2.3 Tree Growth and production (I)

Oral presentations

Hall Q3, 29 May 2024, 11:15–12:00

Young Swiss silvo-arable systems: In what shape are they on their 10th birthday?

Dr. Felix Herzog[1], Prof. Mareike Jäger[1], Giotto Roberti[1], Dr. Sonja Kay[1]

1 Agroscope, Zurich, Switzerland

Introduction

Although agroforestry has been on the agenda in Europe for several years and some farmers have started their own agroforestry plots already decades ago, empirical data about the performance of those systems is scarce, due to a lack of systematic monitoring.

Methods

In the 2010s, we started monitoring the tree growth of four silvoarable systems in the Swiss lowlands. They were established by pioneer farmers who engaged in their own agroforestry experiment for various reasons. The systems can be characterized as follows:

- AF1: 5.6 ha planted in 2007 with 545 apple-trees (Malus domestica) in 15 lines, with a distance of 15 meters between lines. The system is managed conventionally with a crop rotation of maize, strawberries, rotational fallow, and winter wheat. The apples are used for juice.
- AF2: 2.5 ha planted in 2009 with 87 fruit trees (36x Prunus cerasus and 51x Malus domestica), intercropped with vegetables. The distance between the four tree-lines ranges from 15 to 50 meters. It is managed organically. We measured the cherry trees only.
- AF3: 1 ha planted in 2011 with 52 poplar (Populus tremula) trees in three lines 52 m apart. Intercropping consists of a rotation of conventional fodder crops and rotational grassland.
- AF4: 2 ha planted in 2013 with 54 fruit trees (Prunus avium, Malus domestica, Pyrus communis) in three tree lines a distance of 24 m. The land is managed conventionally with a crop rotation consisting of winter wheat, ley, and maize.

We measured the tree growth of a sub-sample of the trees in three-years intervals according to a standardized procedure (Kuster et al. 2012). Diameter at breast height (BDH) was measured repeatedly four times during the study period (2014, 2017, 2020, 2023) using a slide gauge. Tree height was measured using triangulation, with a "Vertex 5" tool. The same trees were always measured and mortality was recorded. Tree biomass was calculated assuming that the tree resembles a cylinder in its shape. The wood density values used for poplar, cherry, and apple were 410, 608, and 610 kg/m3, respectively.

Results

Cumulated mortality ranged from 0 to 25 % for the annual mortality and from 8 to 69 % for the cumulative mortality. The highest mortality was found in AF3 (poplars), almost 50% of the measured trees died or were replanted in the 10 years of the study. However, cumulative mortality was up to 70% as some trees died again after replanting. In AF4 (wild cherries) and in AF2 (fruit cherries) only 8 % of the trees died in 10 years. In the apple agroforestry system AF1, 16 % of the trees died and were replanted.

The variability of the tree growth curves is high (Figure 1), with a particularly high variability for the poplar trees (AF3). The tallest poplar trees have entered the exponential growth phase (up to 14 meters in 13 years). The fruit cherries in AF2 and the apples in AF1 grew comparatively slowly. The wild cherries in AF4 showed a linear and constant growth over the 10 monitoring-years and reached higher values than the fruit cherries in AF2 despite the younger age of the system.

Discussion and outlook

The relatively high mortality rate in the poplar plot was unexpected and is not often mentioned in the agroforestry literature. The mortality of the other agroforestry plantings was in the range of 10 – 15% that is expected in forestry projects. Tree mortality has consequences for the establishment costs of agroforestry and should be accounted for when budgeting for the initial phase. The coming monitoring years will reveal whether over the entire life cycle of an agroforestry system, mortality remains a relevant parameter.

Empirical data are required to parametrize and update the models used to predict the performance of agroforestry systems, such as the Yield-SAFE and Hi-sAFe models (Dupraz et al. 2019; Graves et al. 2010a, 2010b). Here, we only provide relatively short time series covering the establishment and early growth phase of the systems monitored. However, monitoring will continue and more data will be collected. Ongoing work in the context of the Horizon 2020 project Agromix uses measured data from mature agroforestry experiments across Europe to calibrate the above mentioned models. This then allows conducting virtual experiments and to examine the behavior of the systems under climate and management scenarios.

Acknowledgements
Part of the monitoring was conducted with support from the following projects: Horizon 2020 Agromix (https://agromixproject.eu/), Horizon Europe DigitAF (https://digitaf.eu/) and Agro4esterie (https://www.agroforesterie.ch/).

Keywords
temperate agroforestry, farmer perception, tree plantations, trees, simulation model, Monitoring, collaborative research, silvoarable agroforestry

Aditional Attachment II.

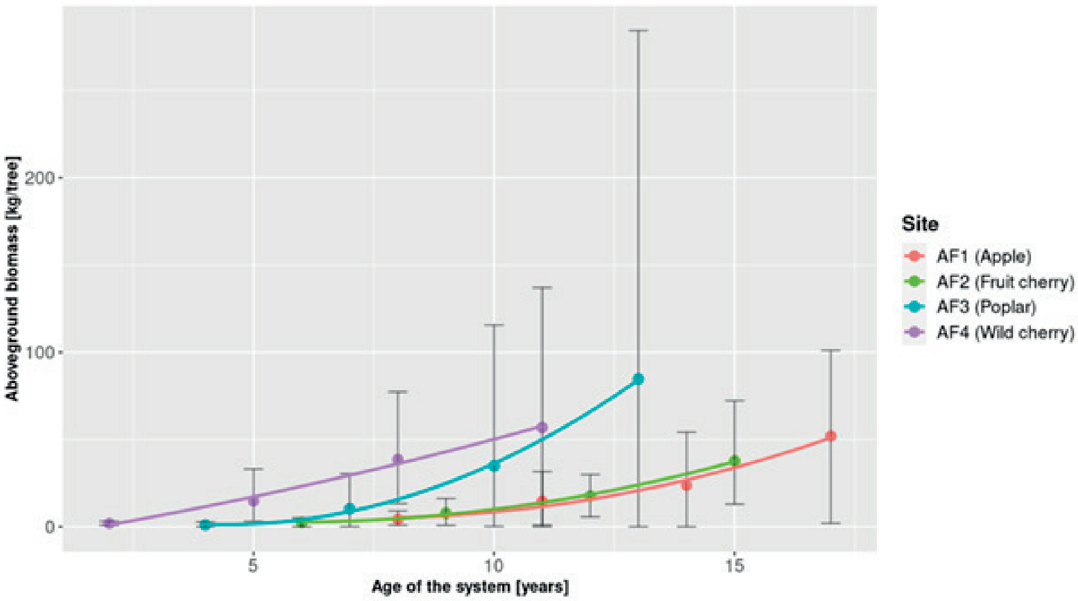

Figure 1: Tree growth (aboveground biomass) in four agroforestry systems. As they were planted in different years, the lines do not overlap. Tree growth monitoring started right after planting in AF4 and only in later years in the other agroforestry systems. The error bars represent the 95% confidence interval of the data.

Bibliography

Burgess, P. J., et al. (2023). Description of the Biophysical Yield-SAFE model as implemented in Microsoft Excel. Cranfield Online Research Data (CORD). https://doi.org/ https://doi.org/10.17862/cranfield.rd.24250549.v1

Dupraz, C., et al. (2019). Hi-sAFe: A 3D Agroforestry Model for Integrating Dynamic Tree–Crop Interactions. Sustainability, 11(8). https://doi.org/10.3390/su11082293

Graves A.R., et al. (2010) Implementation and calibration of the parameter-sparse Yield-SAFE model to predict production and land equivalent ratio in mixed tree and crop systems under two contrasting production situations in Europe. Ecological Modelling 221, 1744 – 1756.

Graves A. R., et al. (2010) Farm-SAFE: the process of developing a plot- and farm-scale model of arable, forestry, and silvoarable economics. Agroforestry Systems 81, 93 – 108.

Kuster M., et al. (2012) Innovative Agroforstsysteme - On farm monitoring von Chancen und Grenzen / Systèmes agroforestiers novateurs - monitoring des opportunités et limites. Agrarforschung Schweiz / Recherche Agronomique Suisse 3(10), 470 – 477. https://www.agrarforschungschweiz.ch/2012/10/innovative-agroforstsysteme-on-farm-monitoring-von-chancen-und-grenzen/