

THE EFFECT OF A YOUNG ALLEY CROPPING SYSTEM ON SOIL MICROCLIMATE

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Abstract

The aim of the present research is to investigate the effect of such a young alley cropping system (planted for experimental purposes) on the soil microclimate, compared with a control site. The trial system, involving the agroforestry plantation and a control site has been implemented in 2013 in an intensive monoculture agricultural environment. Measurement of soil microclimatic parameters started in 2014. Based on the results of the examination carried out in an agroforestry and a monoculture production site, there is a clear difference between soil moisture and soil temperature of the two cultivation systems. This effect can be observed even from the second year of the fast growing tree (*Paulownia*) plantation.

Keywords: agroforestry; alley cropping; microclimate; soil parameters

Introduction

The more and more frequent occurrences of weather extremes such as drought and water floods, have a negative effect on natural vegetation and the qualitative and quantitative parameters of agricultural production as well as its ecological sustainability. One promising aspect of adapting to climate change is agroforestry, which integrates woody vegetation into agricultural cultivation, exploiting its various economic, social and ecological benefits. The importance of this land using system connecting to many disciplines is highlighted by more Hungarian and European literature (Vityi-Marosvölgyi 2014; Bitter 2014; Moreno et al. 2016; Westaway et al. 2016). In addition to traditional agroforestry systems with a history of thousands of years throughout Europe, new, innovative methods such as alley cropping are spreading too.

The aim of the present research is to investigate the effect of such a young alley cropping system (planted for experimental purposes) on the soil microclimate, compared with a control site.

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Materials and methods

The trial system, involving the agroforestry plantation and a control site has been implemented in 2013 in an intensive monoculture agricultural environment. The soil tests show, that both the agroforestry and monoculture sites stand on the same soil parameters (alkaline clay / clayey loam type slightly solonchak soil). On the half of the total area of approximately 2 ha, 126 pieces of *Paulownia tomentosa* var. Continental E. tree saplings have been planted in 14 m distance between row and 5 m distance of trees, with alfalfa intercropping (agroforestry site). On the other site, with the same size and conditions, monoculture alfalfa cultivation was carried out without tree plantation (control area).

Measurement of soil microclimatic parameters started in 2014. On the experimental area, an agrometeorological station records the air temperature, precipitation, relative humidity, wind direction and strength. Tensiometers and soil thermometers installed on three substations measure the water potential and temperature of the soil at four different depths: 0-10 cm, 10-20 cm, 20-40 cm and 40-60 cm. The sensors have been installed so that the intercrop, the tree rows, and also control areas are monitored (Figure 1). Data has been collected automatically for four years, in two hours interval. The daily averages, calculated from the data series in the growing seasons (1. April to 30. September) of the four years has been analysed. The annual changes in soil moisture and temperature values are shown in box diagrams, which also indicate the deviation of data. In the arid periods, of which the agricultural cultivation is particularly sensitive, the typical processes are well illustrated by the curves of daily averages compared to the air temperature, rain amount and wind speed. Statements based on the diagrams has been controlled and supported by statistical t-tests.

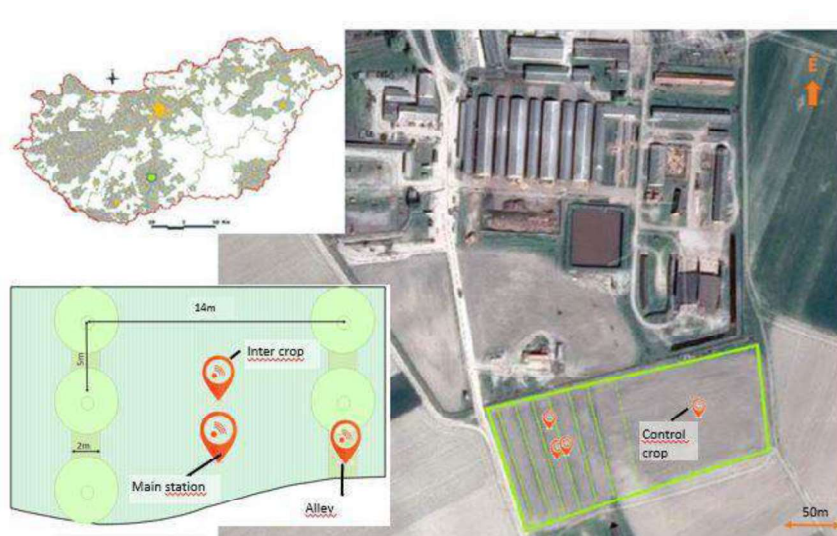


Figure 1: Installation of the sensors to monitor the intercrop, the tree rows and the control areas.

Results

In the upper layer of soil -up to 20 cm depth-, the control site proved to be significantly drier than the agroforestry site. Analysing the soil moisture values, a more frequent and higher soil dryness could be observed in monoculture production, while the majority of the data collected in the agroforestry system was located in a more favourable range, the total dehydration appeared only occasionally. In the deeper soil layers (> 20 cm) this tendency is not so clear; in the last examined growing season the soil moisture of the control area was more favourable (Fig 2). In this depth, soil moisture could be affected by the (partial) aquitard layer in 30 cm depth, the deep roots of trees and alfalfa, and the availability of ground water. According to the data, the presence of trees in the arable cultivation has a favourable effect on the water content of upper soil layers already in the first years, by reducing the drying effect of wind and direct sunlight. During arid periods, dehydration occurred later in agroforestry site and took shorter periods in the upper soil layers than in the control plot. In the deeper soil layers (below 20 cm) the difference in soil moisture values of the agroforestry and control plots was smaller during the same drought period (Figure 2).

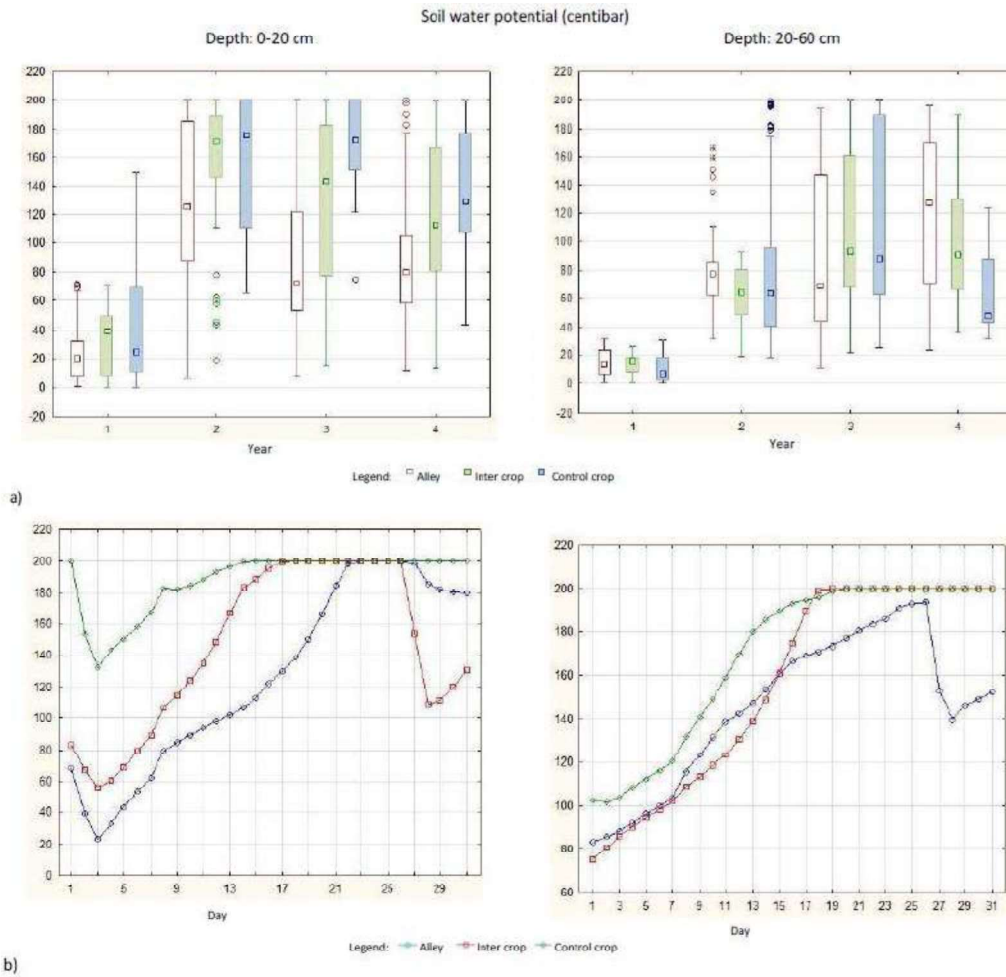


Figure 2: (a) The water potency of the soil moisture measured by tensiometer (water shortage) expressed in centibar in the upper and deeper soil layers in the four growing seasons and (b) during a drought period 21.08.2016 – 23.09.2016 (The soil moisture values measured with the tensiometer indicate the absorption capacity of the soil, so higher values mean drier soil conditions).

By examining the soil temperature data, we can state that the deviation in the control site was higher than in the agroforestry system in all four examined soil layers, but most at the upper measuring points. The annual average of the values and the majority of the data collected in the agroforestry site were in a more favourable range for productivity than in the monoculture.

In the drought periods, while the temperature of the upper (up to 20 cm depth) soil layer of the sites followed the changes of air temperature, the soil in the agroforestry system had a milder degree of warming on the one hand, and was considerably more temperate on the other hand. Although in a smaller extent, but this phenomenon can be observed even in layers up to 60 cm depth (Figure 3).

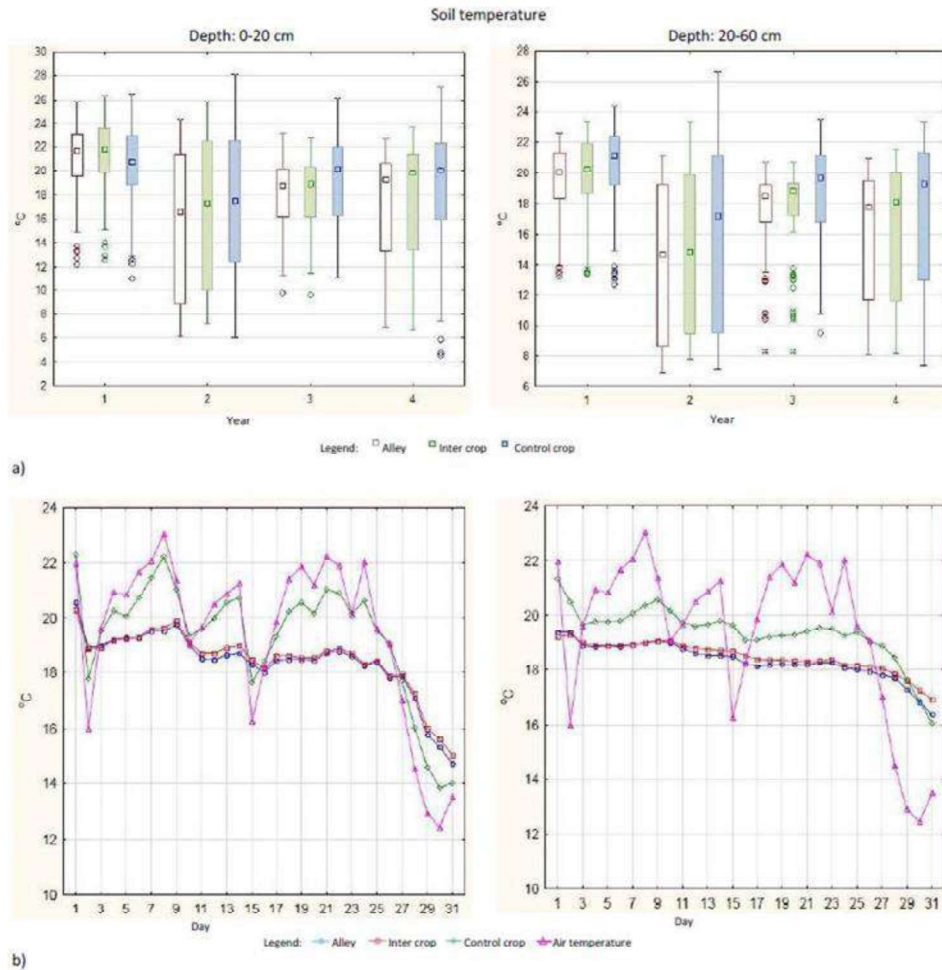


Figure 3: (a) soil temperature values in the upper and deeper soil layers during the four examined growing periods and (b) in a drought period 21.08.2016 – 23.09.2016.

Conclusion

Based on the results of the examination carried out in an agroforestry and a monoculture production site, there is a clear difference between soil moisture and soil temperature of the two cultivation systems. This effect can be observed even from the second year of the fast growing tree (Paulownia) plantation.

Woody vegetation helped to preserve soil moisture in the upper 20-30 cm layer, but caused a decrease in layers below 30 cm (under aquitard layer). The presence of trees is beneficial for the soil temperature; the soil microclimate is more balanced in the agroforestry system than in monoculture due to the decrease of the mean values in the upper layers, the smaller deviance of data and the less frequent prevalence of extreme values of temperature.

Overall, based on the results of the experiment, the alley cropping system can be particularly favourable for shallow-rooted intercrops, by controlling the water and heat balance of the soil and by moderating harmful extremities such as drought, extreme cold or heat.

Acknowledgement

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References

- Moreno G, Berg S, Burgess PJ, Camilli F, Crous-Duran J, Franca A, Hao H, Hartel T, Lind T, Mirck J, Palma J, Pantera A, Paulo JA, Pisanelli A, Rolo V, Seddaiu G, Thenail C, Tsonkova P, Upson M, Valinger E, Varga A, Viaud V, Vityi A. (2016) Agroforestry systems of high natural and cultural value in Europe: constraints, challenges and proposal for the future. 3rd European Agroforestry Conference Montpellier, France.
- Vityi A, Marosvölgyi B. (2014) Agroerdészet egykor és ma. Agroforum 25. Évf. 10. Sz. pp. 80-81.
- Westaway S, Crossland EM, Chambers EM, Gerrard C, Smith J (2016): Does harvesting hedges for woodfuel conflict with their delivery of other ecosystem services? 3rd European Agroforestry Conference Montpellier, France.