Can we optimise feed production and quality in alley cropping systems by adapting grass-herb composition? First results of an artificial shade experiment.

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Abstract

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Abstract

Introduction

To further increase the adoption of silvoarable agroforestry in Europe, system optimisation to improve productivity and performance is key. This starts with disentangling and characterising the wide range of processes at play, including both competitive and facilitative interactions occurring above- and belowground between trees and crops. Furthermore, system optimisation also encompasses e.g., improved tree-crop combinations, selection of adapted crop and tree varieties and smart design.

In North-Western Europe, light is likely to be the principal limiting resource for understorey crops, with trees strongly influencing the fraction of Photosynthetically Active Radiation (PAR) received by the annual crop. Hence, most agronomic studies show a systematic reduction of final yield as shade increases [2,6]. This effect has been thoroughly assessed in previous research for a range of arable crop species through both empirical studies and modelling works [2,4,5,9]. Recent meta-analyses across temperate climate suggest contrasting responses to shade according to crop species, with (i) winter crops being less affected than summer crops[6], and (ii) forages, berries and fruits revealing a more tolerant response than C3 cereals, grain legumes and maize[8]. However, studies comparing the performance of multiple species are less abundant and mainly restricted to the Mediterranean region [1,3,7]. Moreover, at the variety level (intra-specific level), studies become even more rare [1,6]. Arenas-Corraliza et al. (2019)[1] assessed the effect of artificial shade on multiple Mediterranean wheat and barley varieties from different precocity categories. They found significant differences between cultivars in terms of grain yield increase, leaf mass area decrease and total chlorophyll content increase under shade conditions. Additionally, Panozzo et al. (2020)[7] found a clear difference in shade response between old and modern Mediterranean durum wheat varieties, namely in grain yield and grain quality. These studies indicate that varieties can respond significantly different to shade, which allows optimisation of variety choice.

Context specific climate conditions but also other aspects such as soil conditions, nutrient availability, pest and disease risks need to be considered in this search for adapted varieties.

Description of experimental setup, objectives and methodology

In 2021, ILVO set up a program to start field screening of crop species, varieties and mixtures for agroforestry conditions typical for Belgium. In a long-term experimental setup, we have installed an artificial shade construction at our agroforestry research site, mimicking a mature agroforestry system through the use of military camouflage netting to provide discontinuous light through the day (based on Artru et al. 2017 [2]). The construction is made of vertical concrete poles with a height of 3.5 m and with a metal crossbeam of 3 m long attached on the top of the poles. The structure is approximately North-South oriented, with the camouflage netting fixed on top of the crossbeams. In the alleys East and West from this construction, nine crop plots of 12 m long (along the row of poles) and 12 m wide (perpendicular to the row of poles) were installed, enabling us to have three crop treatments with three replicates per season (see Fig. 1- left). An aerial view of the construction can be seen in this short video.

The light reduction is monitored at six positions in the field, i.e., at 3, 6 and 9 m East and West from the row of poles, using pyranometers (type SP-110, Apogee Instruments). At the same positions, also air humidity and temperature (type CS215, Campbell Scientific), soil water content (CS616, Campbell Scientific), soil temperature (type 107, Campbell Scientific) and soil water potential (type Teros21, Meter Group) are assessed.

During the two first growth seasons of 2022 and 2023, we evaluated the impact of the dynamic shade conditions on crop productivity and quality for three different grass-herb mixtures, i.e. (1) *Lolium perenne* + *Trifolium pratense*, (2) *Festuca arundinacea* + *T. pratense* and (3) *F. arundinacea* + *T. pratense* + *Plantago lanceolata*. Harvesting activities are shown in Fig. 1- right.

Our research hypotheses are:

(1) All mixtures generally perform best under moderately shaded conditions, as compared to full shading (too much light competition) or full light (higher drought stress) conditions.

(2) *F. arundinacea* is a more drought resistant grass species, with an overall lower production in the first year of establishment but ultimately higher production as compared to *L. perenne* also in more shaded conditions.

(2) Adding *P. lanceolata* to the grass-clover mixtures further increases drought resistance but also productivity and feed quality in shaded conditions.

Results and perspective

The insights gained over the first two years of monitoring in this trial will be presented at the EURAF 2024 conference in Brno, together with a perspective towards future research at the same site.

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Figure 1. Artificial shade construction at the ILVO experimental site (Merelbeke, Belgium). Left: Field view with light sensors and three treatments of grass-clover mixtures along the length of the construction. Right: Harvesting activities with the Haldrup and manual collection of samples for further analysis.