Research and Development Protocol for Grazed Oak Woodland in Sardinia, Italy

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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 4 (2.3)) for the participative research and development network focused on agroforestry of high nature and cultural value.

2 Background

The Sardinian stakeholder group, created within the activity of the work-package 2 of AGFORWARD, proposed innovations to be tested at field scale by the AGFORWARD team in Sardinia. The innovations were to respond to the need to enhance the availability of forage resources, to improve the valuation of pasture resources, and to increase pasture productivity and quality in silvopastoral systems. One specific request was to identify pastures rich in legumes adapted to shading conditions (due to oak trees) and grazing pressure. These stakeholder expectations were found to have similarities with other stakeholder groups in work-package 2. A multi-site experiment, including sites in Sardinia, Spain and Greece, was started in autumn 2014 to study the effect of shading on the establishment and persistence of some legumes mixtures and on the soil nitrogen (N) balance. This report focuses mostly on the design and the start-up of the experiment which started in September 2014.

Much of the Sardinian rural landscape is characterized by a mosaic of agrosilvopastoral systems of different levels of complexity. The agrosilvopastoral system ranges from grazed forests to wooded grasslands where scattered trees are mixed with permanent or temporary pastures or intercropped with cereals and/or fodder crops (Seddaiu et al. 2013). Semi-extensive livestock farming systems occupy more than the 50% of the regional surface across plain, hill and mountain areas; in total there are about 15000 km^2 of pastures, meadows, and forage crops. Mediterranean maquis and forests are grazed by dairy sheep, beef cattle, goats, and pigs. Half of this grazed land belongs to the category “other wooded areas” (areas with tree coverage lower than 10%, or higher than 10% but with trees or shrubs below 5 m height) and these occupy 26% of the total regional surface. The silvopastoral systems of Sardinia are characterized by *Quercus* spp trees: holm oak (*Quercus ilex*), cork oak (*Quercus suber*) and deciduous oak (*Quercus pubescens*). In such systems, the livestock grazing pressure contributes to promote the presence of several native legume species such as subterranean clover (*Trifolium subterraneum*), and many other self-sown legumes (Ledda et al. 2000). However, in some cases, a reduction of pasture productivity and quality may occur. This may be due to overgrazing that, in turn, is associated to prolonged grazing over the seasons, increased size of the flocks, agronomic and physical marginality of grasslands and unsustainable management in common lands (Porqueddu and Franca, 2013). On the other hand, undergrazing or grazing

exclusion can have negative effects on biodiversity and create the conditions for an increase of fire risk (Franca et al., 2012; Re et al., 2014). Moreover, some other constraints such as recurring wild fires, climate change, human settlement and abandonment of agricultural lands expose several silvopastoral areas to the risk of environmental degradation.

As a result of the above, the overseeding of legumes species is a potential strategy to improve the productivity and the quality of understorey pastures within degraded silvopastoral systems. Annual legumes are a key feature for the improvement of low quality native pastures in these systems (e.g. Dehesa in Spain and Montado in Portugal). When a natural seed bank of pasture legumes is present, fertilisation without over-seeding may be sufficient to obtain satisfactory agronomic results, particularly when repeated over several years (Porqueddu and Gonzales, 2006). However, if the seed bank of pasture legumes in a natural unfertilised pasture is insufficient, the problem can be addressed by the introduction of selected varieties (Roggero and Porqueddu, 1999).

3 Objective of experiment

The main objective is to study the effect of shading by cork oak trees on the establishment and persistence of annual legume-based mixtures in a silvopastoral system. Specific objectives are:

1) Assessing the adaptability and the factors responsible for better adaptation of different pasture mixtures to shade.
2) Assessing the effects of isolated oak trees on soil seed bank dynamics and productivity of pasture species.
3) Assessing the relationships among pasture productivity, vegetation diversity and soil fertility in sown vs spontaneous wooded pastures.

4 System description

The experimental site is located within a private farm in the North-East of Sardinia, Italy and is representative of the Mediterranean cork oak silvopastoral systems (Table 1 and Figure 1).

Figure 1. The experimental site in the summer of 2014

The farm size is about 100 ha, and its main activity is livestock breeding (without 500 head of "Sarda" dairy sheep), with large utilization of natural pastures and supplementary hay production using annual forage crops. The main products are sheep milk and lambs. Cork production is periodic and represents a complement to the farm income. Milk is produced on the farm and is directly collected and transported to supply the local cheese industry.

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

Site characteristics	
Area (ha):	2.32
Co-ordinates:	40° 49' 22.27'' N 09° 19' 18.06'' E
Elevation	308 m
Slope	Maximum 6.4%
Site contact:	Sebastiano Mu
Site contact email address	a.franca@cspm.ss.cnr.it (Antonello Franca, CNR-ISPAAM)

Soil characteristics	
Soil type (WRB classification)	Typic Dystroxerept
Soil depth	Around 100 cm
Soil texture	Sandy-loam
Source:	Lab analyses on samples collected in 2012

Stand characteristics	
System	Agroforestry system
Tree species	Cork oak (*Quercus suber*)
Tree density (ha^{-1})	10 – 40
Tree basal area (m^2 ha^{-1})	Not available
Tree crown cover (%)	< 10%

Understorey characteristics	
System	Agroforestry system
Species	Natural pastures Annual forage crops (*Lolium multiflorum*, *Trifolium michelianum*)

Climate data	
Mean monthly temperature	14.5°C
Mean annual precipitation	629 mm
Weather station	Station of the Regional Environmental Protection Agency
Altitude (m)	290 m a.sl.
Source data	
Details	The weather station is located about 1.5 km far from the site

The experimental design is a completely randomized trial with three replicates represented by three cork oak trees (Figure 2). Three pasture types (F = pasture oversown with Fertiprado commercial legume mixture; I = oversown with ISPAAM mixture based on native pasture species; N = unsown pasture) were compared under (red plots in the Figure 2) and outside (green plots) of the tree canopy (Figure 3). A total of 18 plots (three trees x three pasture types x 2 positions in relation to tree canopy) is under study. The plot size is 5 m x 3 m and they are replicated in three blocks.

Figure 2. An overview of the experimental site

The new seed mixtures were sown on 28 November 2014, with a seed rate of 20 kg ha^{-1} of germinating seeds for both mixtures (F and I) and application of 200 kg ha^{-1} of diammonium phosphate. The composition of mixtures was is described in Table 2.

Table 2. Description of the two seed mixtures

Seed mixture name and abbreviation	Composition
ISPAAM (I)	40% *Trifolium subterraneum* cv Campeda, 40% *Medicago polymorpha* cv Anglona, 10 % *Lolium rigidum* cv Nurra
Fertiprado (F)	60.6%*Trifolium subterraneum*, 4.5% *T. michelianum* var balansae, 3%*T. vesiculosum*, 3% *T. resupinatum*, 6.1% *T. incarnatum*. 1.5% *T. istmocarpus*, 1.5% *T. glanduliferum*, and 19.7% *Ornithopus sativus*.

Figure 3. The plots outside the tree canopy

Figure 4. Counting of seedlings at the establishment of the plots in autumn 2014

5 Measurements

Soil samples were collected before sowing and seedling establishment was estimated counting the seedlings within 2 sampling areas of 1/8 m^2 per plot. A series of measurements are planned in the experiment during 2015 (Table 3).

Table 3. Planned measurements

Component	Planned measurements
Tree	• Dendrometry (tree diameter at breast height, height and horizontal dimension of the canopy) • Tree canopy coverage (PAR- SUNSCAN/FISHEYE photographs)
Pasture	• Phenology of sown pasture species (first flower appearance, complete flowering) (Figure 4) • Morphology of sown pasture species (plant height, number of stems plant-1, stem length) • LAI of the pasture canopy (SunScan) (Figure 5) • Dry matter yield, floristic composition and leaves/stems ratio of mixtures • Forage quality of mixtures • Seedlings re-establishment on autumn
Soil	• Soil fertility traits at the end of the experiment • Soil seed bank at the end of summer after sowing

Figure 5. Measuring Photosynthetically Active Radiation (PAR) and leaf area index (LAI) with a Sunscan light meter within the shaded plot

6 Acknowledgements

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