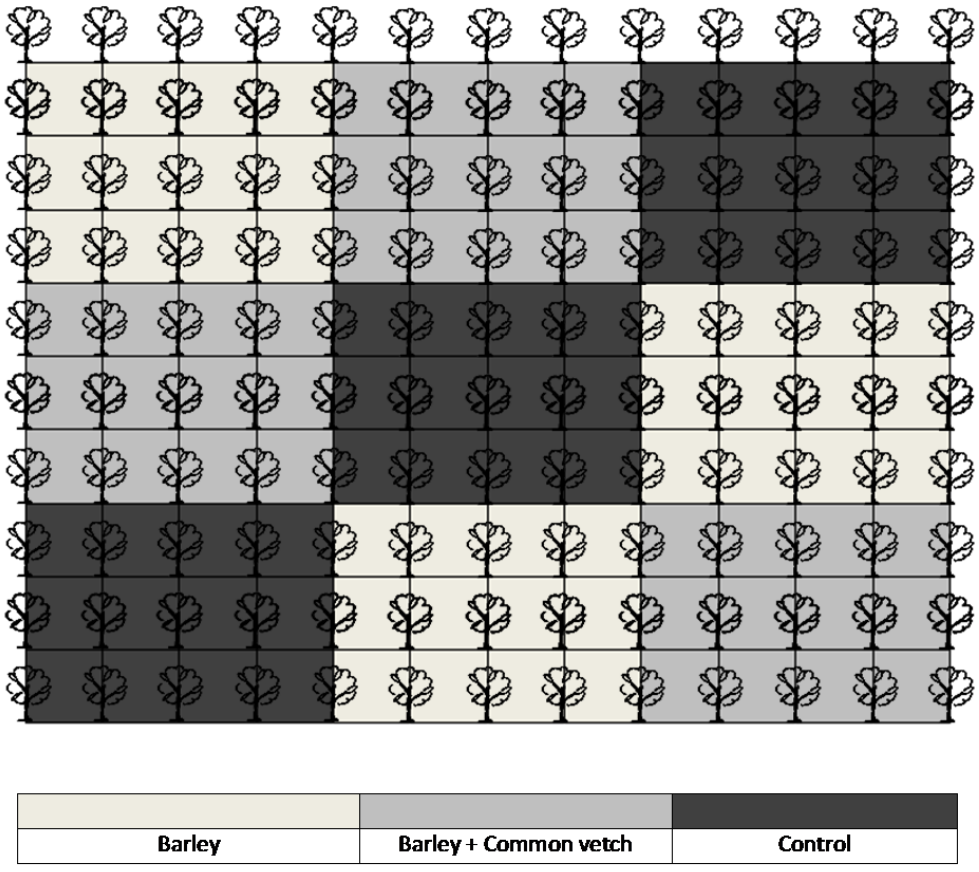
4 System description

Error! Reference source not found. provides a general description of olives intercropped in Chalkidiki, Greece. A description of a specific case study system is provided in Table 2.

Table 1. General description of the olives intercropped in Kassandra, Chalkidiki

General description of system	
Name of group	Olives intercropped in Kassandra, Chalkidiki, Greece
Contact	Kostas Mantzanas
Work-package	3: Agroforestry for High Value Tree Systems
Associated work-package	None
Geographical extent	According to Schultz et al. (1986) olive (*Olea europea*) is the most widespread cultivated tree in Greece. Olive trees alone or in orchards are found in all parts of the country which have a mild Mediterranean climate. It is estimated that olive groves cover an area of 600,000 ha in Greece (Schultz et al., 1986) while a great part of them 124,311 ha forms typical agroforestry systems with various crops or pasture established in the understory of olive trees (Papanastasis et al. 2009).
Estimated area	The total area of the research site is about 500 ha.
Typical soil types	Lithosols – Campisols
Description	Olive tree is considered to have a low demand for soil nutrients, and it is planted in poor, rocky areas with soils mostly derived from hard limestone. Under the olive trees may be found: i) animals (sheep, cattle, goats, even honey bees, pigs or chickens), ii) wheat or other cereals, corn, alfalfa, or grape vines, iii) vegetable crops, or iv) wild herbaceous vegetation, some plants of which are edible. Animals may graze on the spontaneous vegetation or on planted crops (ex. wheat or barley).
Tree species	Olive tree (*Olea europea*); pear (*Pyrus sp.*); pines (*Pinus sp.*)
Tree products	Edible olives and olive oil, pear fruits and wood
Crop species	Cereals (mainly wheat and barley), alfalfa, and common vetch
Crop products	Crops can be harvested on an annual basis
Animal species	Sheep and goats
Animal products	Milk and meat production
Other provisioning services	Possibility for intercrops with aromatic plants and vegetables
Regulating services	Trees provide a microclimate which protect from frost and extreme values of temperature Trees can promote nutrient cycling and increase carbon storage
Habitat services and biodiversity	Many animal species can be use the trees and the edges for habitat resulting in increased biodiversity
Cultural services	The modern silvoarable practice may improve the quality of crop production and reduce the management cost.
Key references	See end of report

Table 2. Description of the specific case study system

Specific description of site	
Area	1.2 ha
Co-ordinates	X450089.747& Y 4428217.075
Site contact	Kostas Mantzanas
Site contact	Konman@for.auth.gr
Example photograph	
Map of system	

Climate characteristics	
Mean monthly temperature	16.2°C
Mean annual precipitation	602 mm
Details of weather station (and data)	Hellenic National Meteorological Service, Weather station in Kassandreia Chalkidiki - Greece, Data from 1955-1997
Soil type	
Soil type	
Soil depth	Approximately 0.6 m
Soil texture	SCL Sandy-clay-silt
Additional soil characteristics	pH 8.43, soil OM 8.51% (measured by LOI – Loss On Ignition)
Aspect	North – South
Tree characteristics	
Species and variety	Olive tree (*Olea europea*)
Date of planting	1935
Intra-row spacing	10 m
Inter-row spacing	10 m
Tree protection	None
Crop understory characteristics	
Species	Barley and common vetch
Management	Conventional arable crop management with ploughing
Typical crop yield	Barley: 1.5 t ha^{-1}, barley + common vetch: 1.5 t ha^{-1} (dry matter)
Fertiliser, pesticide, machinery and labour management	
Fertiliser	Barley treatment: 130 kg ha^{-1} (24-10-0, N-P-K) and barley + common vetch treatment: 120 kg ha^{-1} (0-46-0, N-P-K)
Pesticides	None
Machinery	Need for tractor access in crop alleys to allow soil preparation
Manure handling	None
Labour	For olive harvest
Fencing	Yes

5 Experimental design

The design involves three treatments in three replications in a Latin square design, namely olive trees + barley, olive trees + a mixture of barley and common vetch, and olive trees alone as a control. The distance between the trees is 10 m. So, each treatment covers 0.12 ha and the total area is 1.08 ha. Olive trees were pruned in February of 2015.

6 Description of crop component

Crop sowing took place on 23 December 2014, relatively late for the area due to the very rainy autumn period. However, due to normal spring no particular problems were observed.

6.1 Barley and common vetch results

An analysis of the variance showed that the effect of distance from the tree on total biomass production was not significant at the 5% level, but it was significant at the 10% level (p = 0.088) (Table 3). An analysis of variance showed that there was a significant effect of distance (p = 0.011*) on the number of seeds, with higher seed numbers at the edge of the tree.

Table 3. Effect of distance from tree on various crop parameters in the barley + common vetch plot (values in brackets are standard deviations)

Category	Mean	Position "A" at the edge of the trees	position "K" between the rows of trees
Mean total biomass(tha^{-1})		6.5 (± 2.1)	7.8 (± 1.1)
Number of seeds per head	18.0 (± 5.0)	18.7 (± 4.8)	17.5 (± 5.0)
Density of barley (plants per 0.25 m^2)	10.44 (± 2.04)	10.1 (± 2.1)	11.0 (± 1.9)
Density of vetch (plants per 0.25 m^2)	7.56 (± 1.5)	7.3 (± 1.5)	8.1 (± 1.2)
Number of tillers (per 0.25 m^2)	45.3 (± 8.9)	43.2 (± 9.2)	49.3 (± 6.7)
Barley height (m)	0.74 (± 0.13)	0.71 (± 0.1)	0.81 (± 0.1)
Common vetch height (m)	0.73 (± 0.09)	0.70 (± 0.07)	0.78 (± 0.1)
Number of heads (per 0.25 m^2)	33.3 (± 8.7)	31.3 (± 9.1)	37.1 (± 6.4)

Measurements of density, height, the number of tillers and number of heads were completed within an area of 0.25 m^2. An analysis of variance showed that the mean height of the common vetch was the only parameter significantly different according to the relative position to the tree (p = 0.043*). The common vetch was higher for samples taken between the rows of trees. This result could show a possible competition between the crops and the olive tree. Although the effect was not statistically significant, the barley was also higher between the trees than at the edge of the trees.

6.2 Barley results compared to monoculture

Measurements on the barley were also taken with areas of 0.25 m^2. The analysis of variance showed that the agroforestry treatment, compared to the monoculture treatment, has a significant effect on the density of barley (p < 0.001), barley height (p< 0.001), the number of heads (p = 0.007**), and the number of tillers (p = 0.04).

Table 4. Effect of barley parameters in the agroforestry and monoculture areas (values in brackets are standard deviations)

Category	Agroforestry system	Monoculture
Density of barley (plants per 0.25 m^2)	18.4 (± 5.1)	10.7 (± 1.0)
Height of barley (cm)	72.2 (± 8.0)	91.7 (± 12.1)
Number of tillers (per 0.25 m^2)	80.1 (± 20.1)	97.7 (± 9.1)
Number of heads (per 0.25 m^2)	69.8 (± 19.0)	91.3 (± 6.4)

For each parameter, higher means were obtained in the monoculture rather than the agroforestry treatment. The cultivation of barley in the presence of olive tree led to a slower development rate than in a plot without trees. The competition between the tree and the crops seems to be strong in the case of Kassandra.

7 Soil results

The soil depth was approximately 0.6 m and the texture is sandy-clay-silt. The pH and organic matter are shown in Table 5.

Table 5. Organic matter and pH according to seeding treatment and depth

Seeding treatment	Depth (cm)	Organic matter (Loss of Ignition %)	pH
Barley	0-10	9.5	8.4
	10-20	9.7	8.4
	20-40	6.7	8.5
	40-60	7.9	8.6
Barley + common vetch	0-10	7.5	8.3
	10-20	13.5	8.5
	20-40	6.6	8.4
	40-60	8.8	8.6
Control	0-10	7.5	8.5
	10-20	7.7	8.3
	20-40	8.2	8.4
	40-60	6.1	8.5

8 Acknowledgements

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