# Yield, chemical composition, palatability and *in vitro* digestibility of six fodder tree species managed as hedgerows in temperate permanent grasslands

**Julie Botzas-Coluni[1,2], Alice Manoukians[3], Elisa Manzocchi[3], Myriam Rotacher[4], Melissa Terranova[5], Patrick Ledermann[1], Sébastien Dubois[6], Massimiliano Probo[1], Pierre Mariotte[1]**

[1]Agroscope, Grazing Systems, Route de la Tioleyre 4, 1725 Posieux, Switzerland; [2]EPFL, Plant Ecology Research Laboratory, Station 2, 1015 Lausanne, Switzerland; [3]Agroscope, Ruminant Nutrition and Emissions, Route de la Tioleyre 4, 1725 Posieux, Switzerland; [4]Research Contracts Animals, Route de la Tioleyre 4, 1725 Posieux Switzerland; [5]AgroVet-Strickhof, ETH Zurich, 8315 Lindau, Switzerland; [6]Agroscope, Feed Chemistry, Route de la Tioleyre 4, 1725 Posieux, Switzerland

## Highlights

- *Alnus cordata* was the most productive species and *Tilia platyphyllos* the least.
- Five of the six tree species had crude protein values above 140 g $kg^{-1}$ dry matter, which is higher than most grass-based forage in summer.
- *Salix caprea* was the species with the highest palatability and *in vitro* digestibility and reduced *in vitro* methane production per g of digested organic matter by up to 27%, when included at 60% in the diet.

## Introduction

Climate change has led to more frequent droughts globally, with potential consequences for forage production in permanent grasslands (Moravec *et al.*, 2021). Unlike herbaceous species, many tree species have better drought resistance thanks to their secondary growth and deeper water uptake. Thus, agroforestry systems, which integrate trees into permanent grasslands, represent a potential strategy to provide additional tree-based forage during summer droughts. This study evaluated the productivity, chemical composition, palatability, *in vitro* organic matter digestibility (IVOMD) and methane ($CH_4$) mitigation potential of the leaves of six fodder tree species to evaluate their potential as complementary fodder resources for ruminants, that can directly feed on the hedgerows, and to provide practical information needed for farmers and policy makers for the implementation of agroforestry systems in temperate climates.

## Methods

Six tree species were planted in hedgerows on six permanent grasslands in Western Switzerland in 2021: *Morus alba* L., *Tilia cordata* Mill., *Tilia platyphyllos* Scop., *Fraxinus ornus* L., *Alnus cordata* Loisel. and *Salix caprea* L. The hedgerows were composed of five species (*T. cordata* or *T. platyphyllos*) with three rows of trees planted along or within the grassland. All trees were pruned to a height of 70 cm in the fall of 2024 to promote biomass production. In August 2025, biomass measurements were carried out on 20 trees per species per site. Each tree was completely defoliated to determine the fresh and dry leaf mass. The basal area of all sampled trees was also measured to model its relationship with leaf biomass.

To assess the palatability of the tree species, a feed choice experiment was conducted with six Brown-headed wethers in August 2024 (experimental license 2024-14-FR). Tree leaves and hay represented 20% and 80% of the daily offered DM, respectively. The amounts of leaves and hay offered and refused were weighed each morning to calculate intake and derive a palatability index for each species. Weekly analyses

of leaf chemical composition were carried out, including crude protein, fibre fractions (NDF, ADF, ADL) and condensed tannins. *In vitro* organic matter digestibility (IVOMD) and associated $CH_4$ production were evaluated using the Hohenheim Gas Test. Five diets consisting (on a DM basis) of 80% hay and 20% freeze-dried leaves from five tree species (i.e., all species except *T. platyphyllos*), and a 100% hay diet (as a control) were incubated with a rumen fluid-buffer solution (1:2) with rumen fluid collected from two rumen-fistulated cows (experimental licence ZH113/18) across three experimental runs. Each diet was incubated in triplicates. Since *S. caprea* had the highest leaf condensed tannin content, additional diets containing 20%, 40% and 60% S. *caprea* leaves were tested to evaluate how the increasing proportions affected gas production and IVOMD. After 24 h of incubation, total *in vitro* gas production was recorded, and $CH_4$ concentrations were quantified by gas chromatography.

## Results and Discussion

Tree basal area was a good predictor of forage yield for all species across sites. Forage yield differed significantly among species. *A. cordata* had the highest forage yield (in DM) per 15 $cm^2$ basal area (334 g), followed by *F. ornus* (297 g), *S. caprea* (241 g), *M. alba* (219 g), *T. cordata* (113 g) and *T. platyphyllos* (94 g). All species except *F. ornus* had crude protein concentrations above 140 g $kg^{-1}$ DM, which is higher than most grass-based forage in summer. *S. caprea* was the preferred species and was consumed in similar amounts to hay, resulting in the highest palatability index, whereas *A. cordata* was the least preferred species. Palatability was correlated with leaf chemical composition, with species having a higher fibre content being less preferred. The highest IVOMD was observed for *M. alba* leaves, with values similar to the control hay (65%). The lowest IVOMD was obtained with *A. cordata* leaves, while the other species yielded intermediate values. *S. caprea* leaves had the highest condensed tannin concentrations (32.8 g $kg^{-1}$ DM) and showed the lowest $CH_4$ production per g of digested organic matter, representing a 10.8% reduction compared to the control hay. Furthermore, including 60% of *S. caprea* leaves in the diet reduced *in vitro* $CH_4$ production per g of digested organic matter by 27% compared to the control hay, while reducing IVOMD by only 4.5%.

## Conclusion

All six tree species demonstrated potential to provide additional forage in late summer when herbage yields might be negatively impacted by drought. Trade-offs existed between productivity and digestibility, as the most productive species (*A. cordata* and *F. ornus*) had the lowest palatability and IVOMD. Overall, *S. caprea* was the species with the best compromise between forage yield, palatability, $CH_4$ mitigation and IVOMD. Our study is one of the first to characterize the forage yield, palatability, chemical composition and IVOMD for these six fodder tree species. Continued measurements are planned to understand how fodder tree production will evolve in the long-term.

## Keywords

fodder tree hedgerows, forage production, leaf chemical composition, methane production, *in vitro* digestibility

## Reference

Moravec, V., Markonis, Y., Rakovec, O., Svoboda, M., Trnka, M., Kumar, R., & Hanel, M. (2021). Europe under multi-year droughts: How severe was the 2014–2018 drought period? *Environmental Research Letters*, *16*(3), 034062. https://doi.org/10.1088/1748-9326/abe828