AGROFORESTRY: A POSSIBLE RESPONSE TO THE CHALLENGES OF CLIMATE EXTREMES

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Abstract

The available climate data series from Hungary also indicate a higher frequency of extreme events and water scarcity as well. Adaptation in the field of agriculture requires the use of new technologies and a review of familiar practices. The present technology used in crop production gives optimal results with a broadly uniform rainfall distribution; it needs to be modified and improved. This paper examines the technology of agroforestry systems and its application in a small-scale experiment.

Keywords: climate extremes, crop production, agroforestry, small-scale experiment

Összefoglalás

A Magyarország esetén álló éghajlati adatsorok a szélsőséges események és a vízhiány gyakoribb előfordulását jelzik. Az alkalmazkodás a mezőgazdaság területén új technológiák alkalmazását és a megszokott gyakorlatok felülvizsgálatát igényli. A növénytermesztésben jelenleg alkalmazott technológia egy nagyjából egyenletes csapadékeloszlás mellett ad optimális eredményt, módosításra és fejlesztésre szorul. Ez a tanulmány az agrár-erdészeti rendszerek technológiáját és annak alkalmazását vizsgálja egy kisléptékű kísérletben.

Kulcsszavak: éghajlati szélsőségek, növénytermesztés, agroerdészet, kisléptékű kísérlet

Introduction

The effects of climate change are felt not only over many years, but also on shorter time scales and smaller spatial scales, in the weather, which directly affects agriculture (Mann et al 2018). Looking at our country, we see that the climate of the Carpathian Basin is becoming warmer, while extremes are increasing. The annual distribution and intensity of precipitation is also changing in an unfavourable direction. The frequency of summer heat waves is increasing, and the likelihood of heat stress and sudden temperature changes with it. The common feature of these processes is therefore a quasi-systemic oscillation, i.e. a disruption of the previous dynamic equilibrium and an increase in extremes. This affects temperature (both extremes can be typical, so be prepared for both significant frost damage and extreme heat), precipitation, and other climate phenomena (e.g. extremes of wind speed, hail). It is difficult to prepare for extremes in daily temperature changes, rainfall, frost, or even the increased number of hot days - to call just a few of the less known effects of climate change. In addition, these phenomena cannot be reliably predicted. For more, see Kiss et al. (2019) or Fischer & Knutti (2015).

Green infrastructure methods may improve or restore the water retention capacity of natural and artificial (urban) areas, facilitate the use of rainwater in the natural environment [...] adapting to the impacts of climate change (Mrekva, 2017). The latter means turning to practices that naturally compensate for weather extremes and are designed to incorporate more ecological elements than currently used. An agroforestry system is the combination of arable land and forestry in a spatial sense. An agroforestry system is the combination of arable and forestry cultivation on the same land. It corresponds to the concept of green infrastructure in the above sense and its establishment can reduce the effects of climatic extremes on arable and pasture farming. The sample agroforestry system under study is located in the South Transdanubian region, covering an area of about 8 hectares. The results of the experiment confirmed the positive effects of agroforestry.

Material and method Part 1: the cliamte challenge

One of the most obvious, well-known signs and indicators of climate change is the rise in global average temperatures. However, this warming is not uniformly distributed across the globe, with the higher latitudes of the northern hemisphere and the Arctic warming faster. This also affects Europe, which is warming faster than the global average: the annual mean temperature in continental areas was 1.7–1.9 ºC higher than in the preindustrial period between 2011 and 2020 (EEA, 2021). According to the IPCC (UN Intergovernmental Panel on Climate Change), the warming climate is causing a shift in the temperature distribution, with cold extremes becoming less and warm extremes more frequent (IPCC, 2012). This is also the case in Hungary, as can be inferred from OMSZ (Hungarian Meteorological Service) measurements of extremely hot and cold days. There is a more significant change since the 1980s, with a decreasing trend in the number of extremely cold days (daily minimum temperature below zero degrees Celsius) and an increasing trend in the number of hot days (daily maximum temperature above 35 degrees Celsius). As it was shown by Kiss et al (2019) shown, average temperatures in local weather data for Hungary are increasing faster than linear, and the probability of extreme events has already been shown to increase significantly. The OMSZ also measured the number of heat wave days (when the daily mean temperature is higher than 25 degrees Celsius) in a spatial context, with the increase mainly affecting the Central Hungary and Southern Great Plain regions.

Climate change also leads to changes in precipitation. These changes are mainly reflected in the spatial distribution of precipitation, rather than in total precipitation: the wet parts of Europe tend to be more rainy and the dry regions tend to be drier. In the case of Hungary, annual precipitation shows considerable variability. (Lakatos et al. 2022).

Material and Method Part 2: introducing the site

The agro-forestry system under study is located in the district of Dombóvár, in the municipality of Döbrököz, in the watershed area of the Kapos, south of the river, in the landscape unit of the Somogy-Tolna hills called Völgység. The area of the scheme is 7,06 ha, of which 1,65 ha is forest area divided into 4 forest strips, 1,65 ha is pastureland, the rest is vineyard, orchard and farm buildings.

The soil type of the area is slightly acidic sandy soil at an altitude of between 200 and 226 m above sea level. Soil analysis results show that the soil on the site has a humus content of between 0,7 and 1,2 %, poorly bound and poorly supplied with nutrients.

The development of the agroforestry system is a combination of the subdivision of the land in the context of the development of the enclosed gardens, the ageing of the former owners' estate of Döbrököz and the popular and widespread planting of acacia trees in the area in the 1990s.

The thinning of the acacia plantations on the north-south facing plots was started by the new owners, and the strips were converted into mixed forest strips, leaving the occasional saplings of walnut, oak, other fruit trees, etc.

The orientation of the forest strips is mostly north-south, and as a legacy of the enclosure gardens, their east-west extent is narrow. Experience shows that this has a positive effect on both water supply and conservation of moisture. While in the early morning the forest strips act as a vapour trap, and the shading effect prevents the fields between the strips from heating up rapidly during the day, the midday sun shines into the strips, and the shading effect disappears, but returns to the afternoon, reducing the potential for heat stress.

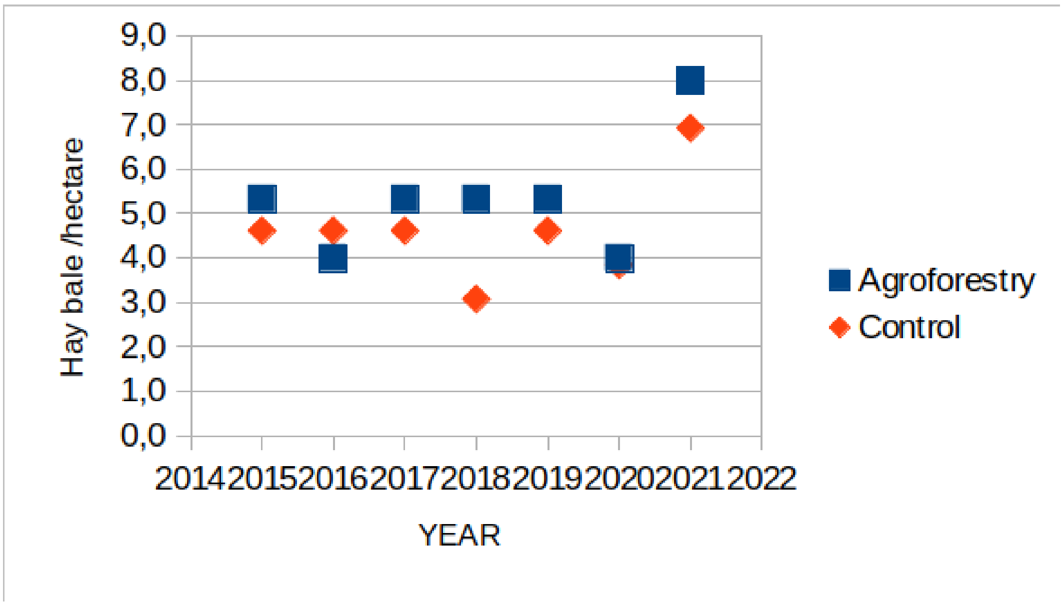
Results

It was found that, similar to the wind shading effect of the bands, the beneficial phenomena were present in the band 3-4 times the width of the forest band, so that the true shade and wind shade adjacent to the bands provided an excess of moisture that was reflected in the size and maturation of the grass/plant.

1. Increasing average temperature. This phenomenon has a negative effect mainly in the summer months, when the weather is warmer and often drier. In later crops (soybean, maize) or in the production of charcoal, dry, warmer weather leads to heat stress and reduced yields. The shading effect of agroforestry systems reduces heat stress. With a north-south orientation, shade is cast on the interspersed field in the morning and afternoon.

2. Rainfall is reduced during the growing season. In utilizing precipitation outside the main growing season, the soil and narrower surroundings of a field protection forest strip with both grassland, shrub and canopy cover have higher groundwater levels and a vapour trap effect that is beneficial for water retention.

In terms of yields, data from the agroforestry system and a control area with similar conditions but without a forest belt are presented, based on the author's measurements. Both the agroforestry system and the control area are sown with a grass mixture, have a surface area of 0.7 ha and both have a low quality (in a hungarian measure, golden crown, AK it is 19). The reference area is 1.4 ha and is the most similar to the study area in terms of soil, both being loamy sandy soils, with part of the study area containing siliceous layers close to the soil surface. Here, even continued grassland management is unfavourable. Despite these drawbacks, the yield per hectare of the study area is almost always higher than that of the control (Figureure 1)



Figureure 1 Yield of agroforestry pastureland vs control area

Conclusion

The agroforestry system has the potential to mitigate the adverse effects of fluctuations in rainfall distribution and quantity due to climate change. The additional yields are mainly due to the retained moisture and the shading effect of the borders. If the aim is to better conserve moisture in extreme weather conditions, agroforestry can definitely be a viable option.

References

European Environment Agency: Trends and Projections in Europe 2021 https://www.eea.europa.eu/publications/trends-and-projections-in-europe-2021

Fischer, E., Knutti, R. 2015. Anthropogenic contribution to global occurrence of heavy-precipitation and high-temperature extremes. Nature Clim Change **5,** 560–564. https://doi.org/10.1038/nclimate2617

Kiss T, Hetesi Zs. Füzi T. 2019. Az átlaghőmérséklet és a csapadékmennyiség alakulása Mosonmagyaróváron. Statisztikai Szemle **97**. 568–593.

Lakatos, M., Bihari, Z., Izsák, B., Marton, A., Szentes, O. 2022. Globális és hazai megFigureyelt éghajlati trendek. Agrofórum, 2022/22. pp. 16–21. (in Hungarian)

Mann, M. E., Rahmstorf, S., Kornhuber, K., Steinman, B. A., Miller, S. K., Petri, S., Coumou, D. 2018. Projected changes in persistent extreme summer weather events: The role of quasi-resonant amplification. Sci Adv. **4**(10). eaat3272. https://doi.org/10.1126/sciadv.aat3272

Mrekva, L. 2017. A zöldinfrastruktúrák szerepe a csapadékvíz-gazdálkodásban és a városi területek lefolyásszabályozásában, I. Országos Települési Csapadékvíz-gazdálkodási Konferencia, Település és lakosságvédelem szekció. Konferencia tanulmánykötet, Dialóg Campus Kiadó, pp. 131. (in Hungarian)

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