Research and Development Protocol for the Olive Agroforestry in Kassandra, Chalkidiki, Greece

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Work-package	3: Agroforestry for High Value Trees
Specific group	Olives intercropped in Chalkidiki, Greece
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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 10 (3.3)) for the participative research and development network focused on the use of agroforestry in high value tree systems.

2 Background

It is estimated that olive groves cover an area of 600,000 ha in Greece (Schultz et al. 1986) with about 124,311 ha forming typical agroforestry systems with various crops or pasture established as understories for the olive trees (Papanastasis et al. 2009).

According to Schultz et al. (1986) olive (*Olea europea*) is the most widespread cultivated tree in Greece. The olive tree is considered as one of the least demanding of cultivated trees in terms of soil nutrients and hence it can be planted in poor, rocky areas in soils derived from hard limestone. Many olive groves on steep slopes are terraced with stone walls to retain the soil.

Olive trees are often the only tree found in olive groves. Quite often, however, other trees including carobs (mainly in Crete), almonds, walnuts, apricots, fig, poplars, and plums are grown with the olive trees or along the boundaries of the olive orchards. In the traditional systems, practically all olive trees came from wild plants which were grafted. Edible olives and olive oil are the main products of olive trees, while secondary products include fodder for animals and firewood and wood for high value furniture and handicrafts.

Olive trees may be grown with: a) animals (sheep, cattle, goats, honey bees, pigs or chickens), b) wheat or other cereals, corn, alfalfa, or grape vines, c) vegetable crops, i.e. potatoes, melons, tomatoes, beans, onions, or fava beans, or d) wild herbaceous vegetation including some edible plants. Animals may graze on the spontaneous vegetation or on planted crops excluding wheat and barley.

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 Objective of experiment

The aim of the experiments is to produce quantitative information about the intercropping of olive trees with leguminous crops or cereals. Key questions include:

- Do we want trees inside the agricultural area or not?
- If we decide to intercrop, which crop species should we use?
- A traditional practice included peas, bitter vetch and vetch for feed (early cut when the fruit size had lentils) and wheat.
- How does agroforestry affect crop yield?
- How does agroforestry affect nutrient cycling?
- When is the best time for pruning? Caution must be taken not to transit diseases by pruning and hence debris should be burnt.

4 System description

In order to comply with the initial idea of the WP3 for the olive tree system of Chalkidiki, it was decided to focus on intercropping. Hence a controlled experiment was established in the premises of the State Agricultural Prison of Kassandra Chalkidiki in December 2014. The olive trees are 80 years old and are cultivated for olives and olive oil (Table 1).

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 experimental design is shown in Figure 1. The distance between the trees is 10 m (Figure 2 and Figure 3). Hence each treatment plot covers an area of 0.12 ha and the total area is 1.08 ha. The seed and fertilizer quantities applied are shown in Table 2. Crop sowing took place on 23 December 2014, which is relatively late for the area due to the particularly wet autumn. However, no particular problems are expected to be phased if spring is normal.

Table 1. Description of the two fertilizer treatments

Practice	Treatment A (Barley)	Treatment B (Barley + common vetch)
Seed rate	Barley 240 kg ha^{-1}	Barley: 80 kg ha^{-1} and Common vetch 120 kg ha^{-1}
Fertilizer application	130 kg ha^{-1} of 24-10-0, N-P-K Hence: 31 kg N ha^{-1} and 13 kg P_2O_5 ha^{-1}	120 kg ha^{-1} of 0-46-0 N-P-K Hence: 55 kg P_2O_5 ha^{-1}

[1]The different level of P_2O_5 was selected due to the presence of vetch

Table 2. Description of the site, with soil, tree, understorey, livestock, and climate characteristics

Site characteristics	
Area:	1.2 ha
Co-ordinates:	X450089.747 and Y 4428217.075
Site contact:	Dimitris Koutsoulis
Site contact e-mail address	

Soil characteristics	
Soil type (WRB classification)	Luvisol
Soil depth	
Soil texture (sand%, silt%, clay%)	
Additional soil characteristics	pH 8.2
Aspect	South

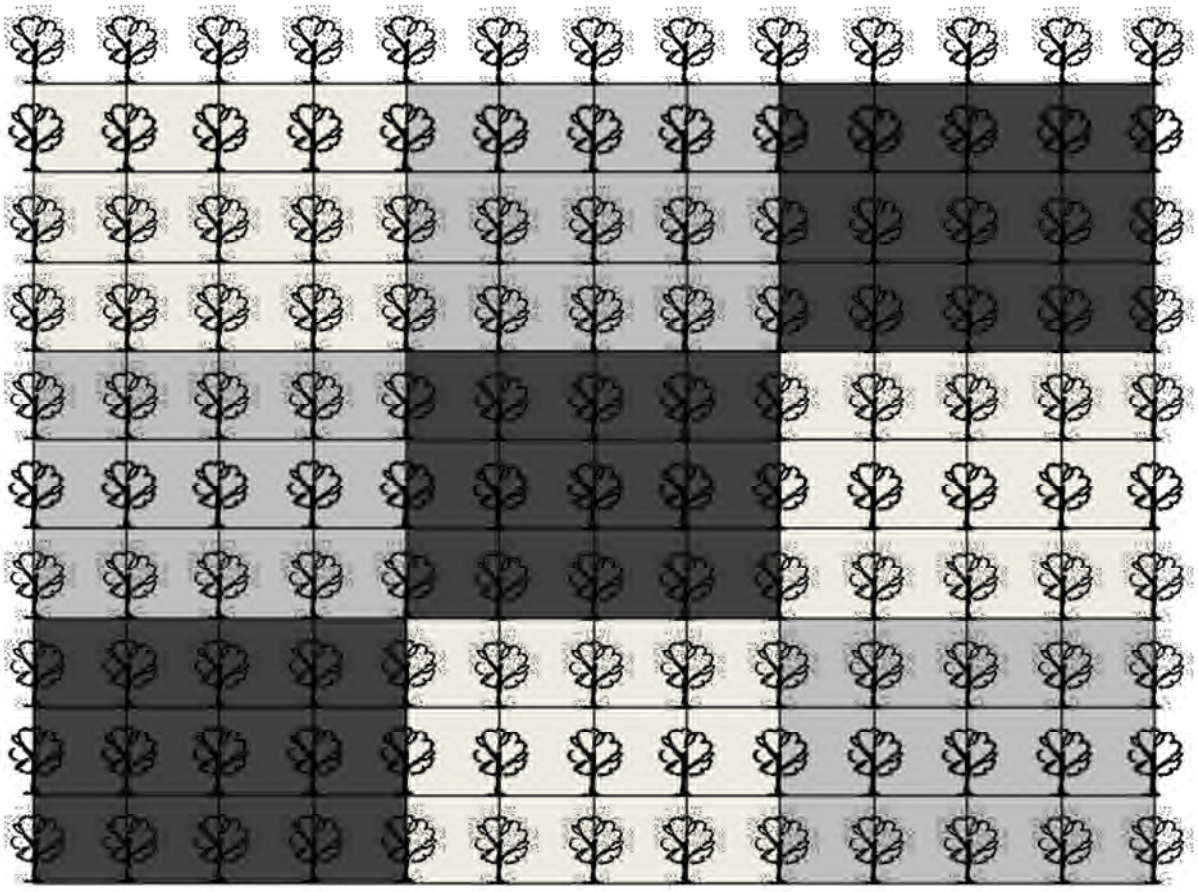
Tree characteristics		
System	Agroforestry system	Reference system*
Tree species	Olive trees (*Olea europea*)	Olive trees (*Olea europea*)
Variety/rootstock		
Tree density (spacing)	10 m x 10 m, trees rows begins from the edges of the plot	10 m x 10 m, trees rows begins from the edges of the plot
Tree protection	None	None
Additional details	80 years-old	80 years-old

Understorey characteristics		
System	Agroforestry system	Reference system*
Species	Barley, mixture of barley and common vetch	Barley which was planted on 15 December 2014
Coverage	Partial (out of tree canopy cover)	Complete
Additional details		

Climate data	
Mean monthly temperature	16.2°C
Mean annual precipitation	602 mm
Details of weather station	
**Agreement with Ensembles data?	No

* To which the agroforestry system is compared

** Does the ENSEMBLES climate data (http://www.ensembles-eu.org/) look to be a good fit for actual data? Accessible as csv here.



Barley	Barley + Common vetch	Control

Figure 1. Layout of the experiment with three replicates and three treatments

Figure 2 and Figure 3. View of the experimental plots before seeding in December 2014

6 Measurements

The planned measurements to be taken in the three treatments are:

6.1. Tree canopy

- Six sample trees selected inside each experimental plot.
- Two diameters of tree canopy in a cross form will be measured for each tree in m.
- The distance from the lowest point of the branch to the bottom of the understory vegetation will be measured for each tree.
- Five measurements are to be taken per tree, and these values averaged.
- Sampling to be completed before the harvest of sowing crops.
- Fruit production (olives and oil)

6.2. Crop yield

- Crop sampling plots will include plots in close proximity to the tree canopy and in the centre between the tree rows. The crop sampling will be concentrated on the area close to the six sample trees selected inside each experimental plot and on the reference site. For the reference site, six crop plots will be sampled.
- Above ground biomass in these plots will be harvested using a 0.5 x 0.5 m square quadrat.
- Plant density (number/m^2 and heads/m^2) will be measured during the spring.
- Weight of 1000 grains, grains per head and length of growing period will be measured at crop harvest.

6.3. Land equivalent ratio

The land equivalent ratio (LER) is the ratio of the area needed under sole cropping to the area of intercropping at the same management level to obtain a particular yield (Mead and Willey 1980). For agroforestry systems it can be calculated as:

$$LER = \frac{Tree\ agroforestry\ yield}{Tree\ monoculture\ yield} + \frac{Crop/livestock\ agroforestry\ yield}{Crop/livestock\ monoculture\ yield}$$

For the calculation of the LER the above described tree and crops yields for the agroforestry and reference site will be used to calculate productivity of both agricultural systems.

7 Biophysical modelling

The second part of this protocol describes attempts to model the system using the YieldSAFE biophysical model. The YieldSAFE model has previously been parameterised for alley cropping systems (Graves et al., 2010). The modelling component will have two objectives:

- Validation of the existing olive tree growth model and additional parameterisation as required.
- Parameterisation of the short rotation system.

To facilitate the modelling activities additional parameters of trees and crops such as tree canopy height, tree height, diameter, tree phenology and maintenance may have to be collected. Some of this information may also be available from the literature.

8 Acknowledgements

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9 References

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