The Impact Of Trees On Growth And Yield Of Barley And Soybean In Alley-cropping systems

Anna Panozzo, Giuseppe Barion, Elia Tognetti, Manuel Ferrari, Alberto Di Stefano, Cristian Dal Cortivo, Teofilo Vamerali

Dep. of Agronomy, Food, Natural Resources, Animals and the Environment, Univ. Padova, IT, anna.panozzo.1@phd.unipd.it

Introduction

Under intensive agriculture, crops yield stability has been increasingly reduced in the last decades due to the negative impact of natural resources depletion and climate change, particularly extreme temperatures and water scarcity. Agroforestry farming, with the integration of woody vegetation and crops on the same agricultural land, has high potential to improve crop resilience to climate change and provide a more stable provision of agricultural products, while contributing to increase ecosystem services delivery such as enhancing resources use efficiency (Jose et al., 2009). Intercropping with tree species for timber production was largely practiced in the agricultural lands of Italy until the ‘70s, but the intensification of agriculture has led to remove trees in order to boost monoculture practices (Paris et al., 2019). In this study we investigated the impact of row-arranged poplar and oak trees on growth, yield and quality of a winter cereal and a legume crop cultivated in the alley, in order to assess the potential of this alley-cropping system to enhance crop resilience to climate change and ensure more stable yields.

Materials and Methods

The trials were conducted during the 2018-19 growing season in the fields of the private farm “Azienda Agricola Casaria” located in Masi (Padova; 45° 08’ N, 11° 30’ E), where an alley-cropping system has been implemented in 2012 with rows of poplars (*Populus* x *euroamericana*, I214 clone) and oaks (*Quercus robur* L.) planted along drainage ditches and regularly alternated every 5 m (10 m between each plant of the same species). Tree rows are 40 m apart and the inter-row is cultivated with a rotation of arable crops under organic management. Plant materials were collected from barley (var. Amistar), sown on 19 November 2018 (300 seeds m^{-2}; 14 cm row apart; Fig. 1) and harvested on 20 June 2019, and on soybean (var. PR91M10, Pioneer-Corteva) sown on 24 June 2019 (45 plants m^{-2}; 45 cm row apart) on the same fields after barley harvesting, and harvested on 14 October 2019. Both barley and soybean have been sampled two times, at flowering and maturity, on the same sampling points (1-m^2 area each) at 3 different distances from the trees (+3 m, +10 m and +20 m), along transects perpendiculars to both poplars and oak trees towards both East and West directions from the tree row (Fig. 1). The sampling points at +20 m from the trees were considered as control area (C), as we assumed they were not subjected to any interaction with the trees (shading or competition for water and nutrients).

Results

The grain yield of barley was increased close to the tree row as compared to controls (middle of the alley), it being +26% at +3 m and +14% at +10 m, as average of positions East and West. As regards the sampling position, barley plants growing to East of the tree row showed higher biomass, LAI and leaf chlorophyll content, that supported higher grain yield ($P<0.05$) and quality (only at +10 m) close to the trees as compared to controls. On the opposite, growth and yield parameters of barley plants growing at West were generally reduced (Table 1). In soybean, shoot biomass, LAI and leaf chlorophyll content (at East only) were negatively impacted at +3 m and +10 m, both at East and West positions, leading to stronger yield and quality reductions than barley, as compared to respective controls, particularly at +3 m (-33% of yield vs. C) (Table 2). Only in position +10 m at East, soybean showed a small increase of yield and total isoflavone content (TIC), with the bioactive aglucones being increased by +104% (P<0.05).

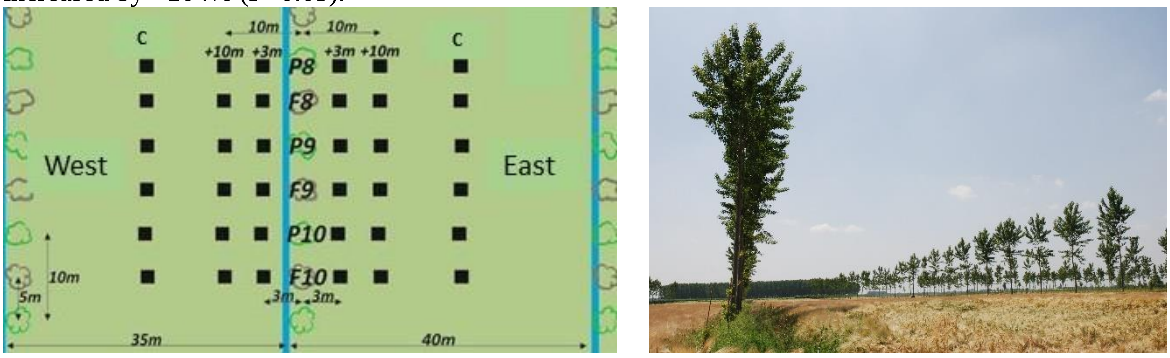

Figure 1. Sampling points along 6 transects (left; P=poplar, F=oak) and barley cultivated in the alley (right).

Plants sampled at flowering were submitted to the following measures: leaf area index (LAI; *LI-3100C Area Meter*, Li-Cor), leaf chlorophyll content (SPAD-502) and dry biomass weight (after 72 hours at 65°C). Plants sampled at maturity have been threshed to determine grains weight. Grain protein content of barley was determined by the Kjeldahl method; soybean total isoflavone content (TIC) was measured by HPLC (Hubert et al., 2005). Different letters indicate statistical significant differences (Tukey's HSD test, $P \leq 0.05$), using R studio (v. 2.7).

Table 1. Growth and yield (n=6) and % of variation vs. C of barley for each sampling point.

		Plant biomass		**LAI**		**SPAD**		**Yield**		**Grain protein**	
		$g\ m^{-2}$	%var/C	LAI	%var/C	Units	%var/C	$g\ m^{-2}$	%var/C	% dw	%var/C
East	+3m	781.5 (a)	+20%	1.5 (a)	+16%	40.6 (ab)	+2%	601.3 (a)	+41%	8.2 (b)	-9%
	+10m	698.3 (a)	+7%	1.9 (a)	+41%	42.4 (a)	6%	580.2 (a)	+36%	9.9 (a)	+10%
	C	653.3 (a)		1.3 (a)		39.8 (b)		427.0 (b)		9.1 (ab)	
West	+3m	537.1 (a)	-31%	1.0 (b)	-47%	39.3 (a)	-5%	672.6 (a)	+16%	9.0 (a)	-6%
	+10m	664.9 (a)	-15%	1.5 (ab)	-20%	41.2 (a)	-0.2%	568.3 (a)	-2%	9.1 (a)	-5%
	C	778.7 (a)		1.9 (a)		41.3 (a)		582.4 (a)		9.5 (a)	

Table 2. Growth and yield (n=6) and % of variation vs. C of soybean for each sampling point.

		Plant biomass		**LAI**		**SPAD**		**Yield**		**TIC**	
		$g\ m^{-2}$	%var/C	LAI	%var/C	Units	%var/C	$g\ m^{-2}$	%var/C	$mg\ g^{-1}$	%var/C
East	+3m	108.7 (a)	-38%	1.5 (a)	-8%	42.8 (b)	-5%	170.9 (a)	-12%	0.8 (a)	-11%
	+10m	116.1 (a)	-34%	1.1 (a)	-31%	43.7 (ab)	-3%	221.3 (a)	+14%	1.2 (a)	+26%
	C	176.35 (a)		1.6 (a)		45.0 (a)		193.9 (a)		1.0 (a)	
West	+3m	113.4 (a)	-25%	1.1 (a)	-12%	47.0 (a)	+2%	84.4 (a)	-55%	0.7 (a)	-33%
	+10m	142.1 (a)	-7%	1.2 (a)	-6%	47.6 (a)	+4%	185.4 (a)	-2%	0.9 (a)	-10%
	C	152.1 (a)		1.3 (a)		45.9 (a)		189.1 (a)		1.0 (a)	

Conclusions

Intercropping winter cereals such as barley with deciduous trees species seems a successful strategy to implement resilient and high-productive alley-cropping systems. Tree-crop resources competition, especially for solar radiation, are limited in barley, it reaching maximum leaf area index before tree leaf sprouting. Soybean is a relevant intercrop for nutrients cycle improvement in agroforestry but, as summer crop, there is large overlapping with trees growing season and shading causes significant yield reductions.

Literature

Hubert J. et al. 2005 Use of a simplified HPLC−UV analysis for soyasaponin B determination: study of saponin and isoflavone variability in soybean cultivars and soy-based health food products. J. Agric. Food. Chem. 53: 3923–3930.
Jose S. 2009. Agroforestry for ecosystem services and environmental benefits: an overview. Agrofor. Syst. 76: 1-10
Paris P. et al. 2019. What is the future for agroforestry in Italy? Agrofor. Syst. 93: 2243-2256.