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Herbage yield and nutritive value dynamics of late cut grass in silvopastoral agroforestry systems

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Highlights

- The varying quality of biomass and forage throughout the growing season suggests the need for a temporally differentiated management strategy
- Proximity to trees significantly influences grass biomass: yield dynamics are reduced near trees and more pronounced between the tree lines
- Forage quality is less affected; the decisive factor is the harvest time. The development of late-cut growth over time has hardly been studied to date

Abstract

In many temperate-zone silvopastoral agroforestry systems, grassland is either farmed intensively or used for animals, with the tree component playing a central structural role. This raises the key research question of how proximity to lines of trees influences the development of grass biomass accumulation and its nutritional value. This is particularly relevant in extensive management systems, where grassland is harvested once per year in order to minimize labour intensity. Although the impact of tree lines on grass sward yield and quality in silvopastoral systems has been studied, little is known about the dynamics of forage quality changes over time in such systems.

To address this issue, a two-year field experiment was conducted at two sites in northern Germany that differ in terms of soil type, microclimatic conditions, and silvopastoral age. One site was planted in 2016 (estimated tree height north side: 7 m, and south side: 13-15 m) and the other in 2021 (estimated tree height 3-4 m). The spatial and temporal dynamics of grass biomass accumulation and nutritive value, such as crude protein (CP) or acid detergent fibre (ADF) concentrations, were investigated in relation to i) the distance from the tree line (1 m, 4 m, and centre between two tree lines), including an open-field control, and ii) the time of the first harvest of the grassland. For this, the harvest dates took place either in spring (May), at the beginning of summer (June/July) or at the end of summer (August) and in autumn (September). The replication number was four. A statistical analysis was performed in RStudio (R Core Team, version 4.0.2) using linear mixed-effects models. The fixed effects included site, distance from the tree line, harvest date and their interactions. Replication was used as the random effect. Post hoc comparisons of means were performed using the Tukey HSD method ($P < 0.05$).

An evaluation of the data from the first year of the study revealed a significant interaction between harvest time and distance from the tree line with regard to biomass accumulation ($p < 0.01$). The accumulation of herbage biomass was significantly lower near the tree line. Biomass accumulation was relatively low in spring and did not differ significantly between the distances to the tree line. As the growing season progressed, biomass accumulation increased towards summer compared to spring (an average difference of 37%), but this increase was smaller near trees (1 m: 15% spring vs. summer) compared to greater distances (centre: 66% spring vs. summer). The distances did not differ significantly in biomass accumulation at the harvest conducted at the end of summer. However, in autumn, there was again a significantly smaller biomass accumulation at the 1 m position compared to areas further away from trees. Harvesting early can mitigate the effects of shading and encourage greater biomass accumulation before competition intensifies at later harvest times.

The CP concentration was significantly affected by the three-fold interaction of site x harvest time x distance from the tree line ($p < 0.001$). The dominant factor was the time of harvest. The lowest CP concentration was observed in June, as a result of intensive biomass accumulation across all positions. The CP concentration initially fell, but recovered in late summer due to regrowth. Significant differences were observed between the sites, with the older site recording a value of 139.5 g/kg DM and the newer site recording a value of 99.9 g/kg DM. While the CP concentration remained stable in one site near the tree line, it decreased significantly with increasing distance from the tree line. The CP concentration was generally below the level considered appropriate for dairy cattle, but it was high enough for beef production. The ADF concentration was significantly affected by the main effect of harvest time as a result of a progressive and significant increase from harvest to harvest. The neutral detergent fibre (NDF) concentration was significantly influenced by the factors of site ($p < 0.05$), harvest time ($p < 0.001$), and distance from the tree line ($p < 0.05$).

The results show that the dynamics of yield and quality development in extensively managed silvopastoral grasslands are significantly affected by their proximity to the tree line. The findings of this study could improve our understanding of the impact of trees on grassland nutrient content and support the development of more sustainable agricultural systems. The ecosystem services examined, including biomass production, nutritional value, and feed digestibility, are categorised according to the CICES (Common International Classification of Ecosystem Services) framework, where they are assigned to provisioning services in the domain of feed production. Further studies will aim to determine the extent to which these findings can be generalized and to identify the relevant causal relationships in this context.

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Keywords

agroforestry, grass biomass, forage quality, feed quality, poplar rows