Impact of age and diversity of Swiss agroforestry systems on soil health

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Introduction

Although traditional agroforestry systems are found across Europe (Dupraz et Liagre, 2008). So-called modern, silvoarable alley cropping systems (ACS) are rather scarce, especially in Switzerland (Jäger, 2019). ACS could be one of the solutions to the major challenges facing agriculture, such as biodiversity loss, climate change adaptation and mitigation (Terasaki Hart et al, 2023; Jacobs et al, 2022; Torralba et al. 2016). ACS offer high potential for improving soil health by reducing erosion, increasing carbon inputs and nutrient availability or enhancing soil life compared to conventional systems (Rolo et al. 2023). Moreover, ACS were shown to increase resource use efficiency and agroecosystem resilience (Sauter et al. 2015). However, under certain circumstances, the presence of intercropped trees may increase competition for nutrients, water and light (Lawson et al. 2019). Furthermore, setting up ACS represent substantial financial investment, as well as a high workload in the first years (Jäger, 2019). Thus, the balance between the advantages and disadvantages of ACS is intrinsically linked to location, as well as to the system design and management practices.

In past years, ACS started to be implemented with increasing frequency in Switzerland. Switzerland has a highly diversified, often hilly landscape, and farmers cultivate rather small fields. Therefore, farmers design specific ACS adapted to their site, resulting in highly diversified ACS. Tree strip orientation and width, cropping alley width and use differ between farms and plots. Among all ACS, trees are used for a variety of purposes, such as the production of fruit, nuts or timber. Additionally, some wild tree species are grown solely for biodiversity purposes. The diversity of systems also varies: some ACS consist of a single tree species, others combine several tree species or uses. Furthermore, farmers grow several crops in their rotation and sometimes grow different crops simultaneously in each cropping alley of the same ACS. This huge diversity increases the challenge to study and compare ACS.

Benefits of ACS for soil health are well established (Beule et al. 2022, Ivezić et al. 2022, Nagba et al. 2023). However, little is known on how different ACS characteristics such as age or diversity affect soil health in temperate regions. Furthermore, individual case-studies focusing on few particular soil properties in topsoil are the most common method of studying ACS. The aim of this study is to conduct an on-farm survey at various sites throughout Switzerland to compare soil health of whole ACS and tree-less arable plots and to shed light on how different ACS implementations and pedoclimatic conditions affect soil health – assessed using biological, chemical and physical soil health indicators. This may give us inferences on: at which (i) age, (ii) density and (iii) diversity level an ACS can have an impact on soil properties.

Material and Methods

Soil sampling protocol (carried out in Feb-March 2024)

We have identified around 30 farms practicing silvoarable agroforestry in Switzerland. For each site, pedoclimatic information and agricultural management data will be collected. ACS's ages range from 1 to 30 years. In order to cope with the ACS diversity, we plan to collect soil sub-samples in 5 transects between two tree strips, each transect being 4 meters apart. Transect sub-samples will be mixed to get representative composite sample for each site. Composite samples will be collected in triplicate at each farm: one in a control tree-less plot, one in the cropping strip of the ACS and one in the ACS tree strip. This allows to weight the effect of the trees according to the dimensions of the cropped area and to compare ACS with each other. In addition to the composite samples, undisturbed soil cores (5 replicates) will be collected at each site. Composite and undisturbed samples will be collected in topsoil (0-20 cm) and subsoil (20-60 cm).

Soil health assessment – Selection of indicators (carried out in Mar-Aug 2024)

The assessment of the soil health will be based on biological, chemical and physical soil properties. For this purpose, the following indicators were collected and evaluated with regard to their relevance and feasibility.

Soil penetration resistance and infiltration capacity will be measured on site using a penetrometer (Sol Solution) and mini disk infiltrometer (Meter group GmBH), respectively. Soil cores will be used to determine soil bulk density and soil structure by visual estimation (Core VESS). Composite samples will be sieved at 2mm and split in two: one part will be stored at 4°C, the other will be dried. Composite cooled samples (4°C) samples will be used to measure soil microbial biomass, soil respiration and composition of soil biota functional community. Composite dried samples will be used to determine texture, pH, cation exchange capacity, total N, available P, K, Mg, Ca, soil organic carbon.

Preliminary results of the physical soil health will be available in spring 2024. The biological and chemical analysis of soil properties will take longer.

Keywords
climate resilience, soil organic carbon, climate change mitigation, soil properties, Age-dependent, alley cropping, Temperate climate, silvoarable agroforestry

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