



Research and Development Protocol for Agroforestry with Orange Groves in Crete, 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

Of the global annual production of 80 million tonnes of citrus fruit, 19 million tonnes come from the Mediterranean and 1.1 million tonnes from Greece. Greek production of citrus fruit originates from an area of about 50,000 ha (500,000 stremma). Of this, there are about 45,000 ha of oranges, with the rest being tangerines, lemon and grapefruit. In Crete, citrus cultivation covers 4500 ha, comprising 3300 ha of oranges, 340 ha of tangerines, about 300 ha of lemons and 70 ha of grapefruits.

In the past, farmers in the Chania area of Crete cultivated crops between citrus trees after pollarding. They also used cypress trees as windbreaks to protect the citrus trees from wind. However many farmers have removed the cypress trees from the windbreaks and have uprooted the citrus trees and replaced them with monoculture stands of monoculture for higher profit. Only a few farmers still practice the agroforestry system of citrus trees with intercrops. This practice can help ensure an economic return each year until the tree canopy fully develops and excludes any form of intercropping. Most of the intercrops are vegetables. After crown development the intercrops are sometimes replaced by poultry production.

Meetings of the ‘Intercropping of Orange Groves in Greece’ stakeholder group were held on 2 August 2014, at which the group identified examples of interesting or best practices that involved the intercropping of orange trees for increased income and soil amelioration (Pantera 2014).

3 Objective of trial

The objective of the trial is to produce quantitative information about the intercropping of orange trees with leguminous crops or cereals. Vegetables (potatoes, watermelons and beans) are presently used as intercrops. Key questions include:

- Do we still want this system?
- If we decide to intercrop, which crop species should we use?
- Intercropping with aromatic herbs may positively affect production. Which herb to intercrop?

- Does tree shade affect crop production?
- What is the most effective way to enhance farmers' income?

4 System description

The physical characteristics of the study site are shown in Table 1. The system is focused on widely spaced orange trees which are 80 years old.

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

Site characteristics	
Area:	0.2 ha
Co-ordinates:	35°26'04"N; 23°22'.82"
Site contact:	Maria Kasselaki
Site contact email address	kasselakis.skines@gmail.com

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	Orange (<i>Citrus sinensis</i>)	Orange (<i>Citrus sinensis</i>)
Variety/rootstock		
Tree density (spacing)	10 m x 10 m	10 x 10 m
Tree protection	None	None
Additional details	80 years-old	80 years-old

Understorey characteristics		
System	Agroforestry system	Reference system
Species	Potatoes and chickpeas	
Coverage	Partially (out of tree canopy cover)	

Climate data	
Mean monthly temperature	18.8°C
Mean annual precipitation	621 mm
Details of weather station	

5 Trial design

5.1 Conceptual design and treatments

The trial design comprises three treatments (Figure 1; Table 2). These are: i) orange trees + chickpea, ii) orange trees + potatoes, and iii) orange trees alone as a control. There is no replication. The distance between the trees is 2 m.

Table 2. Description of the three treatments

Treatment	Tree species	Understorey crop
1	Orange	Chickpea
2	Orange	Potato
3	Orange	Control

Crop sowing was delayed due to the very rainy spring period and was scheduled to take place in the first week of April 2015.

A map of the orange orchards site is shown in Figure 3. A 0.2 ha area will be cultivated by chickpeas and potatoes. Each yellow line includes two rows of chickpeas. Another 0.2 ha of the orchards contains orange trees and other tree species, and the rest are only orange trees and will be used as control.

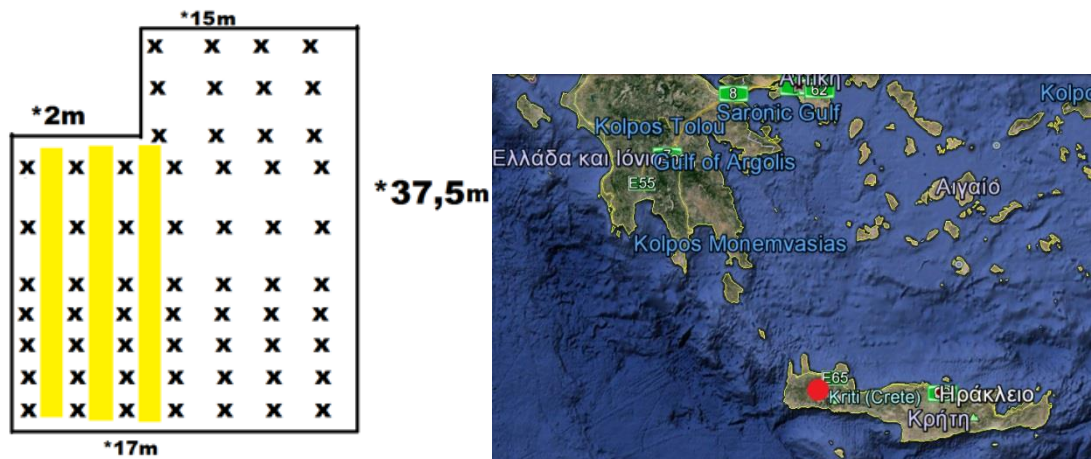


Figure 1. Experimental design with the chickpeas highlighted in yellow. The trial is located in Western Crete (Google maps).

6 Measurements

The planned measurements to be taken in the two treatments are described below (Table 2).

Table 2. Planned measurements at the site

Agroforestry component	Measurements
Tree characteristics	<ul style="list-style-type: none"> • 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) • The height to the base of the tree canopy <p>All measurements will be repeated at the beginning and at the end of the trial</p> <ul style="list-style-type: none"> • Weight and condition of the orange crop
Crop characteristics	<ul style="list-style-type: none"> • Total crop (chickpea and potato) yield will be measured at the end of the growing season • Crop sampling plots will include plots in close proximity to the tree canopy and in the center between the tree rows.
Soil characteristics	<ul style="list-style-type: none"> • Soil pH, and N content at the beginning and the end of the trial. • Soil texture will be assessed at the beginning of the trial.
Management characteristics	<ul style="list-style-type: none"> • Tree damage from machinery operations • Labour inputs • Dates of any field operations such as topping, spraying and mowing • Costs of sprays used • Cost of pruning • Record of the dates, quantity, and types of fertilizer

7 Acknowledgements

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8 References

Pantera A (2014). Initial Stakeholder Meeting Report Intercropping of Orange Groves in Greece. 18 November 2014. 7 pp. Available online: <http://www.agforward.eu/index.php/en/intercropping-of-orange-groves-in-greece.html>