The Impact Of Alley-Cropping On Growth Of Poplars And Yield Of Annual Intercrops Vs. Conventional Farming

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Introduction

Agroforestry (AF) practices fully embrace the strategies of the CAP policies towards the improvement of multi-functionality and sustainability of farming systems, while answering to the rising global demand for food and forest products. The re-introduction of trees in agricultural fields is known to provide environmental benefits and to increase C sequestration, enhancing at the same time the use efficiency of natural resources and the overall productivity per land unit (Santiago-Frejiandes et al., 2018). In the North of Italy there is an increasing interest towards AF systems with poplars; however, farmers are still reluctant to adopt agroforestry practices due to the risk of reduced crop yield in the neighboring of trees and uncertain tree growth (Eichhorn et al., 2006). Here, the productivity of a poplar alley-cropping system in NE of Italy is compared to the respective poplar and crop monoculture systems. The aim was to assess the impact of the alley-cropping design on growth of poplars and yield of annual intercrops, such as common wheat and soybean, until the midpoint (4 years) of the expected poplar lifespan.

Materials and Methods

The trial was carried out during the 2018-2022 period in a silvoarable alley-cropping system (AC) with poplar trees (*Populus* × *euroamericana*;) type HES (Higher Environmental Sustainability) located at the "Sasse Rami" pilot farm of Veneto Agricoltura, in Ceregnano (Rovigo, NE Italy, 45° 05'06" N, 11° 87' 66" W; 0.5-1m a.s.l.). The tree rows are placed along N-S oriented drainage ditches, 40 m apart, with 6 m between trees along the row (44 trees ha^{-1}), while a specialized poplar grove (6 × 6 m; ~290 trees ha^{-1}) was used as control (C). From 2019 to 2022, the diameter at breast height (DBH) and the height of the clone Moncalvo in both C and AC treatments were yearly recorded (n_C=14-15; n_{AC19}=3; $n_{AC20-22}$: 14-15). The radial growth of poplar trees was measured during the 4th vegetative season (2021) through dendrometers (Linear Motion Potentiometer, Bourns-3048). The grain yield of common wheat in 2019 and 2021 (var. Arkeos; CGS Sementi, Terni, Italy) and soybean in 2020 (var. P21T45; Pioneer-Corteva), cultivated in the alley have been revealed at 3 distances from tree row, named ½H (+6m), H (+12m) and C (+20m), where H=tree height and C=middle of the inter-row (considered as control), along transects orthogonal to tree rows both at east and west sides. Statistical analysis was carried out with R studio v. 1.4, using the Tukey's HSD test for means separation ($p \leq 0.05$) and t-test ($p \leq 0.05$).

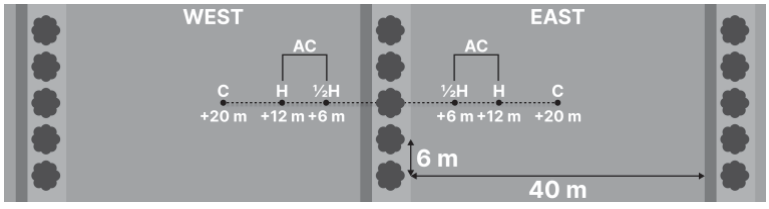

Figure 1. Scheme of sampling points along the transects.

Results

Growth of poplar trees

The DBH of the clone Moncalvo was significantly higher in AC vs. C ($p \leq 0.001$) during the whole measurement period, except for 2020. At the midpoint of expected lifespan (4th year), DBH was +19% higher in AC (24 cm vs. 20 cm in C). Contrarily, the height achieved by Moncalvo at the last year of measurement (2022) was significantly ($p \leq 0.01$) higher in C (15.4 m) than AC (14.3 m) (Figure 2). At the end of 2021 growing season, the annual radial growth of poplar trees was revealed to be slightly higher in AC as compared to C (20.5 and 18.9 mm in AC and C, respectively; $p < 0.1$).

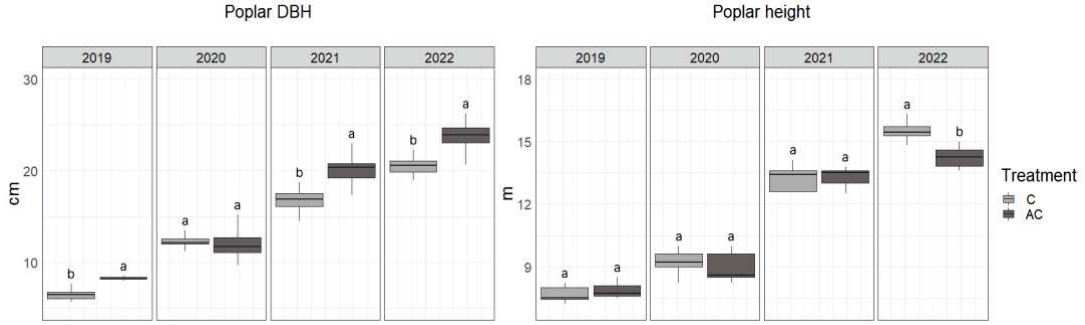

Figure 2. Diameter at breast height (DBH) and height of poplar trees in the poplar grove (C) and alley-cropping system (AC).

Yield of annual intercrops

The grain yield of common wheat was always increased at H distance from the trees as compared to C, particularly in 2021 at west side (+20% vs. C; $p<0.01$), while comparable yields were achieved at ½H position (max -4% vs. C; n.s.). Diversely, soybean was negatively affected the proximity of poplar rows, with a significant yield reduction at ½H (-24% and -43% at the east and west side of the poplar row, respectively; $p < 0.05$) vs. C. At H distance, instead, soybean yield variations vs. C were lower and not significant.

Table 6. Grain yield (g m^{-2}) of the annual intercrops at different distances from the tree row and % of variation (var.) vs. C.

Intercrops	West					East				
	½H	%var./C	H	%var./C	C	½H	%var./C	H	%var./C	C
Wheat (2019)	965.6 - **b**	=	1008.7 - **b**	+5%	965.6 - **b**	1007.0 - **a**	-1%	1038.6 - **a**	+2%	1015.0 - **a**
Soybean (2020)	265.1 - **b**	-43%	448.6 - **a**	-4%	467.8 - **a**	352.3 - **b**	-24%	540.4 - **a**	+16%	464.6 - **a**
Wheat (2021)	612.7 - **b**	+8%	736.2 - **a**	+29%	568.8 - **b**	746.6 - **b**	-8%	1035.4 - **a**	+28%	812.2 - **b**

Conclusions

The cultivation of poplar trees in a widely-spaced alley-cropping system allowed for slightly accelerating the growth of trees as compared to conventional high-population poplar groves, as highlighted by higher DBH and radial growth at the midpoint of tree life-span. Intercropping winter cereals like wheat with a deciduous trees species seems a successful strategy to implement high-productive alley-cropping systems. Instead soybean, as a summer crop, has large overlapping with the growing season of trees, and shading causes significant yield decreases, particularly at the est side.

Literature

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