

Vitamin and mineral content and feeding value of different legume and grass species grown in seven legume-grass mixtures

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Abstract

The aim was to examine if including a range of grassland species could help to balance the diet on organic dairy farms compared with traditional mixtures. Four different grass species and four legume species were grown and harvested in mixtures with one grass and one legume for two growing seasons. The species turned out to have very individual mineral, vitamin and fiber profiles and organic matter digestibility, not influenced by year. Among the legumes red clover (*Trifolium pratense*) and white clover (*Trifolium repens*) had the highest feeding value and red clover had further a high content of Co, Cu and Zn. Lucerne (*Medicago sativa*) had as red clover a high growth potential in mixture but had in general a low content of macro and micro minerals with exception of Se. Lotus (*Lotus corniculatus*) had a low competitive strength, and the effect of the whole herbage was therefore limited even that the content of the vitamins were high. Among the grasses perennial ryegrass (*Lolium perenne*) generally had the highest feeding value, and a higher content of the macro and micro minerals and of vitamins as well than the other grasses (hybrid ryegrass (*Lolium hybridum*), meadow fescue (*Festuca pratensis*) and timothy (*Phleum pratense*)). The only exception was meadow fescue, which had a higher content of alfa-tocopherol.

Introduction

On organic dairy farms self-sufficiency at farm level is a central element in the organic farming principles. One method to increase self-sufficiency of minerals and vitamins is to choose plant species with high cell wall degradability and with different mineral and vitamin profiles that can complement each other. A range of plant species could thus help to balance the diet. We have examined different grassland species with the aim to analyze the possibility of self-sufficiency of mineral and vitamins. As the competition between species affects the growth and mineral uptake, each species were grown in a mixture including one legume and one grass.

Materials and methods

Seven different mixtures each composed of one grass and one legume were established in plots in four replicates at Research Centre Foulum in 2006. The plots consisted of five subplots, one used for five cuts per year and the others for examining the growth during spring growth and 2nd regrowth by harvesting one week before and one week after the normal cutting time. There were four grass species all mixed with white clover: perennial ryegrass, hybrid ryegrass, meadow fescue and timothy. There were further four legumes all mixed with perennial ryegrass: white clover, red clover, lucerne and lotus (birdsfoot trefoil). The plots were fertilized with 300 kg total N in cattle slurry and were irrigated at drought stress. The dry matter yield and the botanical composition measured by hand separation were determined at each harvest. At the three harvests in spring growth and 2nd regrowth in vitro organic matter digestibility (IVOMD, Tilley and Terry method), the fiber fractions NDF, ADF and ADL (van Soest method) and N (Dumas method) were analyzed in the hand-separated species. The mineral composition was also measured in the species. Samples were digested with a mixture of nitric acid and perchloric acid according to the AOAC procedure no. 996.16. The elements were determined using ICP-MS on an X-Series II instrument from Thermo Fischer (Bremen, Germany). Finally alpha-tocopherol, beta-carotene and lutein were analyzed the species by normal phase HPLC after alcoholic saponification and extraction into heptane (Jensen et al., 1998).

Results

Yield and botanical composition: Among the legumes, which all were grown in mixtures with perennial ryegrass, red clover mix gave the highest annual yield with the highest proportion of legumes in the herbage (Table 1). Opposite lotus mix gave the lowest yield with the lowest legume proportion. The yield of white clover mix and lucerne mix were nearly the same but with nearly the double proportion of legumes in lucerne mix. Among the grasses all grown together with white clover the highest yield and highest grass proportion was found in hybrid ryegrass mix and meadow fescue mix.

Feeding value: There were great differences between the legumes (Table 1). In general the highest feeding value was found in white clover with the lowest cell wall content (NDF) and highest organic matter digestibility (IVOMD) and crude protein content. Lucerne had opposite the lowest value with relatively high lignification of cell wall (ADL/NDF). This seems primarily to be due to a high proportion of lucerne stem with a low feeding value (Søgaard and Weisberg, 2007). Even that red clover constituted the highest amount it had a

relatively high feeding value with the lowest lignin content (ADL) and the lowest lignification of cell walls. This seems to be due to a relatively high digestibility of the stem (Søgaard and Weisbjerg, 2007). The grasses were grouped in two (Table 1). The ryegrasses, had the highest and meadow fescue and timothy the lowest feeding value independent of the yield level.

Table 1. Annual dry matter yield of the mixture (t DM ha⁻¹). Proportion of the species in the two species mixtures (% of DM) and feeding value as a mean of samples in spring and summer growth (IVOMD, % of organic matter; the others, % of DM).

	DM-Yield	Proportion	IVOMD	NDF	ADF	ADL	ADL/NDF	Crude protein
Mixed with perennial ryegrass								
White clover	12.6 ^b	37.2 ^c	79.7 ^a	23.9 ^d	21.0 ^c	3.7 ^c	14.8 ^c	22.2 ^a
Red clover	15.6 ^a	78.8 ^a	76.6 ^b	27.4 ^c	22.5 ^{bc}	3.1 ^d	10.9 ^d	19.8 ^b
Lucerne	13.4 ^b	66.3 ^b	67.6 ^d	37.4 ^a	31.1 ^a	6.2 ^a	16.2 ^b	19.8 ^b
Lotus	9.6 ^c	18.8 ^d	71.1 ^c	29.0 ^b	23.6 ^b	5.3 ^b	17.7 ^a	20.3 ^b
Mixed with white clover								
Per. ryegrass	12.6 ^b	62.8 ^b	80.9 ^a	45.3 ^b	26.1 ^b	2.0 ^b	4.3	14.6 ^a
Hyb. ryegrass	13.1 ^{ab}	72.9 ^a	81.3 ^a	42.1 ^c	25.1 ^c	2.1 ^b	5.2	13.5 ^{ab}
Mea. fescus	13.3 ^a	72.4 ^a	78.1 ^b	51.3 ^a	30.2 ^a	2.4 ^a	4.7	13.0 ^b
Timothy	11.8 ^c	63.1 ^b	78.1 ^b	53.1 ^a	30.3 ^a	2.7 ^a	5.0	13.1 ^b

Different letters within variable and group indicate significant differences ($P < 0.05$).

Vitamin content (data not shown): Among the legumes lotus had the highest content of all the components. Among the grasses meadow fescue differ from the others by having the highest alpha-tocopherol content and the lowest beta-carotene content.

Content of macro minerals (data not shown): Lotus differ from the other legumes by having a very high content of K and a low content of Na and Ca. White clover was characterized by having a very high content of Na (0.27 % of DM vs. 0.09% as mean of the others). Among grasses the ryegrasses had the same high level of Na content as white clover. Timothy had in general a low content, especially of Na (0.01 % of DM).

Content of micro minerals: Red clover had the highest content of Co, Cu and Zn, white clover had the highest content of Mn and Fe and lotus had high content of Co, Mn, Zn and Fe (Table 2). Lucerne had low content of micro-minerals, except for Se. Among grasses timothy had, in general, low content of micro-minerals, with Cu and Zn as the only exceptions. Comparing legumes and grasses, then legumes had significantly ($P < 0.05$) higher content of Co, Se and Cu than grasses, and grasses had significantly higher content of Mn than legumes.

Table 2. Concentration of micro-minerals (mg kg⁻¹ DM) in the species as a mean of samples in spring and summer growth.

	Co	Se	Mn	Cu	Zn	Fe
Mixed with perennial ryegrass						
White clover	0.048 ^b	0.019 ^c	51.4 ^a	6.7 ^b	17.9 ^b	89.4 ^a
Red clover	0.057 ^a	0.025 ^b	42.9 ^b	8.7 ^a	22.2 ^a	61.3 ^b
Lucerne	0.041 ^c	0.033 ^a	38.0 ^c	6.5 ^b	18.6 ^b	63.4 ^b
Lotus	0.054 ^a	0.022 ^{bc}	47.8 ^a	6.2 ^b	22.4 ^a	81.7 ^a
Mixed with white clover						
Per. ryegrass	0.031 ^a	0.019 ^a	68.1 ^a	6.7 ^a	22.6 ^a	96.1 ^a
Hybrid ryegrass	0.023 ^b	0.018 ^{ab}	56.8 ^b	6.2 ^{ab}	20.4 ^b	78.0 ^b
Meadow fescue	0.023 ^b	0.016 ^{bc}	56.9 ^b	5.1 ^c	15.5 ^c	75.5 ^b
Timothy	0.016 ^c	0.014 ^c	46.1 ^c	5.9 ^b	24.3 ^a	72.6 ^b

Different letters within variable and group indicate significant differences ($P < 0.05$).

Discussion

In this experiment there were significant differences among grassland species in contents of minerals, vitamins and fibers and in digestibility of organic matter. None of the grass/legume mixture in this experiment had the highest value all the way though. This indicates a potential for optimizing dairy cow intake of mineral and vitamin from home-grown herbage by manipulating grassland species composition. For example, the highest Co concentration of 0.051 mg/kg DM was found in the red clover/perennial ryegrass mixture and the lowest of 0.023 in lotus/timothy. The species composition could thus contribute significantly to the Co content in the herbage. The concentration of Cu ranged from 5.7 to 8.3, Zn from 16.1 to 23.9 and Se from 0.016 to 0.028 mg/kg DM between the different mixtures. Despite species differences, the micro-mineral contents were generally above dairy cow requirements according to the NRC (2001) for Mn and Fe, close to requirement for Cu and Zn, and below requirements for Co and Se. Perennial ryegrass, which is the most used grass species in DK, had in general the highest feeding value, highest content of macro and micro minerals, and highest vitamin content. The only exception was meadow fescue, which had a higher content of alfa-tocopherol. The competitive strength was very different among the legumes. Lotus had a low, white clover a medium and red clover and lucerne had a high strength. Red clover and lucerne had thus a greater effect on the quality of the whole herbage.

References

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