Research and Development Protocol for Olive Agroforestry in Molos, Central Greece

Project name	AGFORWARD (613520)
Work-package	3: Agroforestry for High Value Trees
Specific group	Olives intercropped in Molos
Milestone	Milestone 10 (3.3) Part of experimental protocol for WP3
Date of report	26 March 2015
Authors	Anastasia Pantera, Andreas Papadopoulos, Konstantinos Mantzanas, Vassilios Papanastasis,
Contact	pantera@teiste.gr
Approved	Paul Burgess (24 April 2015)

Contents

AGFORWARD (Grant Agreement N° 613520) is co-funded by the European Commission, Directorate General for Research & Innovation, within the 7th Framework Programme of RTD. The views and opinions expressed in this report are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.

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 806,600 ha in Greece (EUROSTAT 2007) and that about 124,311 ha form agroforestry systems with various crops or pasture established in the understorey of the olive trees (Papanastasis et al. 2009).

Olive (*Olea europea*) is probably the most widespread cultivated tree in Greece. Compared to other cultivated trees, olive trees have a low demand for nutrients and hence it can be planted in poor, rocky areas with soils derived from hard limestone (Gomez et al. 2003; Vossen 2007; Duarte et al. 2008). Many olive groves are found on steep mountain slopes which have been terraced with stone walls to hold the soil.

Olive trees are often grown as a single species. However carobs (mainly in Crete), almonds, walnuts, apricots, fig, poplars, and plums are sometimes 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 high value wood for furniture and handicrafts.

The olive trees may be grown with: a) grazing animals (sheep, cattle, goats, even honey bees, pigs or chickens), b) wheat or other cereals, corn, alfalfa, or grape veins, c) vegetable crops, i.e. potatoes, melons, tomatoes, beans, onions, or fava beans, or d) wild herbaceous vegetation including edible plants. Animals may graze on the spontaneous vegetation or on planted crops excluding wheat or barley (Papanastasis et al. 2009).

The combination of olive orchards with arable crops (cereals) in the same field used to be a traditional land use system in Central Greece (Figures 1 and 2) and is regaining interest. A meeting of the 'Intercropping of olive groves in Greece' stakeholder group was held on 27 June 2014, at which the group identified examples of interesting or best practices that involved trees intercropped with

aromatic/medicinal herbs, leguminous plants for soil amelioration, and higher quality products for human consumption or for feed.

3 Objective of experiment

The aim of the experiment is to produce quantitative information about the intercropping of olive trees and 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?
- Intercropping with aromatic herbs may positively affect oil quality and flavour. Possible intercrops include thyme, oregano and *Origanum dictamnus.*
- Should vegetables be excluded as intercrops?
- How can farmers be better organised and how can products achieve a higher price?

4 System description

In order to comply with the initial ideas of the stakeholder group focused on olive tree agroforestry in Molos, it was decided to focus on intercropping. For this reason, an experiment with a control was established in an olive orchard. The olive trees are 60 years old and are cultivated for olives and olive oil.

The experiment will take place in a 2 ha olive orchard located in the area of Molos, Central Greece. It is different from the other Greek olive orchards in Macedonia since it will examine the contribution of a chickpea (*Cicer arietinum*) as nitrogen fixing companion plant on the chemical and physical properties of the soil and the nitrogen nutrition of the trees. The orchard is composed of rows of olive trees (*Olea europea*) oriented north to south and east to west (Figure 1).

Trees in the orchard are at least 60 years old and approximately 5 m in height. At present the bottom of the canopy is about 1.6 m from the ground. The field is not fenced and there is no need for protection. Chickpea was a chosen to improve soil chemical properties and reduce improve the availability of nitrogen to the trees. Similarly, the introduction of an aromatic herb such as oregano (*Origanum vulgare*) was a popular request to test from the participants of the stakeholders meeting. Further details are given in Table 1.

Figure 1. Looking South-East along the tree rows (27 March 2015)

Figure 2. Some aromatic plants already planted in the orchard (27 March 2015).

Table 1.Description of the site, with soil, tree, understorey, livestock, and climate characteristics.

Site characteristics	
Area (ha)	2 ha
Co-ordinates	38°49'29.25"N, 22°37'22.25" E
Site contact	Dimitris Kitsikopoulos
Site contact email address	dimifree1@gmail.com

Soil characteristics	
Soil type (WRB classification)	Luvisol
Soil depth	≥1 m
Soil texture (sand%, silt%, clay%)	
Additional soil characteristics	pH 7.97
Aspect	East

Tree characteristics		
System	Agroforestry system	Reference system*
Tree species	Olive trees (*Olea europea*)	Olive trees (*Olea europea*)
Variety/rootstock	Local varieties: "Kalamon" & "Amfissa"	
Tree density (spacing)	10 x 10 m	10 x 10 m
Tree protection	None	None
Additional details		

Understorey characteristics		
System	Agroforestry system	Reference system*
Species	Chickpea (*Cicer arietinum*) Oregano (*Origanum vulgare*)	none
Coverage	Partially (out of tree canopy cover)	

Climate data	
Mean monthly temperature	16.5°C
Mean annual precipitation	574 mm
Additional details	There are rarely spring frosts
Details of weather station (and data)	Hellenic National Meteorological Service, Station of Lamia, data from 1970-1997
**Agreement with Ensembles data?	Temperatures: yes Precipitation: no (see appendix)

* 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.

Figure 3. Olive trees and chickpea (2 April 2015)

5 Experimental design

5.1 Conceptual design

The experimental design is a simple experimental plan consisting of three experimental units (Lentner and Bishop, 1993). The experiment units are: i) olive trees + chickpea, ii) olive trees + oregano, and iii) olive trees alone as a control. The experimental design is shown in Figure 4. The distance between the trees is 10 m. The data will be analysed using analysis variance (Gray and Kinnear, 2012)

Table 2. Description of the two intercropping treatments

Treatment A (olives + Chickpea)	Treatment B (olives + oregano)	Treatment C (olives)
Chickpea (5 m x 60 m)	Oregano	Control

Crop sowing was delayed due to the very rainy spring period and is expected to take place in the first week of April. However, no particular problems are expected to be phased if spring is normal.

5.2 Description of design

A map of the site is shown in Figure 4. A 0.2 ha area will be cultivated for chickpeas and oregano. Another 0.2 ha of the orchards contains olive trees and other tree species and the rest are only olive trees and will be used as control.

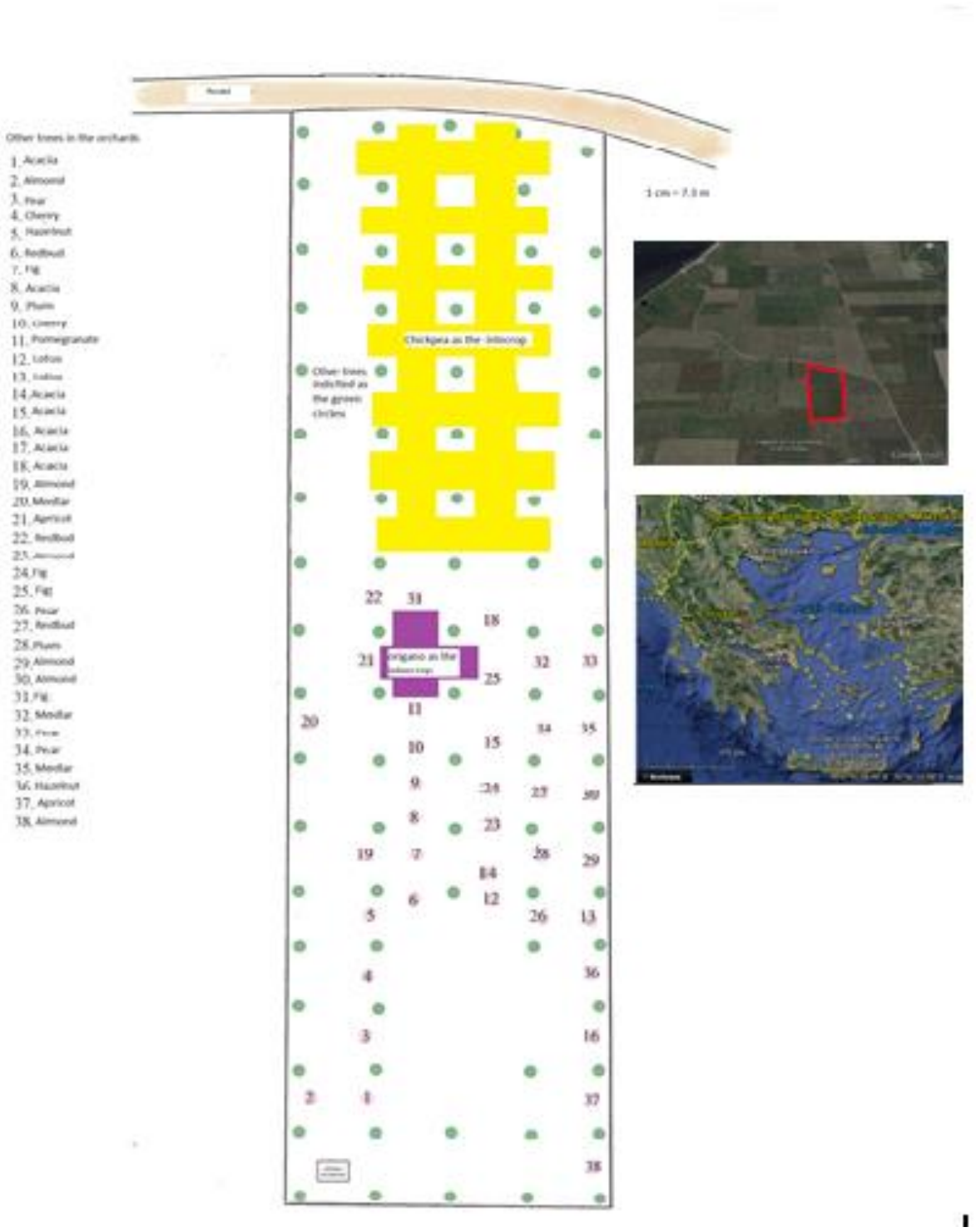

Figure 3. Experimental design with the chickpea highlighted in yellow and oregano in purple. The trial is indicated in the google map of the area and in the country. The rows where chickpeas will be cultivated are 5 m x 60 m wide.

5. Measurements

The planned measurements to be taken in the two treatments are described below.

Measuring tree characteristics

- Trees canopy inside each experimental plot,
- Two diameters of tree canopy in a cross form will be measured for each tree in m,
- Tree breast height diameter,
- Leaves examined for their nutrient content,
- Five measurements are to be taken per tree, and these values averaged, and
- All measurements will be repeated at the beginning and at the end of the experiment.

Measuring yield

- Crop sampling plots will include plots in close proximity to the tree canopy and in the centre between the tree rows.
- Total crop (chickpeas) yield will be measured at the end of the growing season.
- Production (olives and oil) will be measured for the intercropped and the reference site.

Measuring soil characteristics

- Soil pH, N content and texture at the beginning and end of the experiment.

Determination of 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:

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

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.

Table 3. Measurements to be taken in the two treatments

Treatment	Olives and chickpeas	Only olives
Measurements	Bottom height of tree canopy. Weight and condition of crop. A record of dates, quantity, and type of minerals. Labour time spent on cultivating Tree damage from machinery operations.	Bottom height of tree canopy. Dates of any field operations, e.g. topping, spraying, mowing, etc. A record of dates, quantity, and type of minerals. Cost of sprays used, cost of pruning

6. Acknowledgements

The AGFORWARD project (Grant Agreement N° 613520) is co-funded by the European Commission, Directorate General for Research & Innovation, within the 7th Framework Programme of RTD, Theme 2 - Biotechnologies, Agriculture & Food. The views and opinions expressed in this report are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.

7. References

Duarte F., Jones N., Fleskens, L. (2008). Traditional olive orchards on sloping land: Sustainability or abandonment? Journal of Environmental Management 89(2): 86-98.

Gomez J.A., Battany M., Renschler C.S. (2003). Evaluating the impact of soil management on soil loss in olive orchards. Soil Use and Management 19(2): 127-134.

Gray, C. D., Kinnear, P. R. (2012). IBM SPSS statistics 19 Made Simple. Psychology Press.

Lentner, M., Bishop, T. (1993). Experimental Design and Analysis (Second Edition). Valley Book Company, Blacksburg, Virginia.

Mead R., Willey R.W. (1980). The concept of a "Land Equivalent Ratio" and advantages in yields from intercropping. Experimental Agriculture 16(3): 217-228.

Pantera, A. (2014). Initial stakeholder meeting report: Intercropping of olive groves in Greece http://agforward.eu/index.php/en/intercropping-of-olive-groves-in-greece.html?file=files/agforward/documents/WP3_GR_olives_Molos.pdf

Papanastasis, V. P., Mantzanas K., Dini-Papanastasi O. & Ispikoudis I. (2009). Traditional agroforestry systems and their evolution in Greece. Agroforestry in Europe. Advances in Agroforestry 6: 89-109.

Vossen P. (2007). Olive oil: history, production, and characteristics of the world's classic oils. HortScience 42(5): 1093-1100.

Appendix A. Climatic data

Obtaining appropriate climatic data from comparison with the ENSEMBLES predictions was somewhat challenging since the many local weather stations tend to have incomplete or spurious records. All Climatic data were obtained from a local meteorological station operated by the Hellenic Forest Service. The available local climatic data are presented in Figure A1.

Table A.1. Temperature and precipitation data from Hellenic National Meteorological Service stations within a 16.3 km radius of the trial site (Hellenic National Meteorological Service, 1997).

Mean monthly temperature (°C)			Mean monthly precipitation (mm)		
1970-97	Actual data	Ensembles	1970-97	Actual data	Ensembles
January	5.7	7.1	January	51	64
February	7.1	8.0	February	37	65
March	10.4	10.5	March	34	61
April	13.9	14.8	April	21	46
May	19.4	20.1	May	18	34
June	25.0	25.3	June	10	22
July	28.8	26.9	July	3	19
August	28.6	25.9	August	1	27
September	22.9	22.4	September	9	17
October	15.6	16.9	October	51	71
November	10.9	11.8	November	74	73
December	7.4	8.3	December	35	73
Mean	16.3	16.5		574	572