# New LTE in Tuscany to Understand the Potential Contribution of Agroforestry to a More Resilient Agriculture

Alberto Mantino1*, Daniele Antichi 2 3, Massimo Sbrana 2, Giustino Mezzalira 6, Francesco Pelleri 4, Piermario Chiarabaglio 5, Stefano Carlesi 1, Anna-Camilla Moonen1, Paolo Bàrberi 1, Giorgio Ragaglini 1, Marco Mazzoncini 2 3, Marcello Mele 2 3

1 Sant'Anna School of Advanced Studies, Institute of Life Sciences, 56127, Pisa, Italy *a.mantino@santannpisa.it
2 Centre for Agro-Environmental Research (CIRAA) "Enrico Avanzi", 56122, Pisa, Italy
3 University of Pisa, Department of Agriculture, Food and Environment (DAFE), 56127, Pisa, Italy
4 CREA, Research Centre for Forestry and Wood - Forestry Research Centre, 52100, Arezzo, Italy
5 CREA, Research Centre for Forestry and Wood - Forestry Research Centre, 15033, Casale Monferrato AL, Italy
6 Veneto Region Agency for Innovation in the Primary Sector, 35020, Legnaro PD, Italy

**Introduction**

Agroforestry (AF), "the deliberate integration of woody vegetation (trees and/or shrubs) as an upper storey on land, with pasture (consumed by animals) or an agricultural crop in the lower storey" (Mosquera-Losada et al., 2017), is gaining pace as a land-use strategy to cope with climate change and provide environmental, economic, and social benefits (Kay et al., 2019). Recent studies in Italy highlighted the historic importance of traditional and innovative AF systems and their capacity to produce climate-smart food and sustainable high value timber production (Paris et al., 2019). During the past century, the tradition of separating between science and practice in agriculture and in forestry has left many opportunities for a functional use of trees in the agroecosystem unexploited (Duguma et al., 2018). Trees may play an important role in the sustainable management of agricultural landscapes through increased ecosystem services generated by both traditional and innovative AF systems (Jarvis et al., 2013). For this reason, a multidisciplinary team is focusing on the design and the establishment of a 40-ha Long Term Experiment (LTE), to evaluate the transition of a conventional arable system towards AF in Tuscany. The purpose of the LTE is to assess the sustainability and the feasibility of AF compared with conventional arable and forestry systems as well as the potential transferability to real farm conditions. The research team has the priority to investigate synergies and trade-offs among the two main components of the agroforestry system, in order to evaluate whether a diversification, based on annual and perennial herbaceous and woody species consociation, may enhance the resilience of cropping systems to variability of weather conditions. Secondly, it is mandatory to evaluate the potential of AF systems to climate change mitigation and efficient resource exploitation, considering, in particular, the effects on carbon storage, soil fertility and biodiversity.

**Materials and Methods**

The LTE, established in 2018, is located at the Centre for Agro-Environmental Research "Enrico Avanzi" of the University of Pisa, San Piero a Grado (Pisa) (43.667205 N, 10.313160 E). The field trial was established on soils derived from alluvial sediments. They are classified as Typic Haplustert, with loam to clay-loam textures, sub-alkaline pH and soil organic matter varying from 1.5 to 2%.

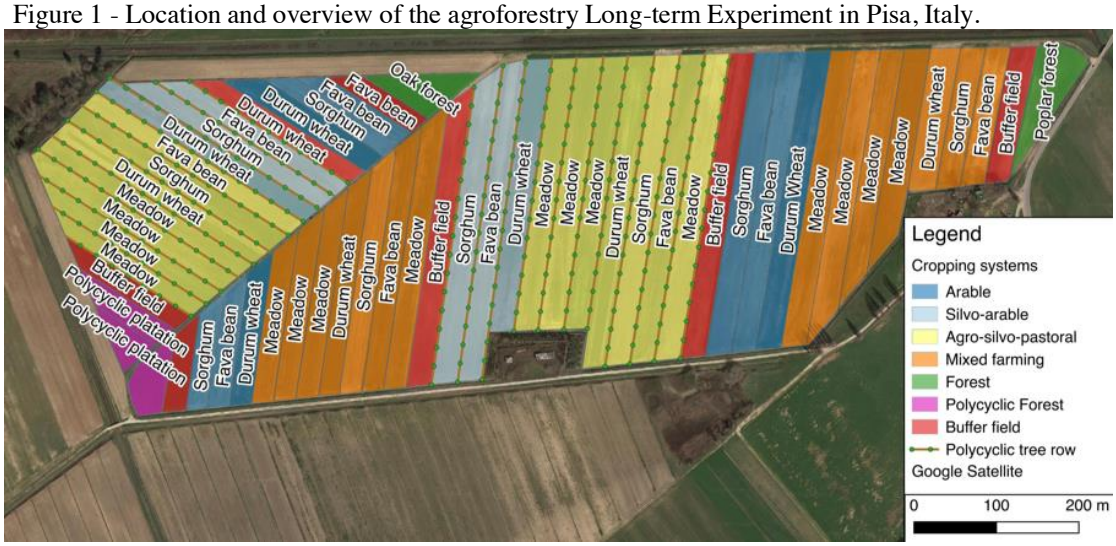
Two AF systems, Silvo-Arable (SA) and Agro-Silvo-Pastoral (ASP), are compared with the respective controls, Arable (AR) and Mixed (MX) systems (Table 1). The AR and SA rotation consists in durum wheat (*Triticum turgidum* subsp. *durum* Desf.), sorghum (*Sorghum bicolor* L. Moench) and faba bean (*Vicia faba* var. *minor* Beck). In MX and ASP, the 3 annual crops are followed by a 4-year meadow of Italian ryegrass (*Lolium multiflorum* Lam. var. *italicum*), orchard-grass (*Dactylis glomerata* L.), tall fescue (*Festuca arundinacea* L.), sulla (*Hedysarum coronarium* L.) and alfalfa (*Medicago sativa* L.). In SA and ASP, oak (*Quercus robur* L.) and poplar (*Populus* spp.) have been planted alternate on the row every 5 m, along one side of each field, 2 m away from drainage ditches, corresponding to a density of 60 trees $ha^{-1}$. The space between tree rows and ditches is managed as semi-permanent buffer strips to

support functional biodiversity and to limit nutrient leaching. Forestry control fields are two pure stands of poplar (*Populus* spp.) and oak and a polycyclic plantation based on oak, poplar, hazelnut (*Corylus avellana* L.) and alder (*Alnus cordata* L.) (Fig.1). In this preliminary stage, different management options for the establishment of trees in rainfed condition and to contrast the action of wild animals are under evaluation. Further activities will regard the development of protocols to assess spatial and temporal relations among trees and herbaceous crops and understand whether trees affect crop yield in positive or in negative, considering the crop rotation, the management intensity and the potential delivery of ecosystem services by trees.

Table 1 – Cropping systems and rotations of LTE

| Arable | Agroforestry | Forestry |
|---|---|---|
| Arable (AR) (3yr) | Silvo-arable (SA) (3yr) | Poplar (10yr) or oak (45 yr) (P), (O) |
| Mixed (MX) (7yr) | Agro-silvo-pastoral (ASP) (7yr) | 3P polycyclic plantation (3P) (45 yr) |

Figure 1 - Location and overview of the agroforestry Long-term Experiment in Pisa, Italy.




**Expected results**

The overall challenge, for agroforestry, is to identify which combination of crop and tree species optimizes the use of light, water and nutrients, and meets farmers' needs for production of goods and its relative income. In the near future, sustainable agriculture research will be called to design new farming systems able to cope with climate change using both adaptation and mitigation strategies. Following this need, this LTE will be the basis for future studies on agroecosystem services of agroforestry cropping systems and demonstration activities aiming to spread innovation among farmers, advisors, local administrators and policy-makers.

**References**

Duguma L.A. et al. 2018. SDG synergy between agriculture and forestry in the food, energy, water and income nexus: reinventing agroforestry? Curr. Opin. Environ. Sustain. 34, 33–42.

Jarvis D. et. al. 2013. Managing Agroecosystem Services in Managing Water and Agroecosystems for Food Security (Vol. 10). EDI CABI.

Kay S. et al. 2019. Agroforestry creates carbon sinks whilst enhancing the environment in agricultural landscapes in Europe. Land Use Policy, 83: 581–593.

Mosquera-Losada M.R. et al. 2017. How can policy support the appropriate development and uptake of agroforestry in Europe? Deliverable 8.24. 7 September 2017. 21 pp. *http://www.agforward.eu/index.php/en/how-can-policy-support-the-uptake-of-agroforestry- in-europe.html* .

Paris P. et al. 2019. What is the future for agroforestry in Italy? Agrofor. Syst.