MICROCLIMATE EFFECTS OF SHORT ROTATION TREE-STRIPS IN GERMANY

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Introduction

Multifunctional land use systems, such as agroforestry, are able to deliver several ecological services to agriculture in addition to the concurrent production of woody biomass and arable crops. For example, trees in agroforestry systems can provide shelter for wildlife and supply additional nutrients to adjacent arable fields through leaf litter inputs and fine root turnover. In addition, tree-strips have the ability to improve the groundwater quality underneath the tree-strip itself and possibly underneath adjacent fields. Unlike these commonly measured ecosystem services the microclimate conditions in temperate agroforestry systems are still a comparatively new study area (Kanzler et al. 2015, Böhm et al. 2014). This might be due to the complexity of the microclimate, which depends on various parameters such as the plant height, the planting density, and the orientation of the tree-strips. The objective of this study was to investigate the potential influence of tree-strips on microclimate using high resolution data loggers.

Materials and methods

Investigations were carried out at an agroforestry research site situated in Germany about 150 km southeast of Berlin (Figure 1). The study area is characterized by an average annual precipitation of 560 mm and a mean annual temperature of 9.3 C (1951–2003, meteorological station Cottbus). The site is mainly level and part of a largely tree-less landscape on the former river Neiße floodplain. It has been used for arable crop production for several decades and was first used for agroforestry in 2010.

Figure 1: Location of the study area in Germany

The tree-strips of the alley cropping system are oriented in a north–south direction and are composed of black locust (*Robinia pseudoacacia L.*) and the poplar clone ‘Max’ (*Populus maximowiczii x Populus nigra*) in different 160 m long pure blocks. The crop alley widths have been adapted to multiples of the standard widths of agricultural machinery (Table 1).

Table 1: Characteristics of study site near the town Forst (in South East Germany)

Feature	research site
Total area of alley cropping field (ha)	40
Overall tree-stripe area (ha)	5
Elevation (m)	70
Slope	Flat
Landscape	Intensively used agricultural landscape
Soil type (WBR classification)	Gleyic Fluvisol
Dominant soil texture (0-30 cm depth; USDA classification)	Sandy loam
Establishment of alley cropping (year)	2010
Tree species/clone	Black locust, poplar Max
Tree densitiy (poplars ha^{-1})	8,715
Planting layout	Double row
Number of double rows per tree-strip	4
Plant spacing (m)	
Within row	0.90
Within double row	0.75
Between double rows	1.80
Width of hedgerows including 0.80 m buffer stripes along both edges (m)	10.00
Rotation period (years)	5
Width of crop alleys (m)	24, 48, 96

The alleys were cultivated with sugar beet (*Beta vulgaris var. altissima)* during the measurement period. Prior to starting microclimate measurements the tree-strips had been harvested in winter 2014/15. They started to resprout at the end of April 2015, and by the end of the measurement period the poplar trees had achieved an average height of 2.8 m.

Shortly after the tree harvest in February 2015, 52 Hobo Pro V2 data loggers with built-in temperature and relative humidity sensors were installed 30 cm above the soil surface within alleys of 3 different widths and at different distances from the tree-rows (Figure 2). Air temperature and relative humidity were recorded on a ten minute basis. Additionally, several weather stations and anemometers (A100R, Vector Instruments) were installed to collect climate data like wind speed, global radiation and precipitation at different distances from the tree-strip. All climate data were recorded over a period of 5 months from May to September 2015.

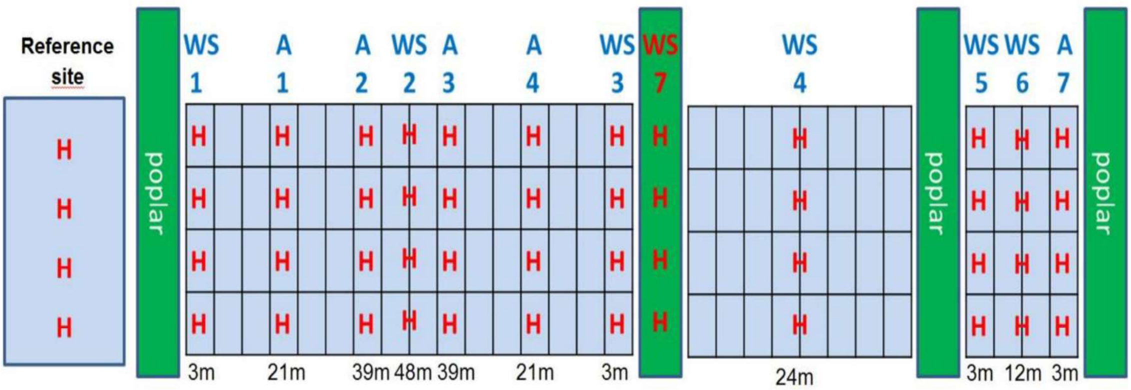
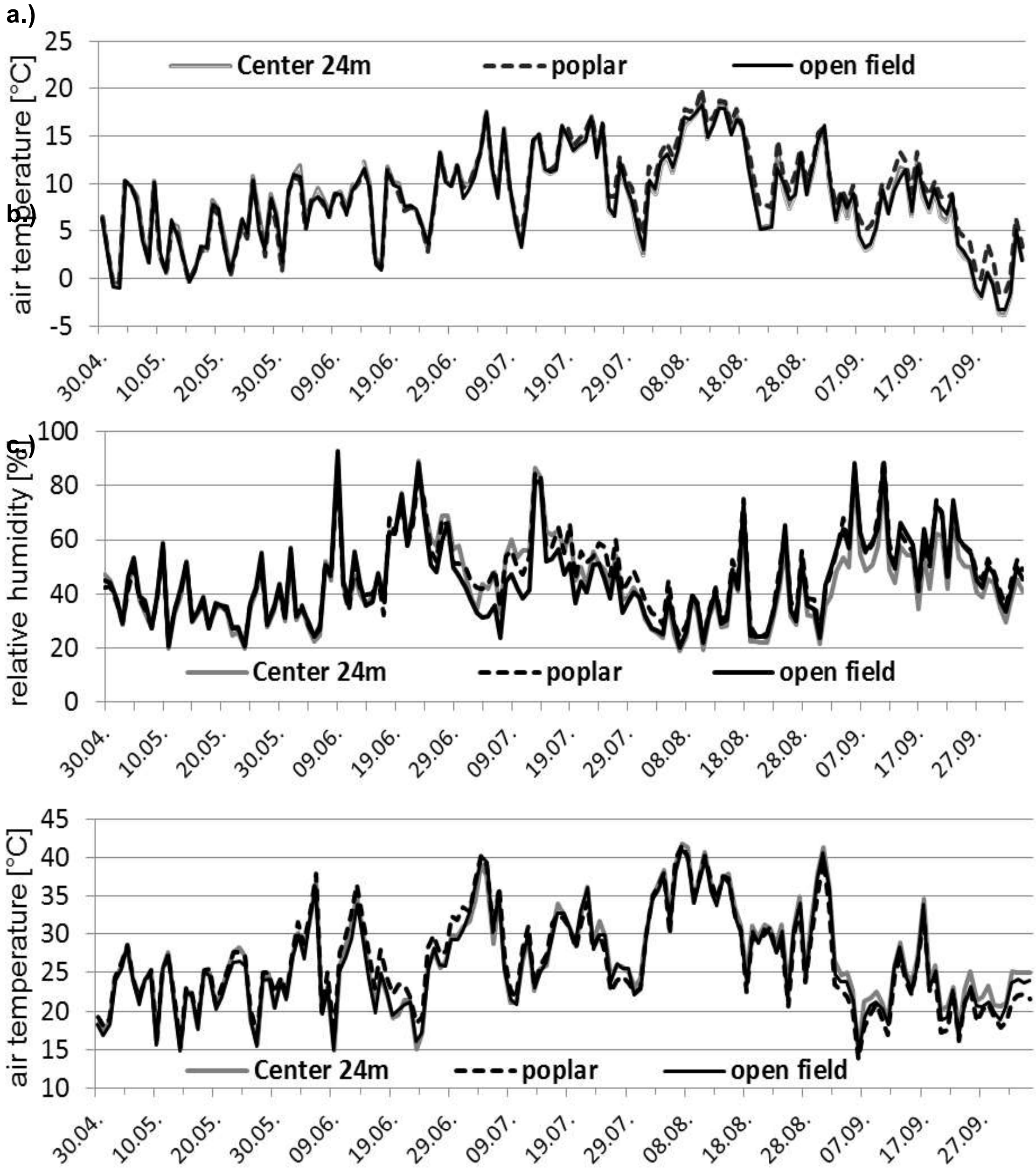


Figure 2: Positions of the Hobo data loggers (H), anemometers (A) and weather stations (WS) on different crop alleys within the study area.

Results and discussion

In May 2015 no obvious difference in air temperature among the plots was observed, but from the beginning of June the impact of the growing tree-strips on temperature became clearer (Figure 3a and b). Compared to the open field, the maximum air temperature from 1st of July to the end of the measuring period was 1.5 % (0.4°C) lower in the poplar tree-strips, presumably due to shading. A 2 % (0.6°C) higher maximum air temperature was detected at the centre of the 24 m wide crop alley, which is a potential effect of the reduced wind velocity (compare Fig. 3c). In addition, the lowest air temperature was detected in the 24 m wide crop alley, which was 0.1°C (1 %) lower than the open field. However, minimum air-temp was almost 1°C (12 %) lower than the tree-strip. Taking into account the whole measurement period, the minimum relative humidity in the poplar tree-strip was 4% higher than on the open field, while the difference between the open field and the centre of the 24m crop alley was 1% (Figure 3c). Compared to the open field the wind velocity in the center of the 24 m wide crop alley has been reduced by up to 17 % (Figure 3d.)



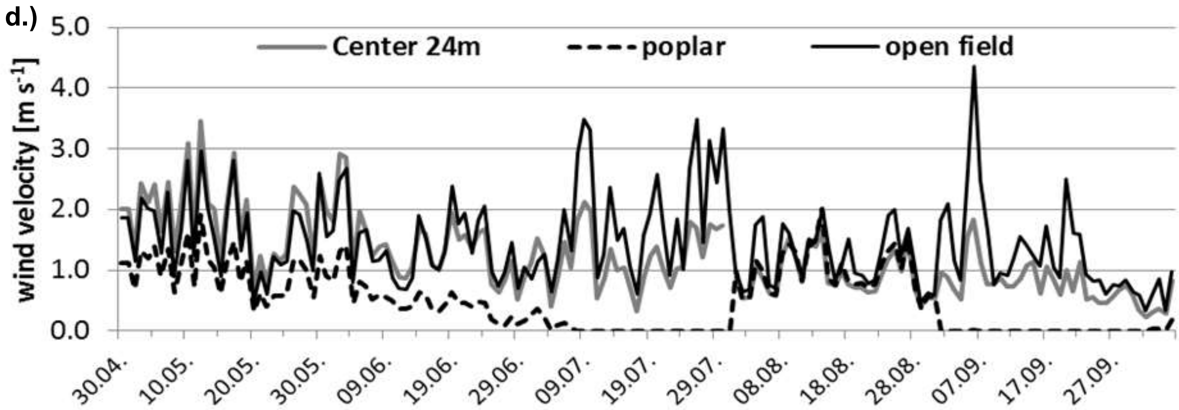


Figure 3: Daily a.) maximum, b.) minimum of air temperature, c.) minimum relative humidity and d.) average wind velocity for the centre of the 24 m wide crop alley, the poplar tree-strip and the adjacent open field (n=4 for 3a,b and c).

In addition, the wind speed has been reduced by almost 67 % within the poplar tree-strips. The highest reduction effect of more than 32 % has been detected on the leeward side, at a distance of 3 m from the tree-strips. Despite the fact that the tree-strips had been harvested in February initial results indicated an early effect on microclimate conditions within the alley cropping system.

References:

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