NUTRITIONAL POTENTIAL OF FODDER TREES: THE IMPORTANCE OF TREE SPECIES, SOIL TYPE AND SEASONAL VARIATION

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Abstract

The objective of this study was to assess the effect of soil type and season on the nutritional potential of leaves from Fraxinus excelsior, Alnus glutinosa and Salix viminalis. Leaf samples ands soil samples were collected at 10 sites in the Netherlands on clay and on sandy soils in June, July and September, which were analysed for several nutritional aspects. We found main differences between the studied tree species and sampling period, but no main effect of soil type was found. Significant interactions were found for species x sampling period (digestibility, calcium, sulphur) and species x soil (digestibility, calcium). For the zinc and selenium concentration in tree leaves, a significant species x soil x sampling period interaction was found. We conclude that trees can play a role for supplying protein, and macro and micro elements to livestock, but that it depends on which tree species is used.

Keywords: leaves; digestibility; protein; macro elements; micro elements; mineral cycles

Introduction

Farmers often report that free ranging cows use trees as fodder. Vandermeulen et al. (2016) found that heifers spent a significant time budget browsing on a variety of shrubs and trees. Available literature shows that different tree species are very interesting in terms of nutritional value for ruminants because of high levels of protein and especially macro and micro elements (Rahmann 2004). However, within literature some tree species show remarkable differences in nutritional values (Luske et al. 2017). Therefore the objective of this study was to investigate the effect of soil type (clay and sand) and seasonal variation on the nutritional quality of three common tree species in the Netherlands; ash (*Fraxinus excelsior* L.), common alder (*Alnus glutinosa* L. Gaertn.) and basket willow (*Salix viminalis* L.). We hypothesized that i) there is a significant difference in nutritional value of tree species, ii) the nutritional value of tree leaves decreases as the growing season progresses due to increasing leaf age, and iii) on clay soils the content of macro and micro elements is higher than on sandy soils.

Materials and methods

Ten organic dairy farms located in the province of Noord-Brabant and Utrecht were selected (five on sandy and five on clay soils). On each farm, one site was selected where the tree species, ash (*Fraxinus excelsior),* alder (*Alnus glutinosa*) and basket willow (*Salix viminalis*), were present next to a pasture (not on the pasture) and growing close together (<50m apart). On each site tree leaf samples were taken at three moments in the growing season of 2013, 17 to 25 June, 29 to 30 July and 9 to 10 September. One leaf sample consisted of approximately 500 grams of fresh hand-picked leaves. During the first sampling period, a soil sample (consisting of 40 subsamples) was taken on each site with an augur at a depth of 0-25 cm. Soil samples and oven dried (at 70°C for 24 hours). They were analysed in the laboratory of Eurofins (Wageningen, NL) for a set of soil parameters (pH-KCl, SOM, N-total, clay content, S-total, PAE-P, Mg, Zn, Se, Si, Mo, Fe). The tree leaf samples were analysed in the same lab for a set of crop parameters (DOMD, total-N, Ca, P, S, Zn, Cu, Se).

A split-split plot design (Genstat 13.3) was used to test for differences in nutritional values of the tree leaf samples. The factors taken into account were 'soil type', 'tree species' and 'sampling period' (June, July and September).

Results

A significant ($P < 0.05$) main effect of tree species on the DOMD, CP, Ca, P, S, Zn and Se concentrations in tree leaves was found. The highest DOMD and Ca concentrations were found for *F. excelsior*, while the highest CP concentration was found for *A. glutinosa*. *S. viminalis* had highest concentrations of P, S, Zn and Se.

Considering the sampling period, a significant ($P < 0.01$) main effect was found for CP, P and Cu concentrations in tree leaves (Table 1). Highest concentrations of these elements were found in June. No main effect of soil type on the nutritional value of tree leaves was found. Furthermore, significant interactions were found for species x sampling period (DOMD, Ca and S) and species x soil type (DOMD and Ca). For *F. excelsior* the DOMD increased from June to September, while the opposite was true for *A. glutinosa*. No trend was found for *S. viminalis*. The Ca concentration in *F. excelsior* leaves almost doubled from June to September, whereas in *S. viminalis* leaves the Ca concentration tended to increase. In *A. glutinosa* the Ca concentration remained stable. For *S. viminalis* a significant higher DOMD and Ca concentration. was found on clay soils. A significant ($P < 0.05$) interaction between tree species x soil type x sampling period was found for Zn and Se. For more details we refer to Luske and Van Eekeren (2017).

Table 1: Nutritional values of tree leaves per species and measured at three sampling periods. The average values are displayed ± SEM. Significant effects are indicated by * ($P < 0.05$) or ** ($P < 0.01$). Group differences based on the LSD's are indicated with a, b and c's. For correct interpretation of this table, take into account the significant interactions which were found between species, sampling period and/or soil type for DOMD, Ca, S, Zn and Se.

		DOMD	Crude protein	Ca	P	S	Zn	Cu	Se
	Unit	%	g kg DM^{-1}	g kg DM^{-1}	g kg DM^{-1}	g kg DM^{-1}	mg kg DM^{-1}	mg kg DM^{-1}	µg kg DM^{-1}
Tree species	Ash *(F. excelsior)*	71.3 ± 0.89 b	171.5 ± 5.42 a	23.9 ± 1.77 c	2.5 ± 0.14 a	4.0 ± 0.20 b	32.5 ± 2.83 a	9.4 ± 0.65	79.3 ± 8.14 a
	Alder *(A. glutinosa)*	61.5 ± 1.25 a	201.0 ± 4.14 b	12.1 ± 0.59 a	2.0 ± 0.08 a	2.3 ± 0.08 a	74.6 ± 6.80 a	11.2 ± 0.62	43.2 ± 3.93 a
	Willow *(S. viminalis)*	61.5 ± 1.48 a	189.8 ± 6.87 ab	15.7 ± 1.05 b	3.3 ± 0.20 b	5.3 ± 0.21 c	227.4 ± 24.48 b	8.7 ± 0.32	193.1 ± 42.95 b
	P	**	*	**	**	**	**	ns	*
Sampling period	June	66.3 ± 0.93	204.1 ± 6.28 b	12.2 ± 0.92 a	3.0 ± 0.19 b	3.2 ± 0.25	109.1 ± 16.74	10.8 ± 0.57 b	87.7 ± 18.89 a
	July	63.2 ± 1.61	178.7 ± 4.67 a	17.5 ± 1.40 b	2.3 ± 0.14 a	4.0 ± 0.30	104.2 ± 19.09	9.3 ± 0.5 a	93.6 ± 21.51 a
	Sept	64.8 ± 1.77	179.6 ± 5.77 a	20.1 ± 1.93 c	2.6 ± 0.19 a	3.8 ± 0.31	121.2 ± 27.01	9.2 ± 0.63 a	134.2 ± 38.53 b
	P		**	**	**	ns	ns	*	*

Discussion and conclusion

We can conclude that the nutritional value of tree leaves differs between the studied tree species. The higher CP content of *A. glutinosa* could be because of the symbiotic nitrogen fixing ability in association with the Gram-positive species of actinomycete filamentous bacterium Frankia alni (Baker and Mullin 1992). Compared to the literature most of the measured nutritional parameters of tree leaves in our study were within the range mentioned in available recent literature (Côté and Dawson 1999; Trémolières et al. 1999; Kemp et al. 2001; Machatschek 2002; Nijman 2002; Rahmann 2004; McWilliam at al. 2005; Smith et al. 2012; Emile et al. 2016; Emile et al. 2017) and only minor differences were found.

We expected to find downward going trends for the nutritional values of tree leaves, due to leaf ageing. However, this was only true for the CP, P and Cu concentration in tree leaves, which decreased from June to September. The specific tree species react differently to soil type. We found a clear effect of soil type for *S. viminalis*, for which we found a higher DOMD and a higher Ca concentration in tree leaves on clay sites than on sandy sites. For *S. viminalis* in September, we also found higher Se concentrations in tree leaves on clay soils, and on sandy soils higher Zn concentrations (Figure 1). Part of our findings coincide with the finding of Robinson et al. (2005) that micro element accumulation (B, Cd, Mn and Zn) in willow leaves was a function of leaf age.

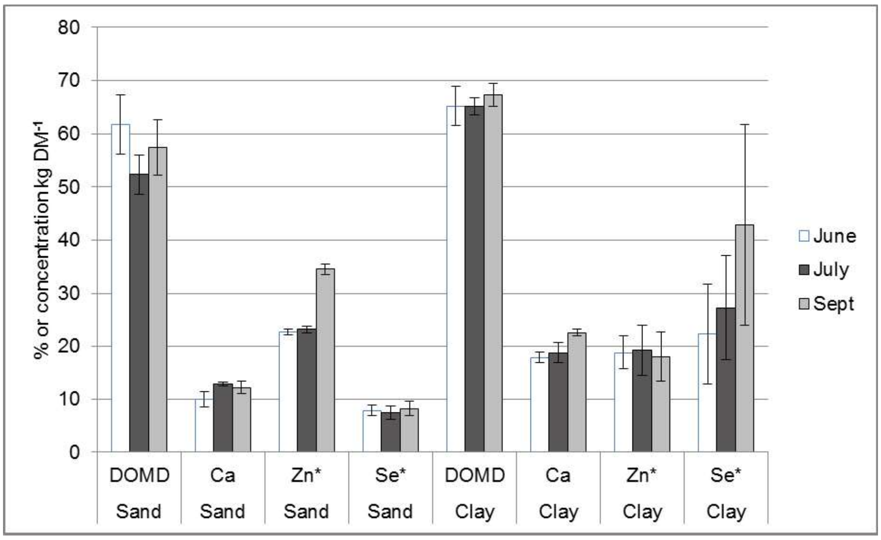

Figure 1. Average digestability (%), calcium (g kg DM^{-1}), zinc (mg kg DM^{-1}) and selenium (µg kg DM^{-1}) concentration in leaves of *S. viminalis* on the sandy and clay sites. Error bars present SEM. *Displayed values are multiplied by 10^{-1} to enable clear presentation of the results.

Our results suggest that the high concentrations of Zn and Se found in tree leaves do not originate from the upper soil, but from deeper soil layers and that trees play a role for supplying micro elements into the agricultural system. Unfortunately, we cannot conclude this directly from our study as we only took samples from the upper soil (<0.25 m deep). For future research it would be interesting to study the correlation between soil components of deeper soil layers (25-200 cm deep), fine root morphology and levels of macro and micro elements in tree leaves. The extreme high concentrations of micro elements that we found in willow leaves on some of our sites might be explained by the fact that willow has a relatively high root length density, root length and fine root biomass (Huber et al. 2012). It is known that plant roots can sense resource availability in the soil and form new roots in places where essential resources are available in high densities (Pregitzer 2008). As Sinclair et al. (1994) stated, tree root characteristics of tree species are increasingly recognized as criteria for the suitability for agroforestry systems. For more detail we refer to Luske and Van Eekeren (2017).

Tree species is the most important factor to take into account when introducing three dimensional grazing with fodder trees or shrubs. *A. glutinosa* is interesting because of high CP and Cu concentrations in the leaves. *F. excelsior* leaves had the highest digestibility and Ca concentration. *S. viminalis* is very interesting for livestock when there is a shortage of micro elements like Zn and Se but less when there is a shortage of Cu. Therefore, before use, we advise to study the nutritional value of specific tree species, for instance by visiting the *Online fodder tree database for Europe* (Luske et al. 2017). Additionally, analyses of locally collected leaf samples can give insight in the local nutritional potential of tree leaves.

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